Getting down to **BUSINESS** with your **MICROCOMPUTER**

James A. Gupton Jr.

SOURCEBOOKS

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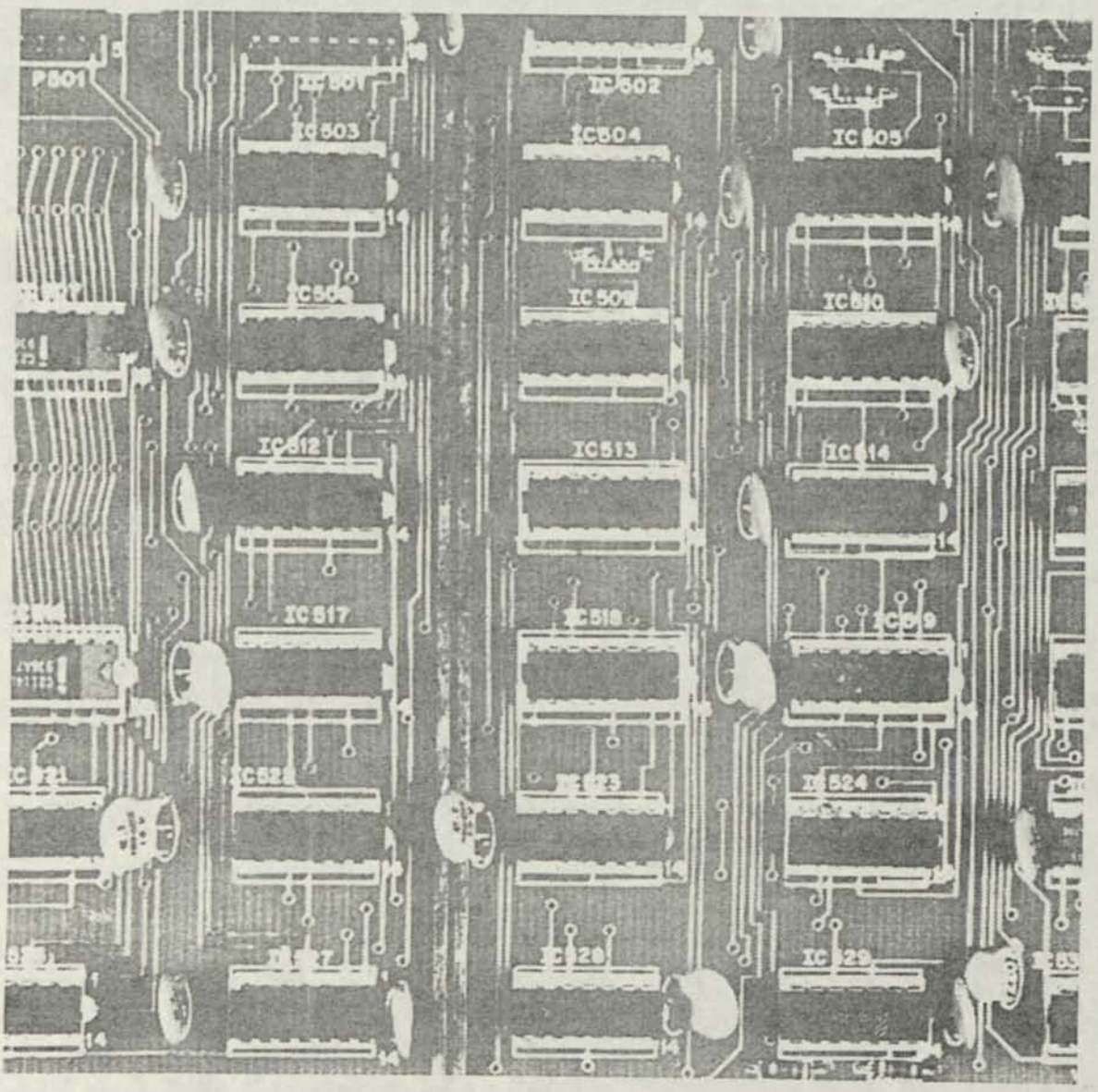
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AN INTRODUCTION TO PERSONAL COMPUTING

This book is about the new personal microcomputers. It is written for the hobbyist, the experimenter, the student, the homemaker, the small businessman, and for the general public. Its purpose is to dispel the mystique surrounding the word computer and to provide an understanding of the new language of the computer age. It will serve as a guide to the intelligent selection of computer components and will aid in the assembly of your own personal computer system for home or business.

Over the past 30 years we have become a society dependent on the computer. Try to name one single everyday transaction that does not tie into a computer. Every credit card transaction must have computer approval. A request for credit requires a computer credit check. Our pay check is prepared by a computer, and when we deposit it in the bank, the bank's computers adjust our checking account balance. Our tax payments go immediately into computer memory banks. Each time we purchase a car . . . this too goes into a computer and becomes part of a direct-mail list. A computer even controls the inventory of the stores where we purchase the daily necessities of life. A computer-like cash register automatically totals our purchases and adds the appropriate local and state sales tax. Most large commercial computer systems are far too expensive for the ordinary person. Their prices usually begin around $20,000 and can extend into the millions of dollars for a massive military or government computer system.

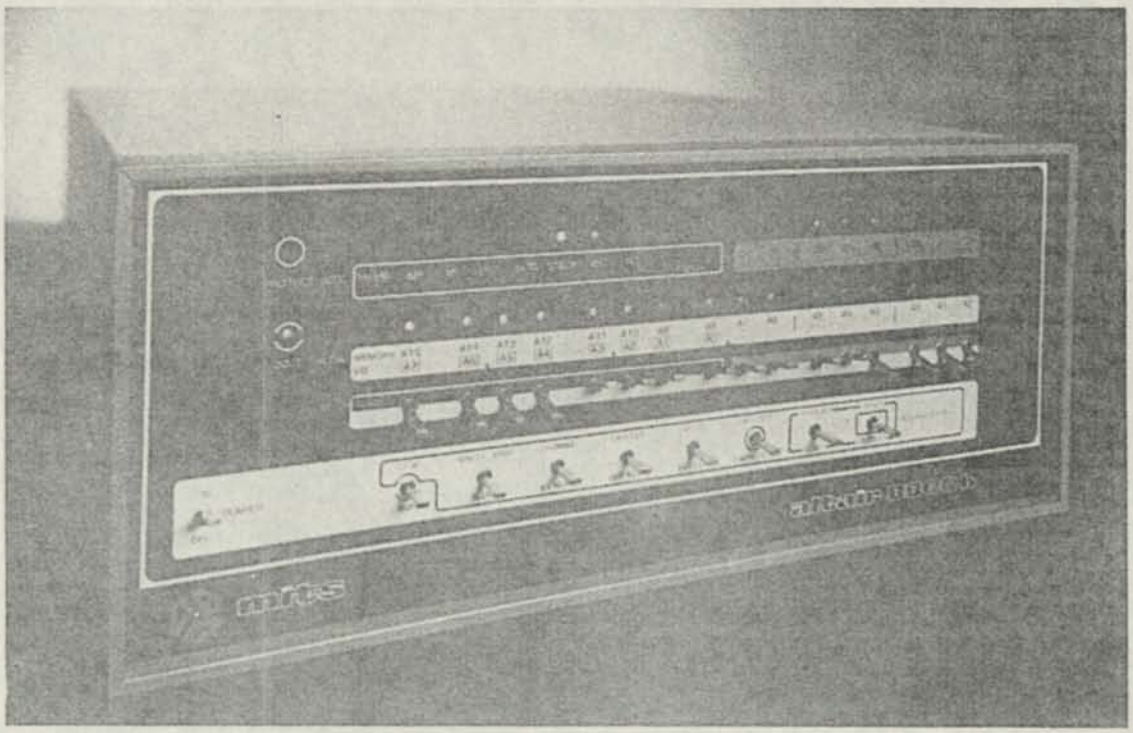

Figure I-1. The 1978 Altair 8800b microcomputer. This front-panel-controlled microcomputer is basically identical in appearance to the original 1975 Altair 8800. Photo courtesy of the MITS/ Pertec Computer Corporation.

For most of us the question is, "Is there really a need for a personal computer in my life?" The answer seems to be a resounding yes. A small group of engineers, who operated an electronics manufacturing firm called Micro-Instrumentation Telemetry Systems, Inc. (MITS, Inc.) in Albuquerque, New Mexico, created the first personal microcomputer to be offered to the public for less than $400—the Altair 8800. The first prototype was completed in August of 1974. The name of the microcomputer came from a science-fiction movie called "Forbidden Planet" set on a planet of the star Altair and from an episode of the science-fiction television program "Star Trek" with the same locale. This small company projected a year's sales of just 800 Altair 8800 microcomputers for 1975. Yet, by March 1975 they had orders for more than 1500 Altair microcomputers. While these 1500 orders did not constitute a landslide, they marked the beginning of the microcomputer revolution. The chapter heading photograph of Chapter 11 shows the Altair 8800b as it is today as part of the Altair Business System sold by the MITS/ Pertec Computer Corporation.

Almost exactly 3 years after the completion of the Altair 8800 prototype, Radio Shack, which is the largest retail electronics firm in the United States, announced the introduction of a new low-cost personal microcomputer. Within 2 months their orders exceeded 20,000 units. By November of 1977 the Heath Schlumberger Company, the largest producer of electronic construction kits, announced their entry into the microcomputer field with the introduction of kits for complete microcomputer systems. Not just one but two systems were offered: the Heath H8 system and the Heath H11 system. Both are in do-it-yourself kit form.

What has stimulated such interest in microcomputers? Is it the relatively low cost that enables almost any home or small business to own a microcomputer for about the price of a color television set? Is it that we are accustomed to push-button conveniences such as the telephone, the pocket calculator, the programmable microwave oven, and the computerized television receiver? If we already use computerized appliances, then why not go all the way and install our own personal computer

Figure I-2. A Bell System telephone with a computer-like Touchtone keyboard for dialing.

