GENERAL INDUSTRY AND TECHNOLOGY

LINDBECK

General Industry and Technology

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Dr. John R. Lindbeck
Professor of Engineering Technology
Western Michigan University

Dr. Irvin T. Lathrop
Professor Industrial Arts
California State University
Long Beach, California

Consulting Editor
Dr. John L. Feirer
Distinguished Faculty Scholar
Western Michigan University

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Plan of This Book

A general course should be an integral part of all modern industrial education programs. Such a course has the following major objectives:

1. Students learn about the fields of computer technology, graphic communications, metalworking, plastics, woodworking, building construction, power, and transportation at the introductory level. Furthermore they are led to explore these areas in order to learn how products are designed and manufactured.

2. Students learn how to design and make projects related to these areas. They are encouraged to experiment and do further study to increase their understanding of the principles which underlie materials processing.

3. Students learn basic hand, machine, and drawing skills which are helpful to all people living in an industrial society.

4. Students are encouraged to think seriously about their futures by familiarizing themselves with the various opportunities in industry. Such an exploratory program aids students both vocationally and avocationally.

5. Students learn how industries function and that industries are essentially the same with respect to planning and manufacturing. They also are helped to understand how such areas as power, electricity, and computer technology relate to the broad field of industry.

General Industry and Technology is designed for such a general industrial education course at the beginning level. It introduces students to modern industry and technology, its products, and the world of work. This book is divided into seven Parts: High Technology; Basic Shop Practices; Graphic Communications; Production (Manufacturing and Construction); Power and Energy; Transportation; and Modern Industry. Some of the Parts are further divided into Sections. Graphic Communications, for example, has two Sections: Drawing and Graphic Arts.

General Industry and Technology incorporates numerous features that facilitate teaching and learning:

- Because the book is long and ranges over a wide variety of topics, it is divided into Parts, Sections, and Chapters. Individual chapters are short, presenting the information in easily manageable amounts.
- Within the chapters, material is subdivided according to topic and relative importance. Three levels of subheads are used. **NUMBER 1 SUBHEADS** are printed in capital letters and centered. **Number 2 Subheads** are printed in capital and lowercase letters and centered. **NUMBER 3 SUBHEADS** are in capitals and small capitals, flush with the left margin.
- Information of special interest has been placed in sidebars set off by rules. Some sidebars give information related to the main topic of the chapter. For example, Chapter 6, "Laser and Fiber Optics Technology," includes the sidebar "What Is Light?" Other sidebars provide useful information about new technologies (as in "Superplastics," Chapter 58) or about issues of concern to modern society ("The Future of Work" in Chapter 107).
- Wherever a particular tool or procedure is discussed, safety rules are included. These are set off by the heading "For Your Safety . . ." and by color bars to make them easy to find.
- Sentence structure and vocabulary have been controlled to keep this book within the reading abilities of most high school students. If a word is likely to be unfamiliar to the student, it is defined in the text where first used. In addition, there is a glossary of high-tech terms at the back of the book.
- Each chapter is followed by review questions which reinforce key information found in the chapter.
- The book is generously illustrated with drawings, tables, and photographs. Many of the illustrations use color to emphasize features or facilitate comprehension. Layout has been organized to keep illustrations as close as possible to their text references.
- Every attempt has been made to point out similarities and close relationships among the industrial areas covered, so that the student can realize how much the major American industries have in common. Subconcepts are listed under each major concept to show further the many similarities among the methods of transforming materials into products. The subconcepts of mechanical linkage, adhesion, and cohesion which fall under the major concept of metal-fastening theory are examples of this.

The authors realize that the information in this book could have been organized in various ways; they feel, however, that the organization they have chosen is valid, functional, and understandable.

The authors wish to thank all of the many individuals and companies who have made valuable contributions to this book. (Specific acknowledgments are listed below.) It would have been difficult, if not impossible, to realize this publication without the generous assistance of those named. The authors also welcome any suggestions or comments from individuals who may use this book.

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PART 1

High Technology

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CHAPTER 1

Introduction to Industry and Technology

Science is the study of the laws of nature. Technology is the application of science for some practical purpose. Industry, in turn, uses technology to produce the products we use every day.

Since earliest times, humans have been builders. Nearly 5000 years ago the Egyptians built the Great Pyramid of Khufu (or Cheops) near Cairo. One of the largest structures ever built, it covers 13 acres. The pyramid contains 2 300 000 blocks of granite and limestone, each weighing up to 2.5 tons. The Egyptians built all of it without the wheel or iron tools. This is one of the best examples of early technology, and it still stands.