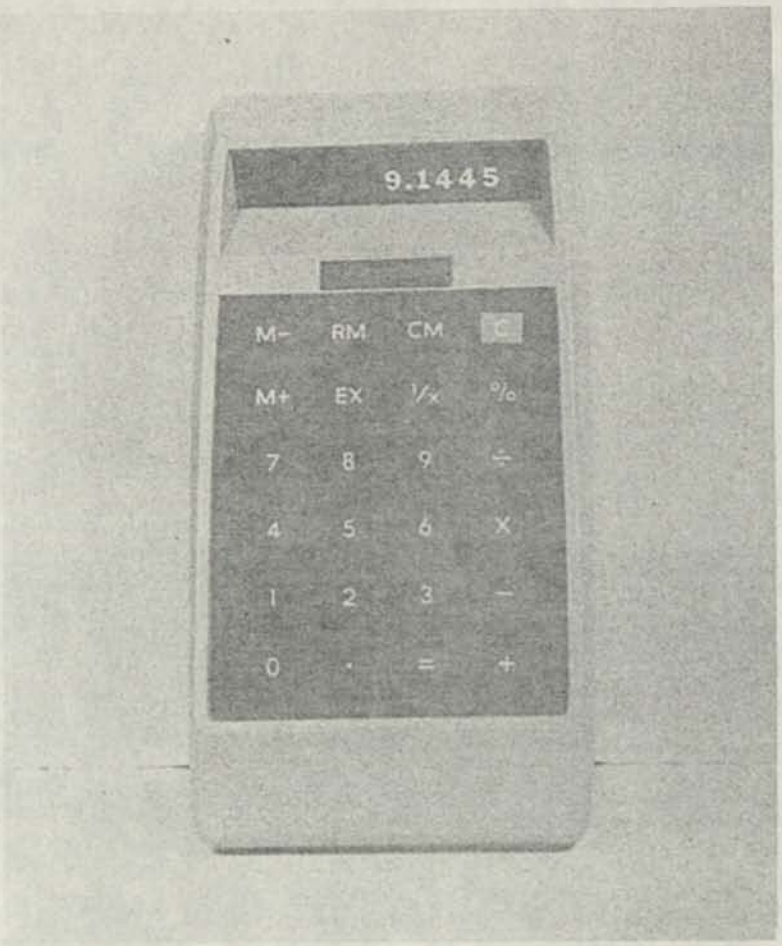

Figure I-3. A typical pocket calculator. This calculator with memory capability is a rudimentary microcomputer because it can store data and perform calculations.

system? At home these microcomputers can keep our income records, our address files, and our cooking recipes. They can also provide hours of exciting entertainment for all members of the family, and they can provide our children with educational exercises. In a business they can do accounting, payroll, record keeping, work processing, and process control to mention but a few possibilities.

Today franchised and independent computer stores operate throughout the nation. There are the Altair Stores, Byte Shops, Computerland, and the Radio Shack stores, which are associated with the Tandy Corporation. Soon computers will be available in Sears & Roebuck, J.C. Penney, and many local and chain stores. With the rapid development of the microcomputer field and the overnight appearance of computer specialty stores, it would be a monumental task to staff each store with trained

and knowledgeable personnel to guide you through the maze of computer technology in order to select a microcomputer system tailored to your specific needs. Without specific knowledge you might end up with a system ill-suited to your requirements. This book will attempt to simplify and explain microcomputer technology. It will explore microcomputer applications so that the reader will be able to understand what a microcomputer can do and what he needs to perform his applications. You are urged to visit computer speciality stores in your area. Then you will see first hand what these microcomputers can do, and you will be able to ask as many questions as necessary. Sensible product comparison will aid you in your microcomputer selection. When you finally select the system of your choice, buy it and bring your home or business into the computer age.

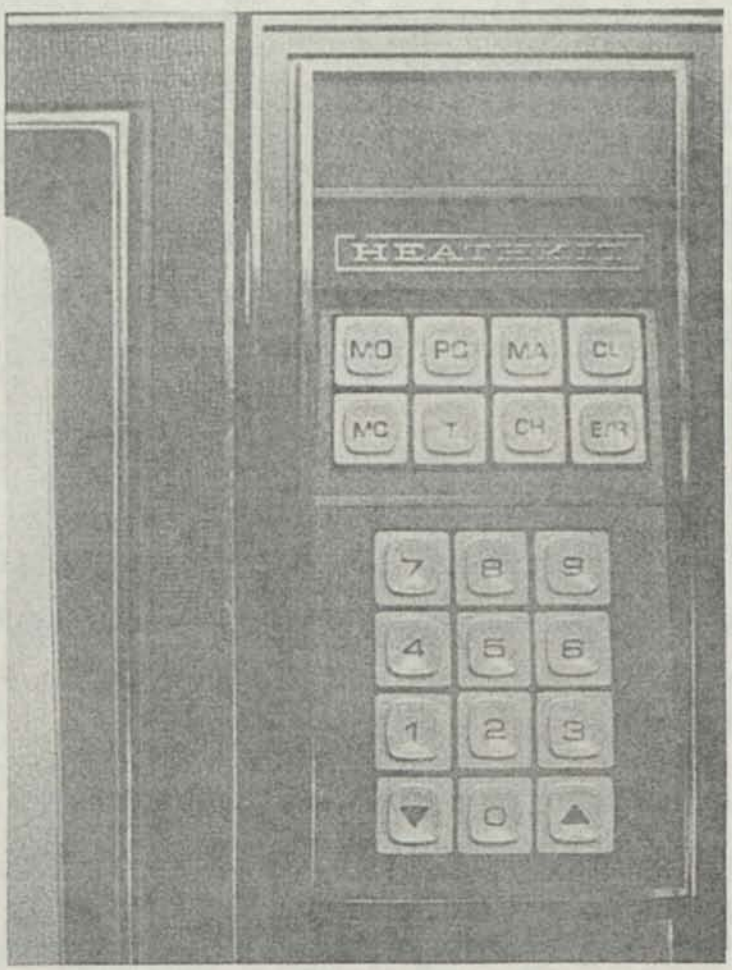

Figure I-4. Programmable television channel selector. Using a real-time clock the time and memory sections implement channel changes at the programmed time.

APPLICATIONS

One question often asked is, "What can I do with a microcomputer?" The answer is that a vast number of applications exist. Here are just a few:

HOME APPLICATIONS

- address files
- recipe files
- utility records
- telephone number files
- income tax records
- correspondence editing
- home security systems
- games for adults and children
- educational training
- creation of computer art
- puzzles
- composition of music
- hobby activities
- personal investment management

PROFESSIONAL AND SMALL BUSINESS APPLICATIONS

- accounts receivable
- accounts payable
- employee payroll
- state tax records
- federal tax records
- gasoline tax records
- petty cash records
- business security systems
- product shipments
- receiving reports
- process control
- procurement control
- manufacturing control
- correspondence editing
- customer accounts
- requests for quotation
- profit-and-loss reports
- retirement accounts
- social security accounts
- W-2 form account records
- business expense records
- inventory control
- back order follow-up file
- Mil-Spec documentation file
- production control
- equipment control
- product specifications file
- salvage control

Naturally, not every function listed above can be performed by every microcomputer now on the market. Some can be adapted with special interface circuit boards or by the addition of extra memory capacity. One aim of this book is to

Figure I-5. Radio Shack's PRO-2001 UHF/VHF Communications Scanner. This device is programmable and receives 6 bands. Frequencies being scanned, monitored, or programmed into its memory are displayed on a digital readout on the front panel.

show what makes a microcomputer tick and which accessories are needed to perform specific home and business applications.

Like any hobby, sport, or recreation, the microcomputer field uses a number of new words whose meaning may not be clear to the uninitiated. Your understanding of the microcomputer field depends to a significant extent upon how well you grasp the meaning of these new terms. The glossary at the end of this book defines many computer-related words, and the text explains them as they first appear.

By the time you have read this book, you should be able to converse intelligently with computer experts. You will understand the operation of the microcomputer, and you will have a good idea as to the special accessories needed to adapt a microcomputer to your individual requirements. In addition, you will be knowledgeable about the product lines of the major microcomputer manufacturers in the United States, and you will be able to decide on the type of equipment you would like to purchase. It is conservatively estimated that by the year 1985 one in every eight people will use some type of microcomputer in their home, business, or profession.

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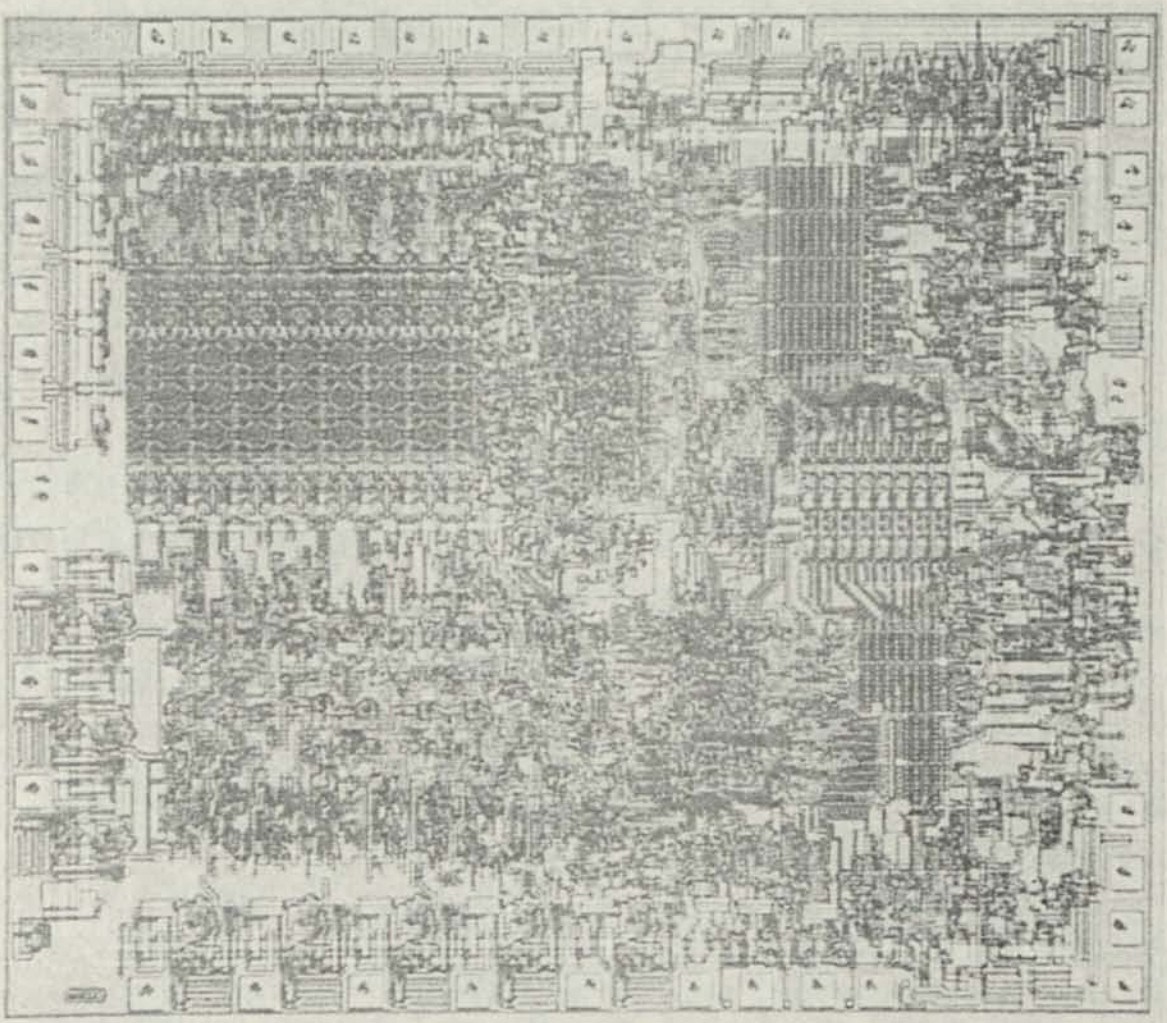


WHAT IS A MICROCOMPUTER AND HOW DOES IT WORK?

INTRODUCTION

The growth of the microcomputer field has been nothing less than fantastic. Since the introduction of the Altair 8800 microcomputer in early 1975, more than 100,000 microcomputers have been purchased by hobbyists, experimenters, and small businessmen. Many of these microcomputer users have some background in electronics or computer programming. But how can the average person understand these machines? Fortunately, a technical background is not necessary to successfully use a microcomputer. In this book we will describe how a microcomputer works, and then we will describe some of the commercially available microcomputers. Finally, we will describe a few microcomputer applications including the use of a microcomputer in a small business.

As important new terms are introduced, they will be capitalized. As an example, a BYTE is a basic unit of data storage capacity in a microcomputer. A byte is a group of eight binary digits used to represent a character such as a letter, number, or symbol. Definitions of all these terms are collected in the Glossary at the end of this book.

An important factor for almost anyone interested in a microcomputer is the overall cost of the system. As you learn more about microcomputers and their capabilities, you will be better able to judge the size and cost of the system best suited to your needs. For instance, some microcomputers are advertised

for under $400, but such "bare bones" machines are seldom usable for serious applications. At the other end of the scale, there are microcomputer systems for over $10,000. These are extremely powerful machines. In the range between these two extremes there are many different systems suitable for the hobbyist or small businessman.

Let's take a brief look at three major types of computer systems. Among these types there are vast differences in cost, capabilities, and physical size. They are described in Table 1-1:

Table 1-1. Categories of Computer Systems

Type	*Purchase Price*	*Memory Size and Accounting Capabilities*
Commercial Business Computers (room sized)	$60,000 to $500,000	Memory in excess of 200 million bytes; complete accounting capabilities
Minicomputer Systems (size of a filing cabinet)	$10,000 to $60,000	Memory in excess of 50 million bytes; major accounting capabilities
Microcomputer Systems (desktop space required)	$600 to $10,000	4000 to 1 million byte memory; some accounting capabilities

Until the early 1960's most computers were huge, expensive, room-filling collections of hardware. They used large amounts of electricity and required substantial air conditioning. In addition, they needed frequent maintenance. Today's large business computer systems are still physically big, but their reliability and computing cost effectiveness have increased significantly. In the latter part of the 1960's a new type of computer emerged—the minicomputer. Physically a lot smaller and costing much less, the mini could perform many of the tasks previously done by larger machines. By the mid 1970's advanced technology had created an even smaller, less expensive descendant—the microcomputer. Microcomputer systems offer much lower cost, smaller size, and almost the speed of larger computer systems. Microcomputer systems now selling for about $3000 have the capabilities of systems that sold for $40,000 to $60,000 a

few years ago or those that sold for as much as $20 million 15 years ago.

In order to be able to compare different microcomputer systems, we first need to learn a little about a typical machine. All the parts are housed inside a MAINFRAME. The CENTRAL PROCESSING UNIT, or CPU, makes decisions, does computations, and often calls upon other parts of the microcomputer to perform specified tasks. The CPU also calls upon the MEMORY for data, and the CPU stores data in memory. SOFTWARE (or PROGRAMS) tells the CPU how to do things. The POWER SUPPLY supplies energy to all parts of the machine. The BUS is the principal data transmission path within the microcomputer. INTERFACES and CONTROLLERS enable the microcomputer to communicate with PERIPHERAL DEVICES.

Figure 1-1 shows a simplified block diagram of a microcomputer. We will examine each of its major sections in detail. Then you will be able to understand how the different sections

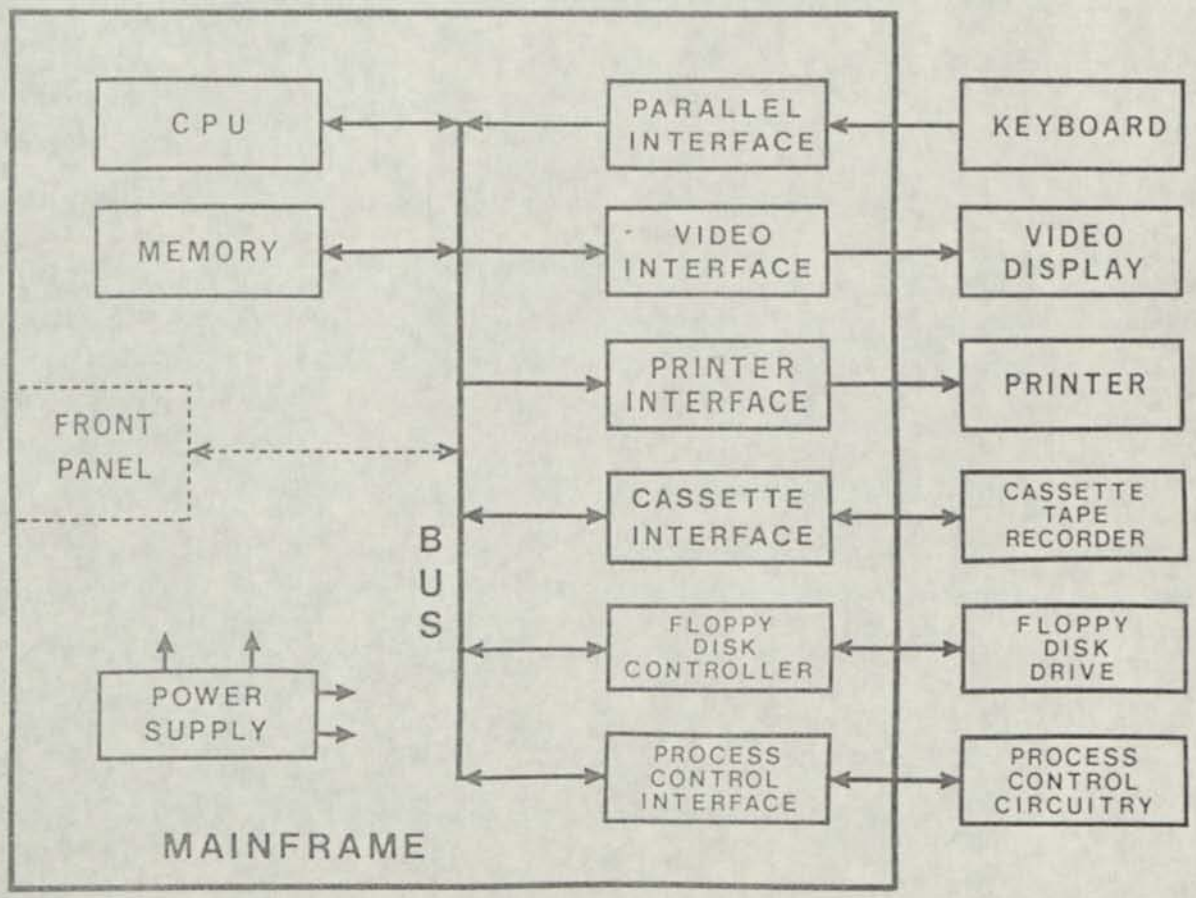


Figure 1-1. Block diagram of a microcomputer system.

work together and why parts from one microcomputer system won't always work in another machine. However, before we do this, it will be worthwhile to learn just a few of the basic concepts underlying microcomputer operation.

SOME BASIC CONCEPTS

The key to computer logic is the BINARY NUMBER SYSTEM, which is explained in more detail in Appendix I. For now, we will just say that the binary number system uses a base of 2 in the same way the more familiar decimal system uses a base of 10. The decimal system uses ten different digits (0 through 9), and the binary system uses only two (0 and 1). A single BInary digiT is called a BIT. Binary numbers consist of a string of bits just as decimal numbers consist of a string of digits. Each bit in the string has a different weight determined by its position in the string. These weights help determine the numerical value of the string. A byte is a string composed of eight bits, and a byte can represent any of 2^8 or 256 different characters.

Computers use binary logic circuits to manipulate binary numbers. Each bit of a binary number is represented by a signal that is either high, ON, plus 5 volts for a binary ONE or low, OFF, 0 volts for a binary ZERO. This is the simplest and least expensive way to handle information with electronic circuits. Since people normally don't use binary numbers, all information typed into the keyboard of a microcomputer system is usually converted by the keyboard from English letters, numbers, and symbols into their binary coded equivalents. Similarly, all data sent from a microcomputer to, for instance, a printer is converted by the printer from binary code to a specific character or symbol. The American Standard Code for Information Interchange, also known as ASCII, is one standard that defines which binary number represents which English character, number, or symbol. Most microcomputers and their software recognize the ASCII code. The ASCII code is described in more detail in Appendix I.

Because binary numbers can be represented by an ON or an OFF condition, some microcomputers display data using indicators that are either lit or dark. Light emitting diodes, or LED's, are often used on the front panel of a microcomputer for

this purpose. However, there are easier ways to read data from a microcomputer, and we will learn about them in Chapter 2. For now, we have learned all we need to know about binary numbers, and we are ready to examine the major parts of a microcomputer.

THE MAINFRAME AND POWER SUPPLY

The mainframe is the physical housing for the microcomputer's components. It contains the power supply and the power and data buses. The power suply provides the electrical power necessary to operate the microcomputer's circuitry. A power transformer in the power supply reduces the power line voltage to the levels required by the microcomputer. Electrical components called rectifiers and capacitors change the alternating current to direct current, which is essential for proper operation. Finally, each major section of the computer usually has its own separate voltage regulator circuit.