The methods used by people to make things are constantly changing. For example, in ancient times, if someone needed a chair, he or she had to make it. Later on, the people who were especially good at making chairs and other furniture became cabinetmakers. They did nothing else but make wooden articles which they sold or traded to other people. These craftspeople had to be very skilled. They had to know about the different kinds of wood and how to season it. They had to design furniture and therefore know joinery methods. They had to know how to use tools to work the wood and what kind of finishes to use and how to apply them. In other words, they had to know about all aspects of their craft. Fig. 1-1.

A cabinetmaker with a successful business could not do all the work alone. Other people were hired and trained to help, and a "cottage industry" began. *Cottage industries* were small factories, with a few workers, located in or near a craftsperson's home. Here labor was divided up according to skill. For example, an apprentice might cut logs into boards and smooth them into lumber. The craftsperson was then free to use his or her special skills to design and make furniture or cabinets.

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1-1. ***In early times, a carpenter used hand tools to build homes, cabinets, and furniture.***

With the industrial revolution in the late 1700s, the factory system of production began. Now the cabinetmaker started a furniture factory where large numbers of people worked at highly specialized jobs. One person made only chair legs, another only the seat. Machines were developed to aid the people in their work and to make them more productive. As more and better machines, newer methods of joining and working woods, and better, more efficient mass-production techniques were developed, the modern factory emerged.

HIGH TECHNOLOGY

Today we are experiencing a very exciting change in the way we produce goods—"high technology." *High technology* can be simply defined as the use of computers and other modern technical machines to produce goods and control the production system. In the photo essay on pages 32A-H, you will see some outstanding examples of high technology in American industry. Other examples, along with technical information and descriptions, are found throughout this book.

You will see from these high-tech examples that American industry is changing dramatically in two ways—in the *way* things are made and in the *kinds* of things that are made. Perhaps even more important is the fact that the industries of the future will need people with very special technical skills. Fig. 1-2.

ABOUT THIS BOOK

The purpose of this book is to introduce you to modern industry and technology, its products, and the world of work. Through this book you will be given a beginning course in general industry. You will gain an appreciation of the importance of crafting and technical skills and of industrial products. You will also have a chance to explore your interests in making and doing things. In addition, you will learn about career opportunities in industry and how your interests may lead you to a challenging job.

Every learning activity has objectives or aims. The objectives of a general industry course are as follows:

1. To develop an understanding of industry and technology. You will learn of the marvels of modern technology as well as some of industry's problems. It is important for you to gain an understanding of the place of industry and technology in our society.

2. To develop technical skill and knowledge. As a part of your work in this course, you will learn skills in metalwork, woodwork, electronics, drafting, graphic arts, and other areas. You will explore the materials and measuring devices used. You will learn safe work habits and tool skills and how to make project drawings. You will learn how the computer is used in product design and manufacture. This exploration can help you become aware of your talents and interests. It will also help you become an informed consumer. By learning how products are made, and making some yourself, you will be better able to judge the quality of commercially made goods.

3. To develop creative problem-solving skills using the materials and processes of industry. The joys of crafting are important to you as a human being. You should explore, design, create, and invent. You will be faced with many problems in your work which require intelligent solutions. Through shop experimentation and planning you can know the pleasure of successful solutions. These skills can lead to satisfying hobbies as well as successful careers.