The Heath H8 mainframe shown in Figure 1-2 has its power supply at the rear of the enclosure and shields its parts

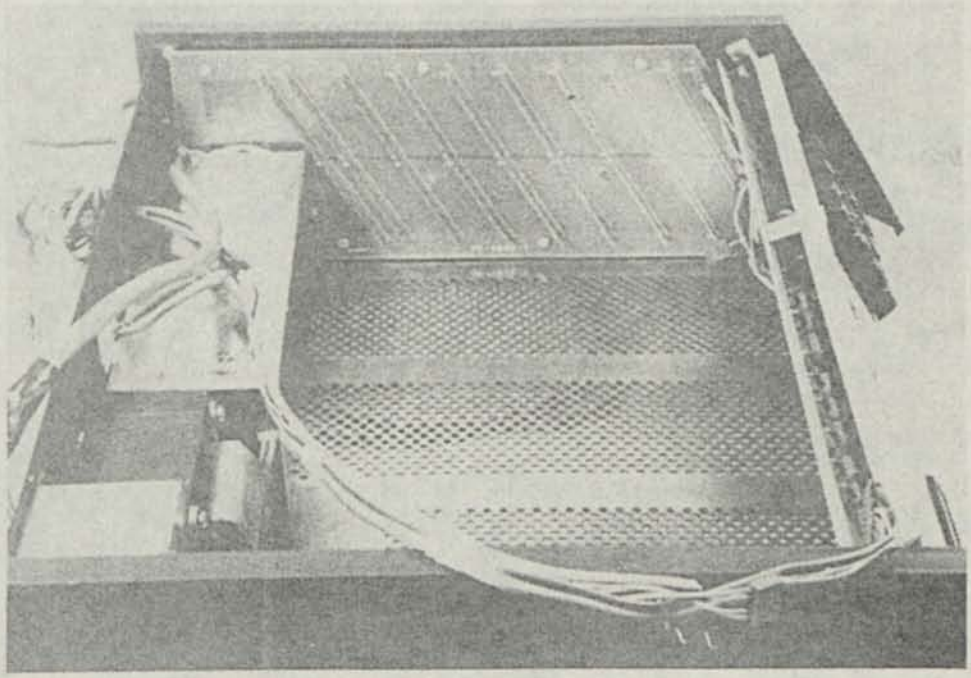


Figure 1-2. The Heath H8 mainframe. The motherboard is visible to the rear, and the power supply with step-down transformer is visible to the left.

with metal housings to prevent accidental electrical shock. Like many other microcomputers, the H8 contains a special printed circuit board called a MOTHERBOARD. The CPU and other circuit boards plug into connectors on the motherboard. It distributes power to each circuit board and provides a BUS, which is a set of many separate signal lines that allow data to flow from circuit board to circuit board. The Heath H8 mainframe also has a front panel display and keyboard. These allow the user to enter data or examine the CPU or memory contents directly.

The Altair 680b microcomputer shown in Figure 1-3 also has a mainframe. The power supply is also at the rear of the case. Here the similarity to the Heath H8 ends. The Altair 680b is basically a single-board microcomputer. It combines CPU, memory, and interface circuits together on the motherboard. For expansion, additional circuit boards can be plugged into the main circuit board by means of edge connectors such as the one visible in Figure 1-4.

The Radio Shack TRS-80 microcomputer goes one step further. It combines CPU, memory, and a video display generator all on a single circuit board with an ASCII keyboard attached. The high-impact plastic case serves as a mainframe. For convenience, the power supply is a separate unit that connects to the mainframe by means of a small cable (see Figure 1-5).

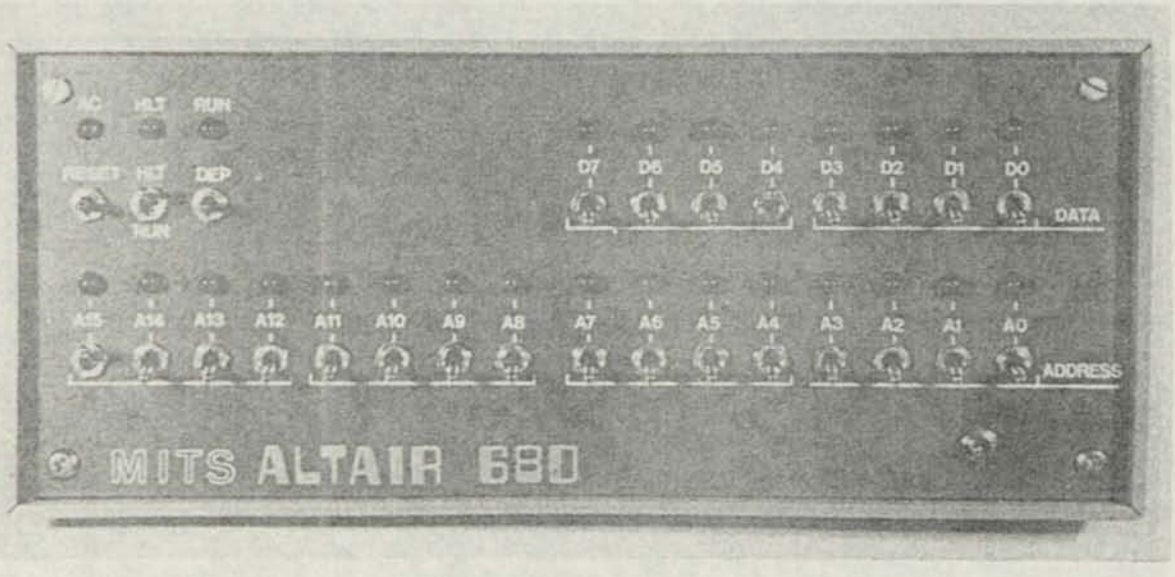


Figure 1-3. The Altair 680b microcomputer with switch-controlled data and address entry.

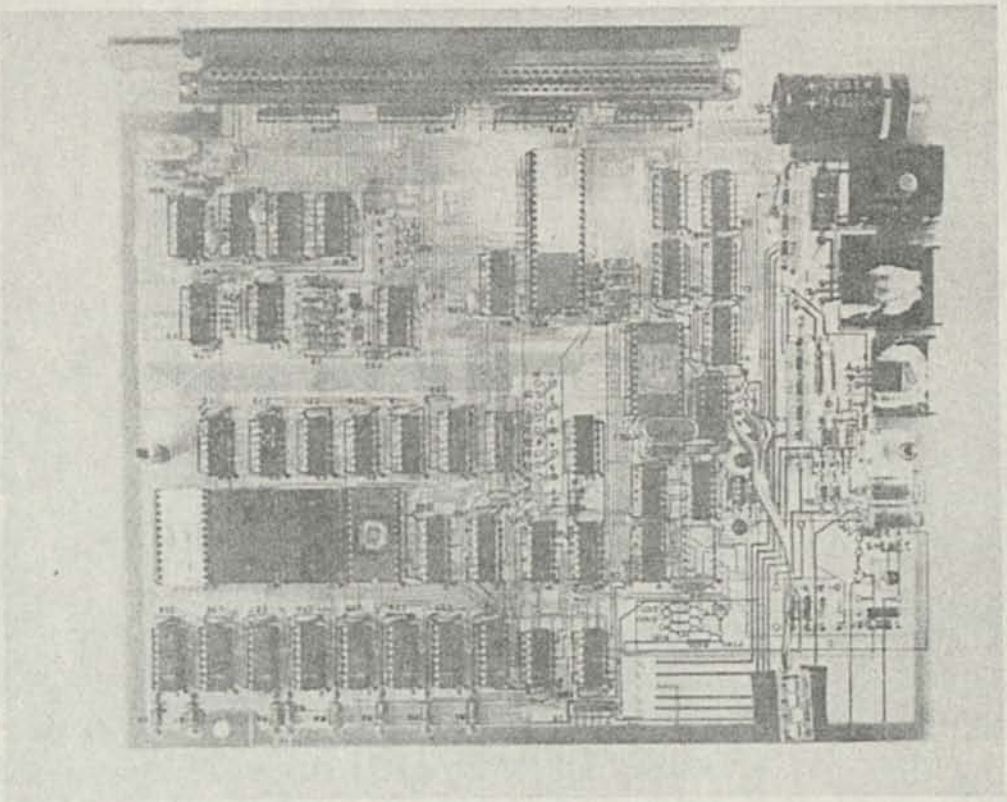


Figure 1-4. The Altair 680b main circuit board containing CPU, ROM, and RAM.

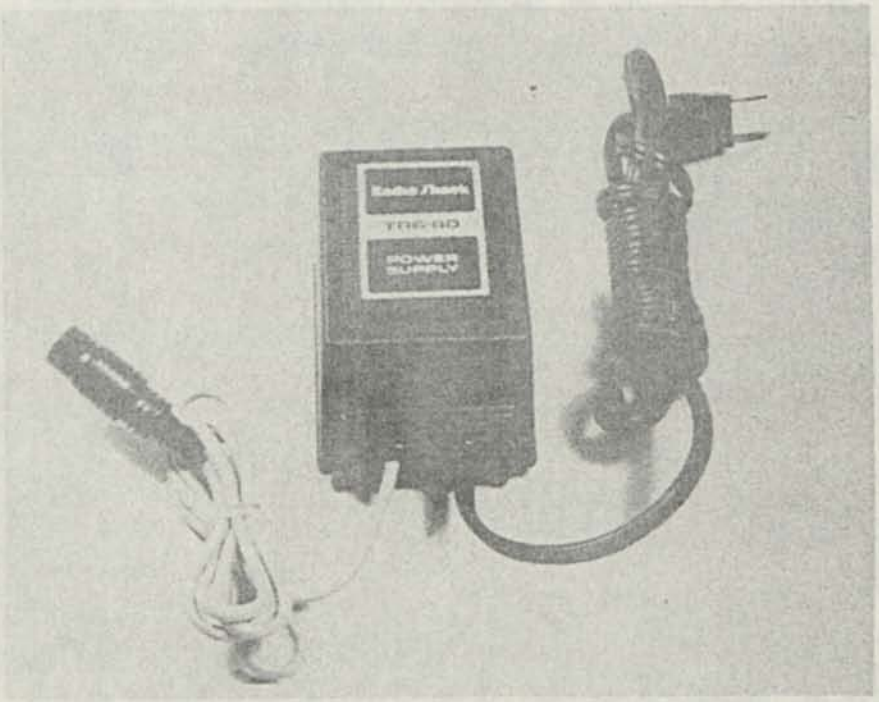


Figure 1-5. The Radio Shack TRS-80 microcomputer discrete power supply.

FRONT PANEL MICROCOMPUTERS VERSUS VIDEO DISPLAY MICROCOMPUTERS

Microcomputers have steadily become more sophisticated and easier to use. Early machines were usually available only with front panels for control and data entry. Once the power had been turned on, the user tediously entered the required initial information by setting a number of front panel switches. In addition, the state of the computer could only be read by interpreting the pattern of lights on the panel. This procedure is fine for people who enjoy playing with switches and watching flashing lights, but for serious use it is quite impractical and error prone.

The next step was the development of microcomputers equipped with digital numeric display showing actual numbers and with push-button keyboards in place of the toggle switches. Data entry was much easier. Also, control programs called MONITORS were made available stored in read only memory (ROM). A microcomputer with a monitor in ROM is available for use immediately after the power is turned on. An example is the Heath H8 microcomputer, shown in Figure 1-6. It employs a front-panel data entry keyboard and digital data display. For simple applications it can be used without an external computer terminal such as a Teletype or CRT terminal. The Altair 680b can be equipped with a ROM monitor, but it does not come with a keyboard or numeric display. Instead, it must be connected to a computer terminal.

Most recent microcomputers are controlled using a video terminal instead of a front panel, and many offer a monitor program stored in ROM. The user no longer must learn to read cryptic patterns of lights. Instead, information is shown on a cathode ray tube (CRT) screen. Data and commands are typed in using a keyboard much like that on a standard typewriter. Microcomputers of this type include the Radio Shack TRS-80 (shown in Figure 1-7), the Apple-II, and the IMSAI machines. Video terminal microcomputers are easier to communicate with than front panel machines, but usually they are more expensive. However, front panel microcomputers are suitable for simple applications where the cost of a computer terminal would be too great. They help the user develop a very close relationship with

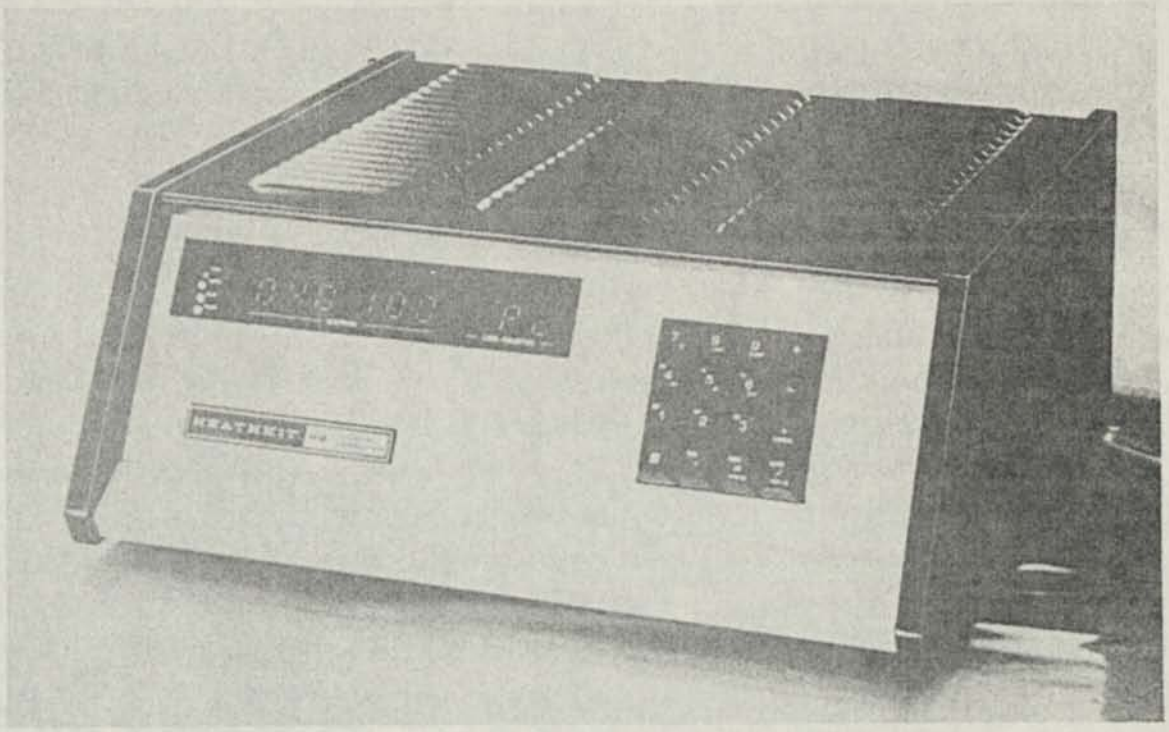


Figure 1-6. The Heath H8 microcomputer with front panel digital display and 16-key octal keyboard. Photo courtesy of the Heath Company.

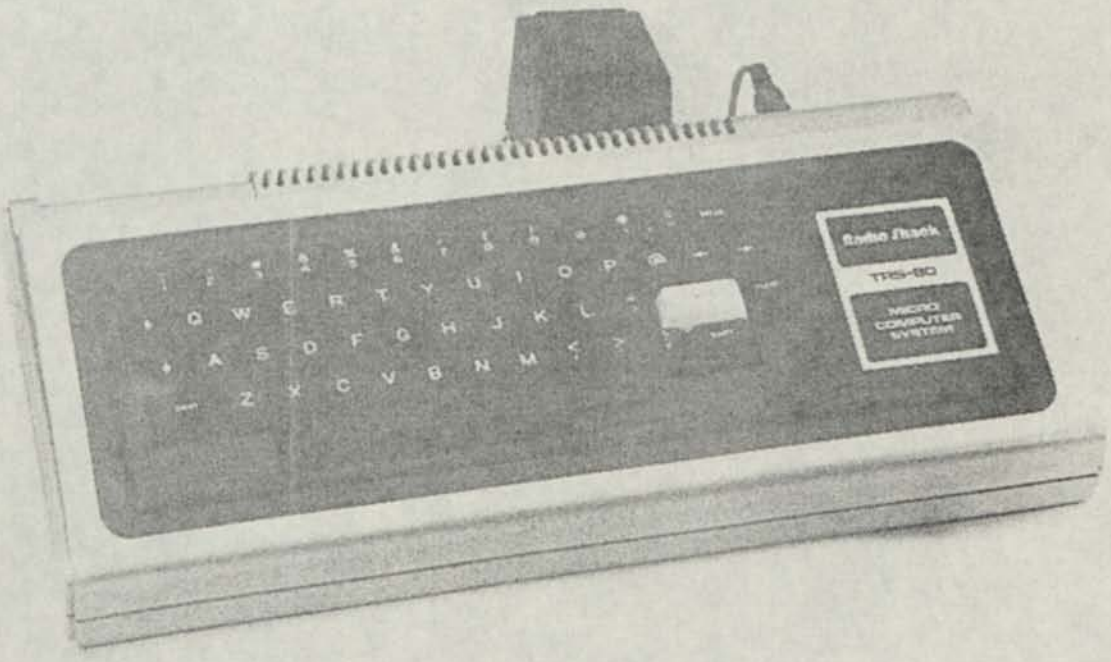


Figure 1-7. The Radio Shack microcomputer keyboard with power supply. Photo courtesy of Radio Shack International Headquarters, Fort Worth, Texas.

the internal workings of the machine. Generally, a front panel microcomputer alone has limited usefulness, and a keyboard, video terminal, or else a printer terminal must be added for serious applications.

Usually, both types of microcomputer can be expanded by the addition of circuit boards containing semiconductor random access memory. Special interface circuit boards can be added to allow the microcomputer to communicate with printers and bulk memory devices such as cassette recorders and floppy disk drives. At present, many plug-in circuit boards are available that perform special functions for the S-100 bus microcomputer. Not quite as many are available for other types of microcomputers. In the future, manufacturers will no doubt offer more accessories for all major microcomputers.

THE CENTRAL PROCESSING UNIT

The CPU is the brain of a microcomputer. In this section we will explore the CPU, its functions, and the differences between popular brands of CPU's.

The central processing unit responds to instructions given it by the programmer. It analyzes data or performs computations based on these instructions. It can fetch data from memory or read data from a peripheral device. It can send data to an interface in order to control a printer or CRT terminal. In short, this highly versatile device acts like a servant that is fast but not very independent.

Not many years ago, the CPU's of large computers and minicomputers usually were composed of many separate integrated circuits, and they occupied one or more printed circuit boards. Sometimes the CPU required a large cabinet. In recent years, semiconductor manufacturers have learned how to miniaturize most of the CPU circuitry and place it on one tiny square of silicon measuring less than ¼ inch on a side. This miniaturized CPU is called a MICROPROCESSOR. The chapter heading photograph shows a highly magnified view of the Intel 8080A microprocessor chip. It contains thousands of transistors in a very small area.

The CPU in a microcomputer consists of a microprocessor together with other components, such as a timing or synchronizing circuit called a clock. The central processing unit may be contained on a separate printed circuit board. Figure 1-8 illustrates the Heath H8 CPU circuit board. Alternately, the CPU may be placed on a single circuit board with the other major microcomputer components. Figure 1-9 shows the Radio Shack TRS-80 circuit board, which contains RAM, ROM, and the microprocessor unit (MPU).

A typical microprocessor executes an instruction in a few millionths of a second. This means that a microcomputer can respond very quickly and can perform very complex tasks within a period of time short by human standards. In fact, the CPU is seldom the limiting factor as far as speed is concerned. Usually the speed of peripherals limits system performance.