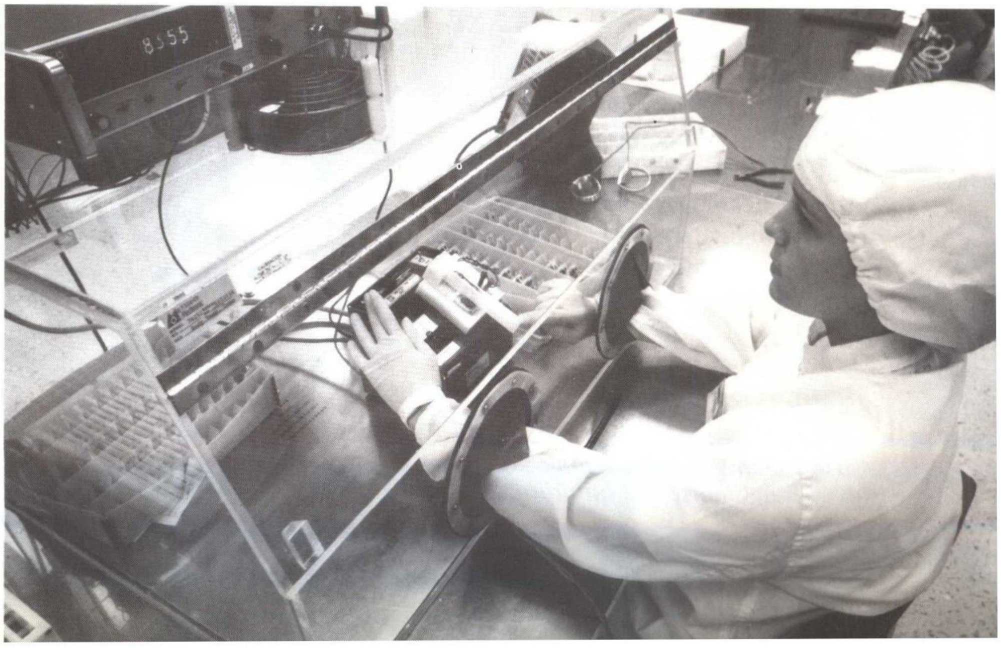
4. To learn about the effects of industry on our environment. Technology aids people in many ways, but it also causes some problems. Perhaps more serious than any other is pollution.

Pollution is a problem in all technical societies. One reason for this is that such societies create a large amount of waste. This may seem surprising at first, since efficient production would seem to eliminate waste. However, such efficiency is not the whole story. There is a point at which it becomes cheaper and more profitable to waste a material than to reuse it.

For example, labor costs have become so high that it is cheaper to throw away "tin" cans than it is to collect them, melt them down, and reuse the metal. Likewise, it is easier for a beverage firm to use throwaway bottles instead of the type that must be returned to the store, hauled to the bottling factory, washed, inspected, and refilled.

Such practices pose a big problem for society: what to do with the huge accumulation of cans, bottles, and other junk. It is interesting to note that in nonindustrial, developing nations, waste disposal problems of this sort are practically nonexistent. Every material is too valuable to throw away. By contrast, every year Americans discard millions of autos, tires, bottles, and cans and many tons of paper. We also dirty the air we breathe by gushing vast amounts of smoke and fumes into it. Because of our carelessness, we dump many tons of waste into our waterways, polluting the water we need for drinking, washing, transportation, and recreation. In this course you will learn about some

1-2. Jobs in industry are becoming highly specialized, requiring technical training. This worker is performing a calibrating operation on a heart pacemaker.



of the solutions to the problems of industrial wastes.

5. To develop your leadership potential. A good leader motivates others to work efficiently and to do their best. A good leader also helps others work together effectively. In a general shop class, there are many opportunities for you to develop leadership abilities.

Everyday activities in the shop can help develop leadership skills. For example, you may be asked to serve as the safety officer or be placed in charge of the tool room. Both of these jobs involve responsibility, and responsibility helps develop leadership.

Perhaps your class will set up a student company to mass-produce a product. You can practice leadership by serving as one of the officers in the company, by helping to plan and set up the production line, or by taking charge of some other activity, such as advertising.

You may also have the opportunity to join a student club. By taking part in club activities, you can learn skills in planning, organization, and getting along with others that will help you become an effective leader.

6. To explore career opportunities in industry. Industry needs people trained in a variety of skills. Skilled craftspeople, technicians, engineers, scientists, managers, and clerical workers—these are all typical of the kinds of jobs available in business and industry. High technology demands highly skilled workers.

7. A general industry course requires that you work safely and in cooperation with both the teacher and other students. Good work habits and attitudes are important if you are to get as much as possible from your shopwork experiences.

Consumer Choices and the Free Enterprise System

In a free enterprise system, private businesses compete with each other for profit. The government does not interfere beyond what is necessary to protect public interest and keep the national economy in balance.

In such a system supplies of goods and services, and their prices, will respond to consumer demand for them. Consider the microcomputers. At first, these were built from kits by hobbyists. Supplies were low and prices high. In the mid-1970s the first mass-produced microcomputers were introduced. They transformed the micro from a hobbyist's toy into a tool for businesses, schools, and the home. As sales (demand) increased, production became more economical and prices went down. Other companies began manufacturing microcomputers. The competition drove prices down still further. The lower prices meant more people could afford a computer. Thus demand increased.

From this example, you can see that price, supply, and demand are related to one another. You can also see that the products people buy help decide what products will be made.

QUESTIONS AND ACTIVITIES

1. List seven objectives for a general industry course.
2. What is a cottage industry? In what ways is it like today's factories? In what ways is it different?
3. What is *high technology?*
4. American industry is changing dramatically in what two ways?