Since a microprocessor is so fast, it would be very inefficient if it had to wait for the programmer to respond each time it needed a new instruction. For this reason, programs and data are often stored in random access memory (RAM) or read only

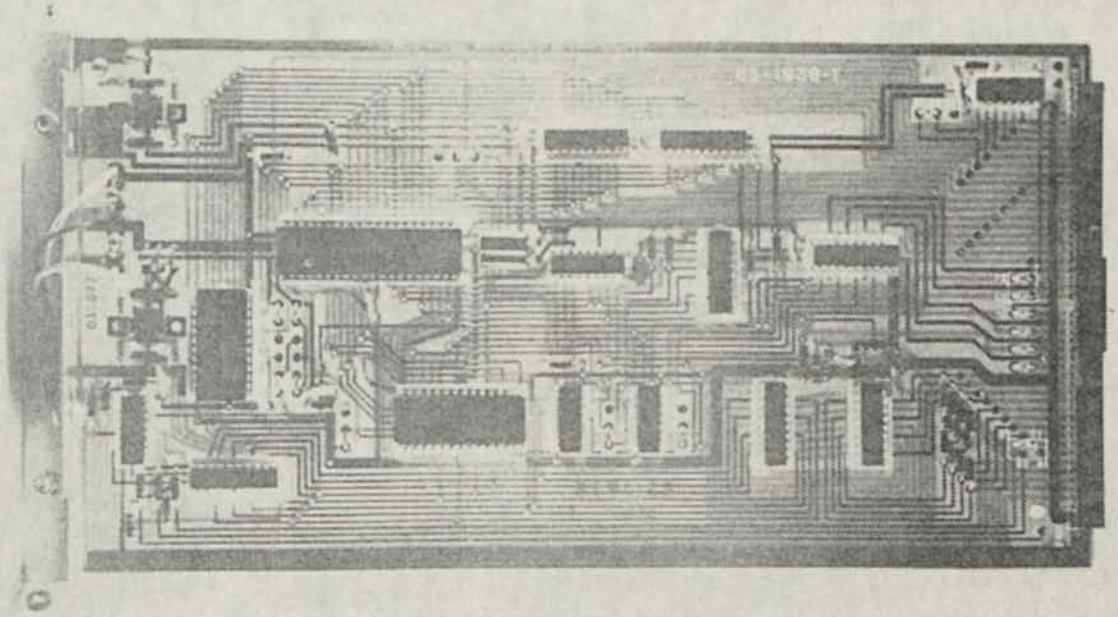


Figure 1-8. The Heath H8 CPU circuit board. In this microcomputer the central processing unit is placed on a separate circuit board.

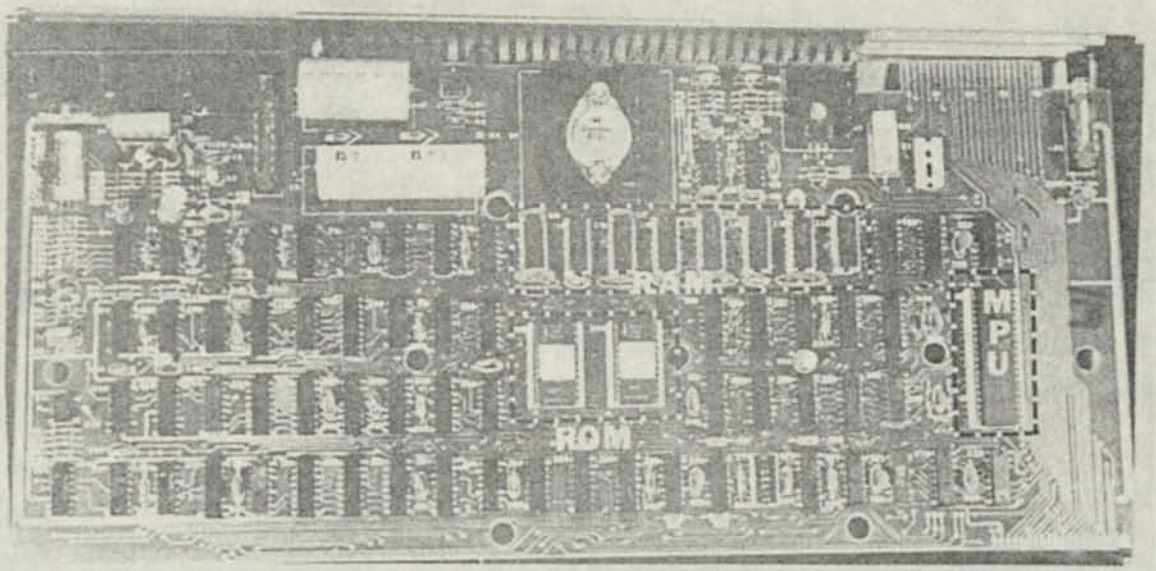


Figure 1-9. The main circuit board of the Radio Shack TRS-80. Major microcomputer sections are placed on one printed circuit board.

memory (ROM). Then the needed data can be retrieved in less than a microsecond. These types of memory are said to have a fast ACCESS TIME.

Microprocessors in common use include the Intel 8080A, the Motorola 6800, the MOS Technology 6502, and the Zilog Z-80. The Heath H11 microcomputer, which will be discussed later, uses a custom set of four large integrated circuits to make an extremely powerful central processing unit. Before we examine the differences between microprocessors, here are some of the terms used to describe microprocessors and their functions:

ACCUMULATOR	A register used to hold data for processing in arithmetic, logical, or input/output operations.
ADDRESS MODES	The ways in which a CPU computes the location of data it needs to access, whether in registers or memory. The types of addressing modes available are a measure of the power of the CPU.

ADDRESS REGISTER	A location in a CPU for the storage of an address value.
ARITHMETIC LOGIC UNIT (ALU)	The part of the CPU that performs arithmetic or logical operations.
BIT	A binary digit.
BUFFER REGISTER	A register that temporarily holds data being routed from one place to another.
BYTE	An eight-bit binary number.
CLOCK	A timing device used to generate a signal or waveform for synchronization of microprocessor functions.
INDEX REGISTER	A CPU register used to modify an address value. This is a powerful feature used in some microprocessors.
INSTRUCTION REGISTER	A register that holds an instruction during its execution.
PROGRAM COUNTER	The register that holds the address of the next instruction.
RAM	Random access memory can be read or written into in any address sequence. RAM is usually semiconductor memory.
REGISTER	A location in a CPU used for the storage of data. Data in a register can be more easily tested or changed than data in external RAM.
ROM	Read only memory can be read in any address sequence. It contains permanently fixed, unalterable data or instructions.

Let's begin our examination of microprocessors with the Intel 8080A, shown in block diagram form in Figure 1-10. In the diagram, two parallel lines denote a bus of eight or more data lines. Numbers within parentheses give the number of bits that can be held by a register. Originated by the Intel Corporation,

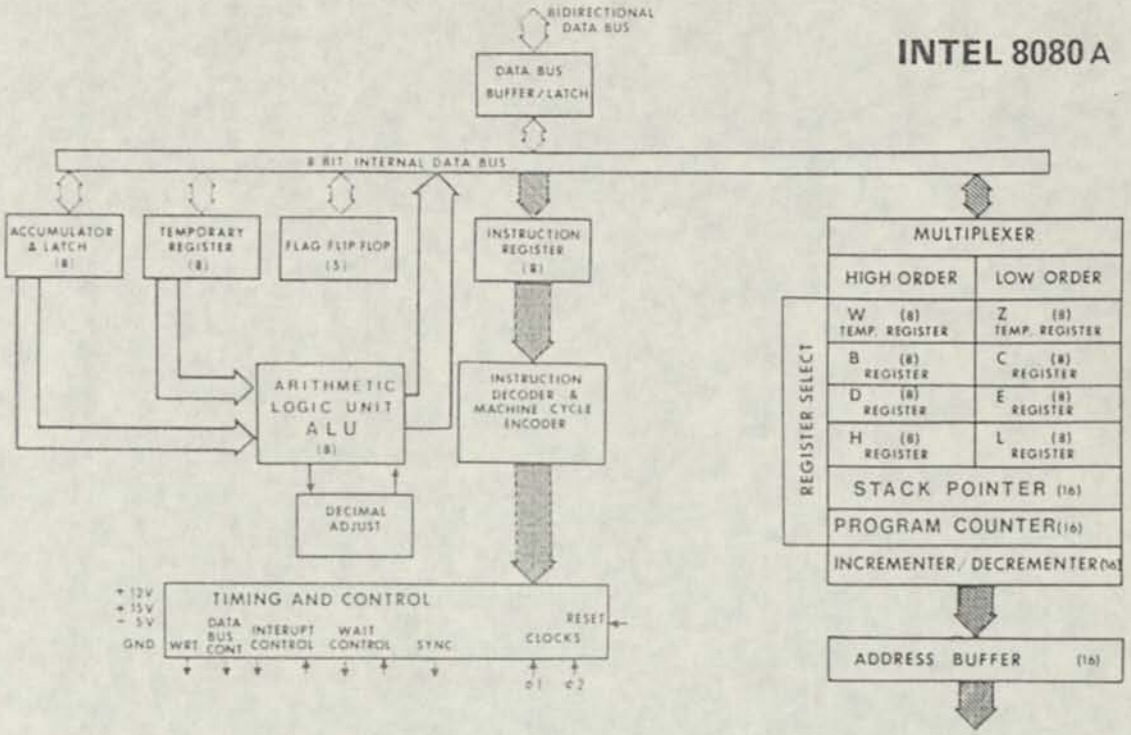


Figure 1-10. Block diagram of the Intel 8080A microprocessor.

the 8080A has a large number of eight-bit registers including an accumulator and six general-purpose registers. Like most microprocessors it can address up to 64K of memory. However, it features only four basic addressing modes. It uses an instruction set containing 78 different instructions with execution times ranging from two to nine microseconds. It is the oldest practical microprocessor, and it is used by many manufacturers. Much software has been written for it.

In the early days of the microcomputer revolution, the main competitor to the Intel 8080A was the Motorola 6800 microprocessor. A block diagram of the Motorola 6800 microprocessor is shown in Figure 1-11. Figure 1-12 shows the 6800 mounted on a circuit board. The entire microprocessor is contained in a package roughly the size of your thumb. The 6800 has two accumulators, but it does not have as many general-purpose registers as the 8080A. Unlike the 8080A, it features a 16-bit index register. The 6800 can address up to 64K memory using six addressing modes. Its instruction set has 72 instructions including a very useful set of branch test instructions. Typical execution times are like those of the 8080A. A fairly large amount of software is available for the 6800.