CHAPTER 2
Computer Technology

A *computer* is an automatic machine that makes calculations and processes information at very high speeds. Today computers have many and varied uses. They bring us video games and war games. They can tell when to pick oranges or which team to pick in a football game. They are used to keep track of all the items a company has in its warehouse and all the satellites that are orbiting the earth. They help writers prepare novels and homemakers prepare menus. Computers are even being used to design other computers. Fig. 2-1.

HISTORY OF COMPUTERS

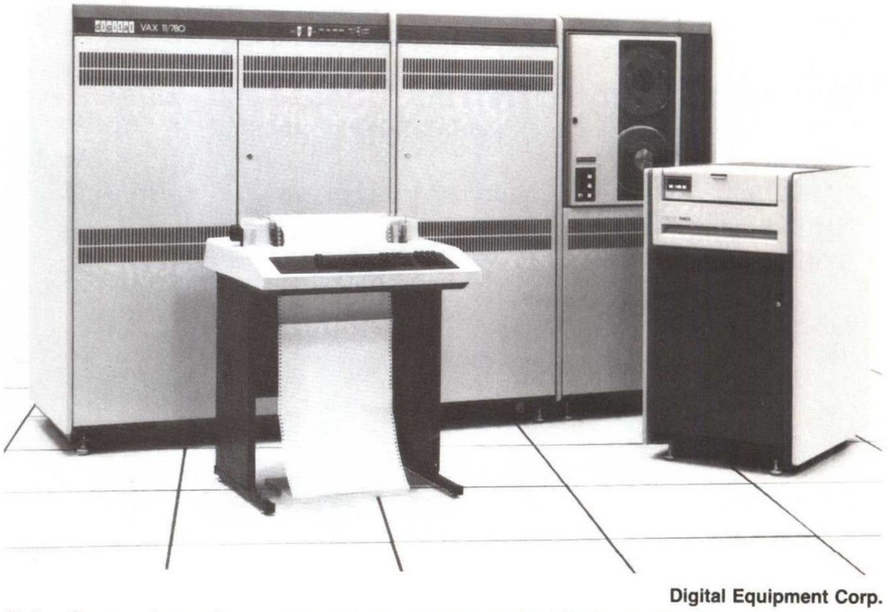
From earliest times people have had the need to compute (make calculations). At first they probably used their fingers and toes. Then devices were invented to help compute. One of the earliest was the abacus. The abacus consists of rows of parallel wires, rods, or grooves on or in which slide small beads or blocks. Calculations are performed by moving the beads or blocks. Fig. 2-2. The abacus was invented over 5000 years ago, probably in Babylonia. It is still used in parts of Asia and the Middle East.

In 1642 the French scientist and philosopher Blaise Pascal built an adding machine to help his father with his tax collecting duties. This machine used a mechanical gear system to add and subtract numbers with as many as eight digits. Fig. 2-3.

Pascal's machine could only count. Later, other machines were invented which could also multiply, divide, and figure square roots.

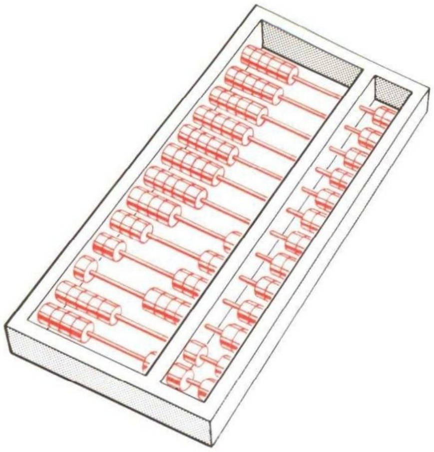
Charles Babbage, an English inventor, designed the first true computer. His "analytical engine" combined arithmetic processes with decisions based on its own computations. In other words, the answer that the machine computed could be used by it to solve subsequent steps of a complex problem. Babbage worked on the analytical engine between 1834 and 1854. He was never able to finish building it because of a lack of money and because the technology of the 1800s was not refined enough to make metal parts to the required precision.

In the late 1800s, Herman Hollerith was working for the United States Bureau of the Census. He developed a way to quickly tabulate the huge amount of information from the 1890 census. Information about each person was recorded on a card by a system of punched holes. A machine read the cards and totalled up the statistics. Fig. 2-4. Hollerith later formed his own company, which eventually became IBM.



Digital Equipment Corp.