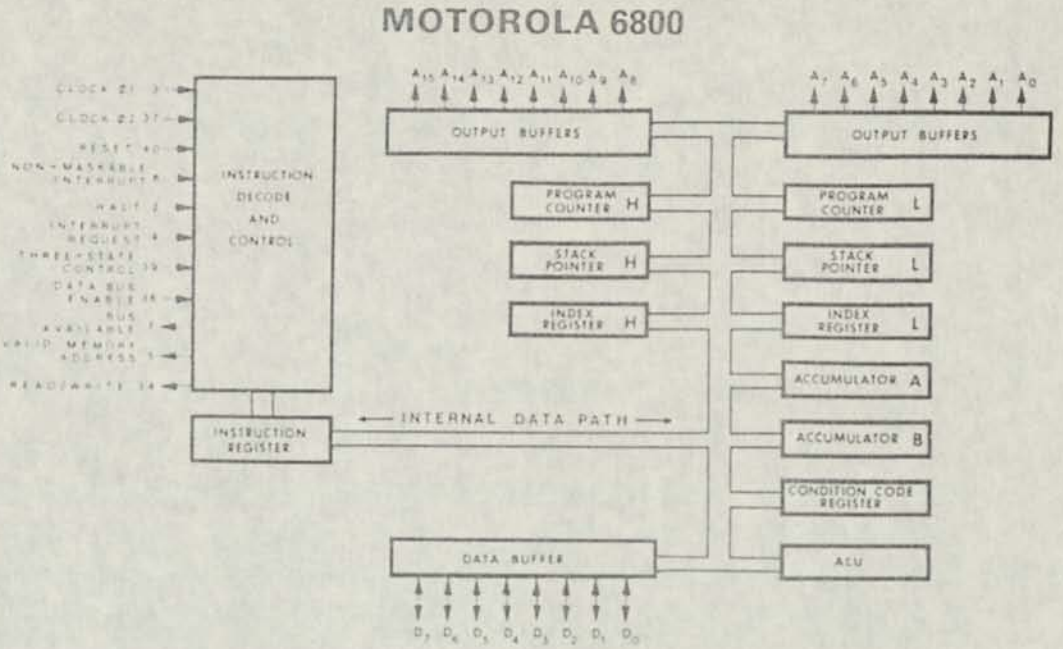


Figure 1-11. Block diagram of the Motorola 6800 microprocessor.

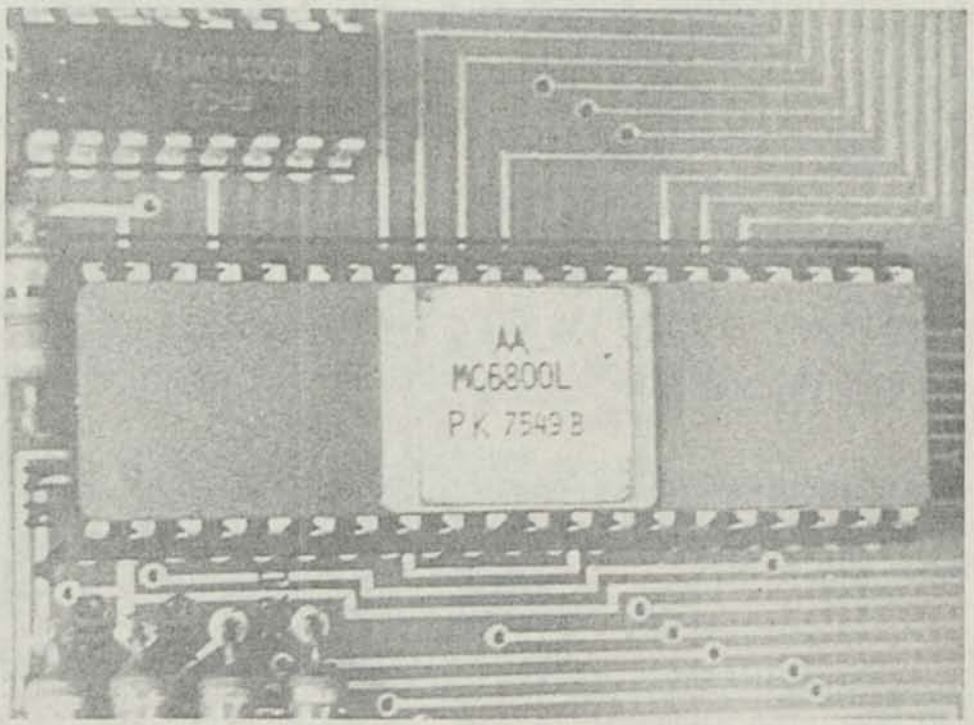


Figure 1-12. The Motorola MC6800 microprocessor shown mounted on a circuit board.

The 6502, originated by MOS Technology, is diagrammed in Figure 1-13. It is a descendant of the 6800 although made by a different manufacturer. It has only three major registers: the accumulator and two index registers. Each of these

holds eight bits. The 6502 has a number of useful features. It has the largest number of addressing modes of any popular microprocessor, and for this reason it is extremely powerful and fast. Many BASIC language interpreter programs written for the 6502 are faster than BASIC interpreters written for other microprocessors. Although there are only 56 individual instructions for this processor, the available combinations of instructions and addressing modes make it a powerful contender in the market. It is used in several microcomputers including the Apple II and the OSI Challenger series.

The Zilog Z-80 microprocessor is block diagrammed in Figure 1-14. It was developed much later than either the 8080A or the 6800. As a result it is more advanced than these earlier microprocessors. The Z-80 contains two sets of main registers. Each of these sets is equivalent to the 8080A's main register set! In addition, it has two 16-bit index registers and several special purpose registers. It has a powerful instruction set containing 158 instructions. The Z-80 has more addressing modes than the

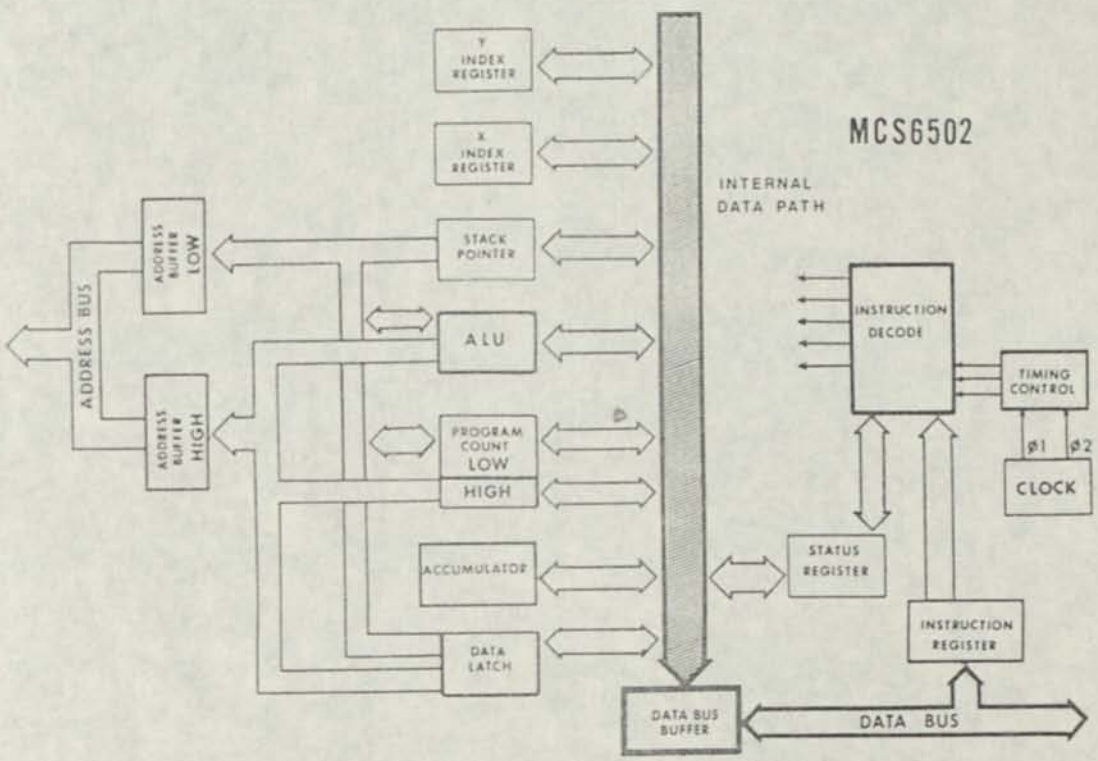


Figure 1-13. Block diagram of the MOS Technology MCS6502 microprocessor.

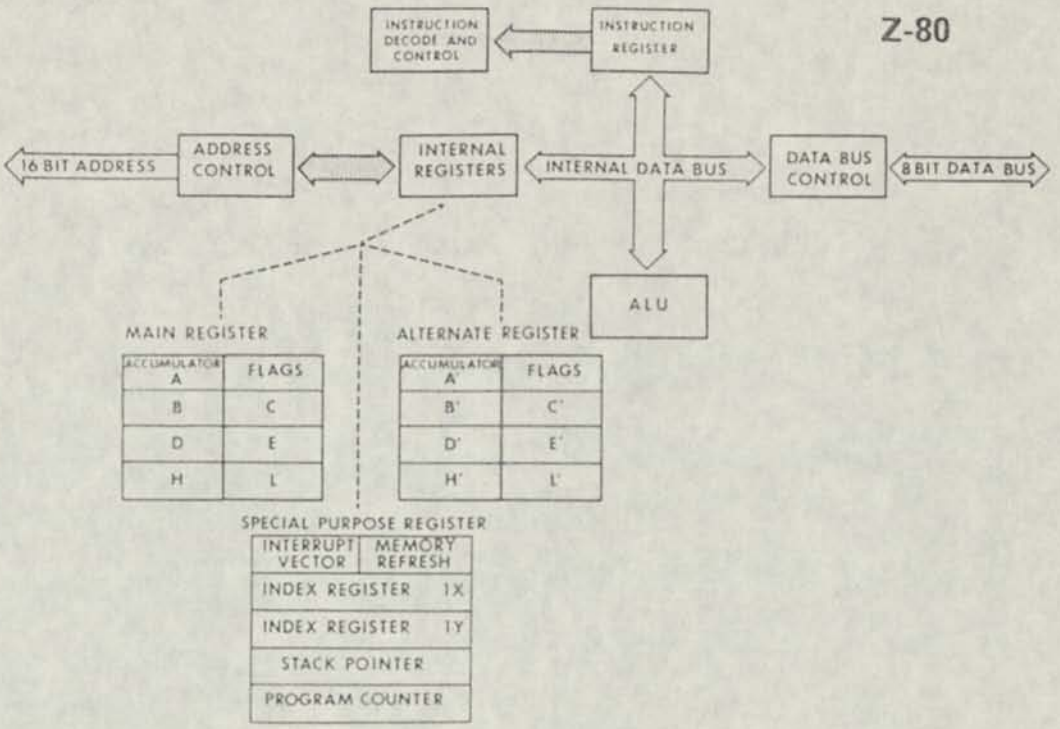


Figure 1-14. Block diagram of the Zilog Z-80 microprocessor.

8080A, but not as many modes as the 6502. The Z-80 runs 20 % faster than the 8080A. In many ways it is top contender for the title of most powerful eight-bit microprocessor currently on the market for hobby or small business applications. Since it responds to all 8080A instructions, most existing 8080A software can be run on the Z-80. The Z-80 microprocessor is used by the Radio Shack TRS-80 and the Cromemco Z-2.