***2-1.** Computers play a big role in modern life. Their ability to process information at high speeds has many applications. Can you think of some in addition to those already mentioned?*

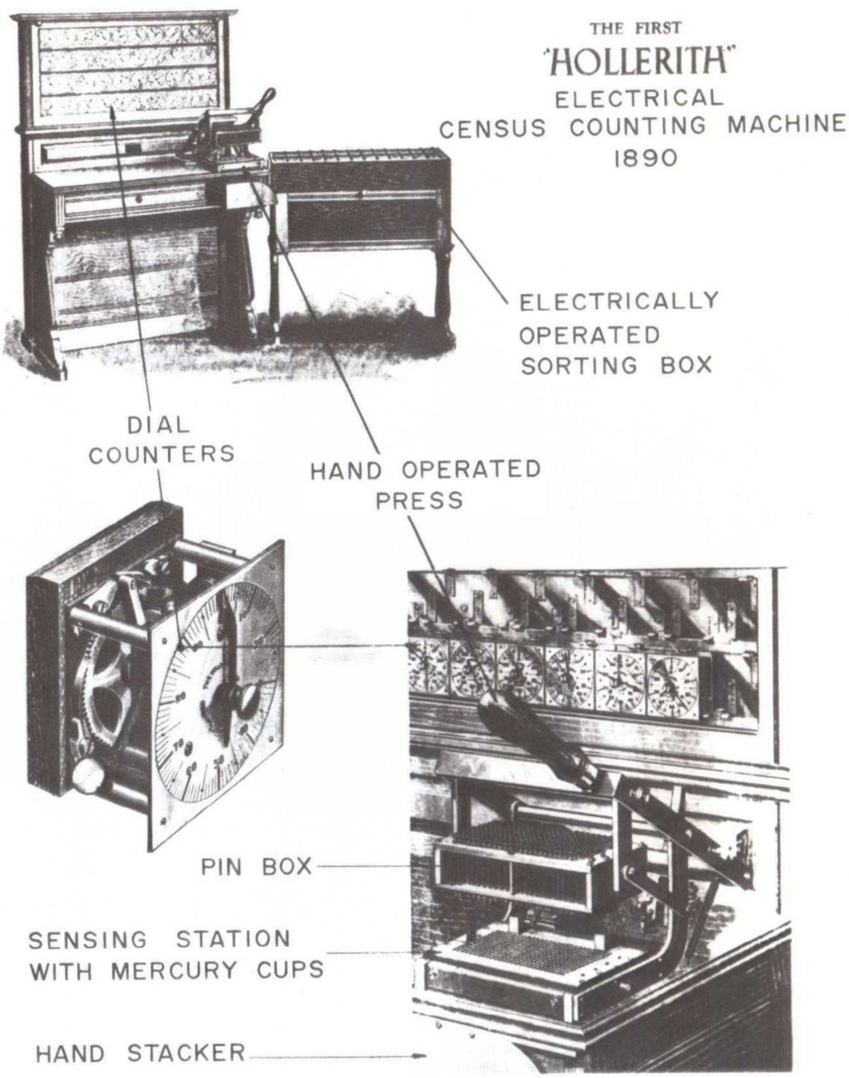


2-2. ***An abacus. This was one of the earliest calculating instruments.***

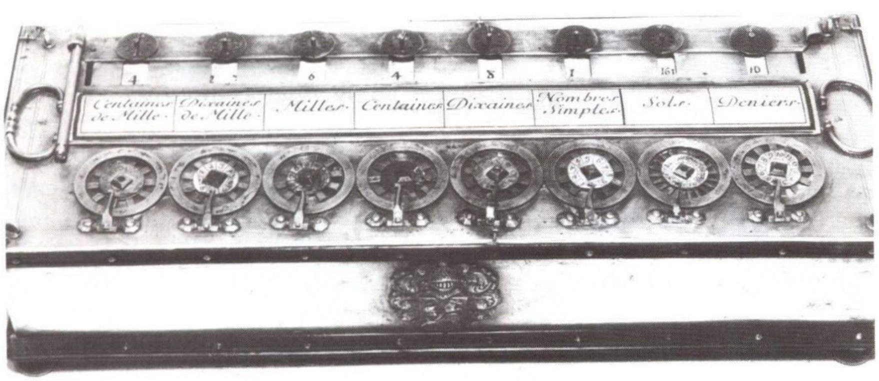
In 1939 a young man named Howard Aiken came to IBM with an idea for a fully automatic calculator. During the next five years, he and a team of engineers developed what came to be known as the Mark I. The Mark I was used during World War II to calculate mathematical tables used for navigation and targeting.

The Mark I was slow compared to today's computers. It completed one instruction in one one-hundredth of a second. Modern computers can complete instructions in billionths of seconds. This means that if the two computers did the same task, the modern computer would finish ten million times faster.

The Mark I had no electronic parts. Its internal structure was a maze of gears and machinery. The first electronic computer was designed and built at the University of Pennsylvania in 1946. This computer was named ENIAC (Electronic Numerical Integrator and Calculator). ENIAC had 18 000 vacuum tubes, which failed on the average of one every seven minutes. After the ENIAC came the Univac. The Univac was the first commercially available computer. The first customer was the United States Bureau of the Census.



2-4. ***This is the machine Herman Hollerith invented to tabulate information from the 1890 census.***



2-3. ***Pascal's adding machine. The wheel at the far right was for units; the one next to it, for tens; the third from the right, hundreds; and so on.***

```
5  HOME
6 I = 0:S = 0:Q = 0
10  PRINT "HOW MANY NUMBERS DO YOU WISH TO AVERAGE";
20  INPUT N
30  IF N >  = 1 AND N <  = 100 THEN 80
40  PRINT
50  PRINT "YOU CAN ONLY AVERAGE BETWEEN 1 AND 100 NUMBERS"
60  PRINT
70  GOTO 5
80  PRINT
90  PRINT "INPUT YOUR NUMBERS, 1 PER QUESTION MARK"
100  PRINT
110  FOR I = 1 TO N
120  PRINT I;
130  INPUT Q
140 S = S + Q
150  NEXT I
160  PRINT
170  PRINT
180  PRINT "AVERAGE=";S / N
190  PRINT
200  PRINT "WOULD YOU LIKE TO AVERAGE ANOTHER SET";
210  INPUT A$
220  PRINT
230  IF A$ = "YES" THEN 5
240  END
```

2-5. This is a BASIC program for calculating averages on an Apple computer. Once this program has been entered into the computer, you only need to give the computer a set of numbers and it will tell you their average. The words inside quotation marks are the ones that will appear on the screen when you use the program.

TYPES OF COMPUTERS

Modern computers can be divided into three types: analog, digital, and hybrid. *Analog computers* solve problems by expressing one physical quantity in terms of another. To understand this principle, think of an analog watch. In this type of watch, the passage of time is indicated by the movement of the hands around the dial. Thus one quantity (time) is measured in terms of another (the position of the hands).

Analog computers are used to solve problems in which several quantities vary continuously over a period of time. For example, analog computers are used in airplane simulators because they can describe the relationships of speed, altitude, and lift and thus imitate the behavior of a real aircraft. Most analog computers are special-purpose machines. They are designed for a particular task.

Digital computers, on the other hand, are general-purpose machines. They work with numbers (digits) to solve problems. The rest of this chapter will deal with digital computers.

Hybrid computers combine analog and digital operations. One example of a hybrid system is numerical control (NC). You will learn more about numerical control in Chapter 4.

DIGITAL COMPUTERS

Unlike analog computers, digital computers respond only to exact signals, not to varying degrees of signals. The signals for a digital computer are electric pulses called *bits.* These electric pulses can be in only one of two states: on or off; they either exist or do not exist.

People use the number 1 to represent an on-bit and 0 to represent an off-bit. Patterns of bits are used to form characters called *bytes.* One byte usually contains eight bits. Computers recognize a value for each byte. For example, in one computer language, the letter A is represented by 11000001. A byte does not always stand for a letter, however. It may be a number, a punctuation mark, or a command.

These patterns of ones and zeros are a kind of language. They give the computer data (information) and instructions. This language is called *machine language.* It is easy for computers to work with but difficult for humans to use. Therefore, other computer languages have been developed that are more like human language. One of the most widely used is BASIC (Beginner's All-purpose Symbolic Instruction Code). BASIC was developed by John Kemeny and others at Dartmouth College in the 1960s. It uses English words, punctuation marks, and algebraic notations. People write programs (instructions for the computer) in BASIC, and the computer then translates these programs into machine language. Fig. 2-5.

BASIC is the most popular language for microcomputers. The *microcomputer* is a computer that is small enough to be portable. Some will even fit into a briefcase. Even though they are small, microcomputers can be as powerful as some computers that are much larger. In recent years, microcomputers have become very popular for use in small businesses, homes, and schools. Most of the discussion which follows is about microcomputers.

Hardware

The equipment that makes up a computer system is called the