Each major microprocessor has both good and bad points. For the average microcomputer user, who programs in a high-level language such as BASIC, the quality of the available software is an even more important consideration than the specific type of microprocessor used in his system. To understand why this is so, let's take a look at software.

SOFTWARE

Good SOFTWARE is essential to any useful microcomputer system. The term software is another name for a microcomputer program or collection of programs. Similarly, the term

HARDWARE designates all the electronic components in a microcomputer. A PROGRAM is a list of instructions that tell a microcomputer what to do and how to do it. It might cause a microcomputer to solve a mathematical problem, play a game, compute your income tax, or do your firm's weekly payroll. The instructions in a program provide very specific directions to the microcomputer. For instance, they might tell it to fetch a number from storage, add another number to it, and return the sum to storage. Alternatively, the microcomputer might be told to search a list for a particular name and respond if a match is found. The extreme flexibility of the microcomputer comes from the fact that it can be loaded with different programs to solve different problems or to handle different tasks. Unfortunately, a microcomputer cannot understand English directly. This is not really a problem as there are widely used programs that automatically translate English-like instructions into machine language. These are discussed in Appendix I.

SEMICONDUCTOR MEMORY—RAM AND ROM

All microcomputers employ some form of semiconductor memory. Semiconductor memory is very fast, but the cost per byte is rather high. Bulk storage magnetic memory, such as a floppy disk, is lower in cost per byte, but the access time is much longer. Bulk memory peripherals will be discussed in Chapter 3.

There are two principal types of semiconductor memory. One is called random access memory (RAM), and the other is called read only memory (ROM). Both types are made of tiny, thin rectangles of specially treated silicon, and these are enclosed in small rectangular packages with metal pins. These packages plug into the memory circuit boards in the microcomputer. The memory capacity of a microcomputer can be increased up to the maximum allowable by simply plugging in more memory "chips" or circuit boards.

Storage of data in random access memory (RAM) is controlled by the CPU. A commonly used unit of RAM or ROM capacity is the metric term kilo or "K", which is equivalent to 1024 bytes. A byte designates one 8 bit alphanumeric character such as a letter, a number, or a symbol. So, 4K of memory

can store 4 X 1024 or 4096 characters. This is roughly equivalent to 2½ pages of double-spaced typewritten material. Likewise, 16K or 16,384 (16 X 1024) bytes of memory is equivalent to between 10 and 11 pages of material.

RAM comes in two forms: static and dynamic. At present, dynamic RAM is somewhat cheaper per byte and is physically smaller. However, it can only be used in systems designed to accommodate its special electrical timing requirements. Some disk drive controllers do not work well with microcomputers equipped with dynamic RAM. For this reason buyers must be aware that is not always possible to buy a floppy disk controller from one source, plug it into another manufacturer's microcomputer, and have complete assurance that it will work properly. However, when a system manufacturer offers a microcomputer equipped with dynamic RAM and his own disk drive, the buyer can be sure that the two components will function together.

Static RAM is more expensive than dynamic RAM, and it requires more space and power. However, it does not usually have the highly critical timing requirements of dynamic RAM. As a result, it has high compatability with most disk drive controllers. The Heath H8 static RAM plug-in circuit board is shown in Figure 1-15. The basic Heath RAM circuit board offers 4K RAM, which can be expanded to 8K by the addition of eight extra RAM chips and sockets. The board contains an on-board voltage regulator to assure stability of the memory contents. The Heath H8 can accept up to 4 RAM circuit boards to increase total memory capability to 32K.

The basic Altair 680b microcomputer kit contains only 1K RAM. With the addition of the 680b-BSM kit, total memory can be increased to 17K. Figure 1-16 illustrates an assembled Altair 680b-BSM board. Because the 680b-BSM board is a high-density printed circuit board with closely packed components, good soldering skills are required to assemble it.

Some microcomputers, such as the Altair 8800 or IMSAI 8080, can accept either static or dynamic RAM plug-in circuit boards. The newer microcomputers such as the TRS-80 or the Apple-II generally use dynamic RAM. It is usually much less expensive to expand the memory capability of one of the newer machines.

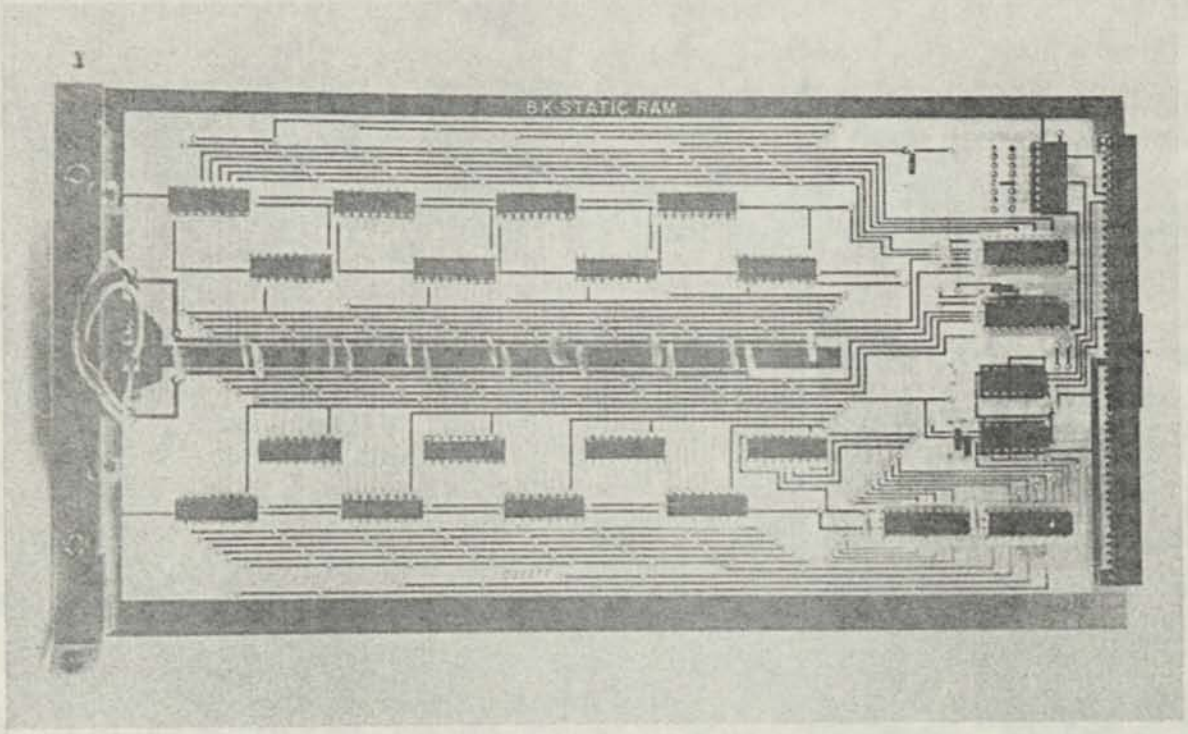


Figure 1-15. The Heath H8 static RAM circuit board.

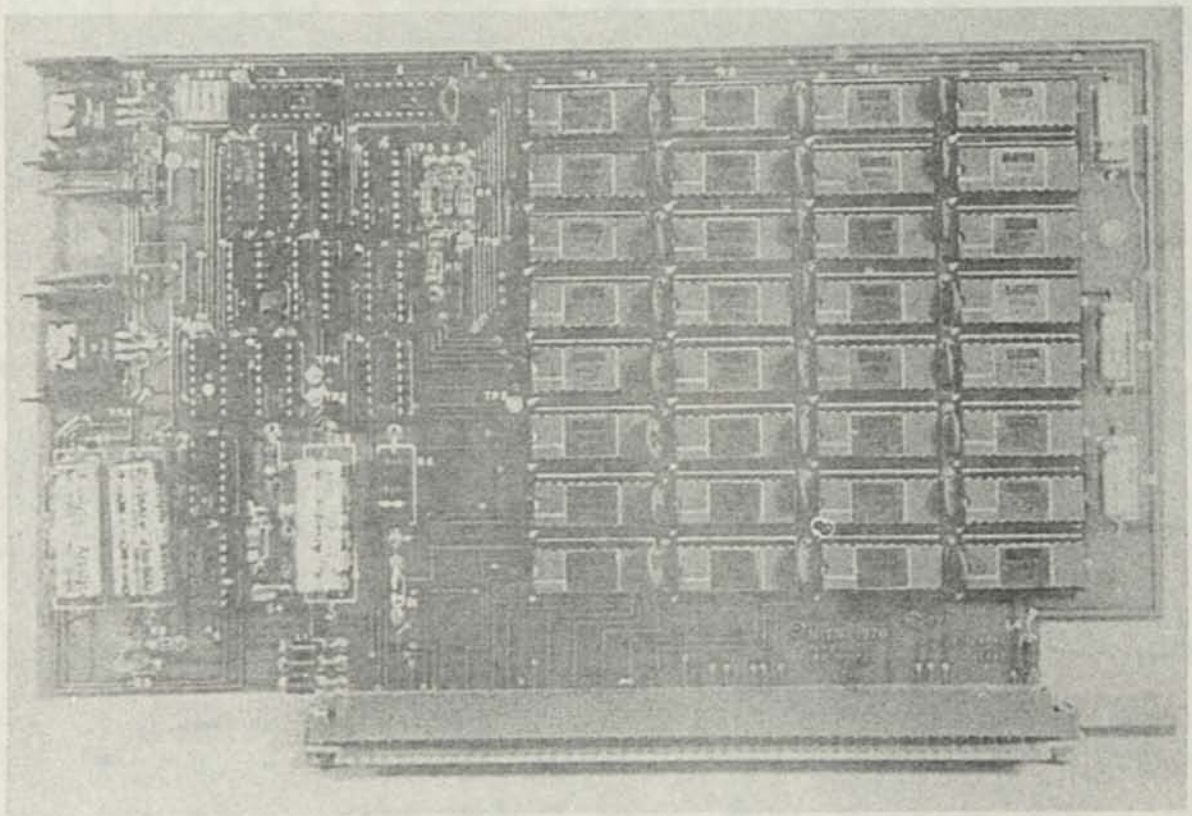


Figure 1-16. The Altair 680b-BSM 16K static RAM circuit board.

In a later chapter we will see how programs and data are entered into RAM. RAM is a form of VOLATILE MEMORY, because if the electrical power is turned off even momentarily, all data stored in RAM is lost. You cannot turn off a microcomputer, come back, turn it on, and expect to find the data you entered. To achieve non-volatile data storage, data must be placed on a storage medium such as a cassette tape or a floppy disk.

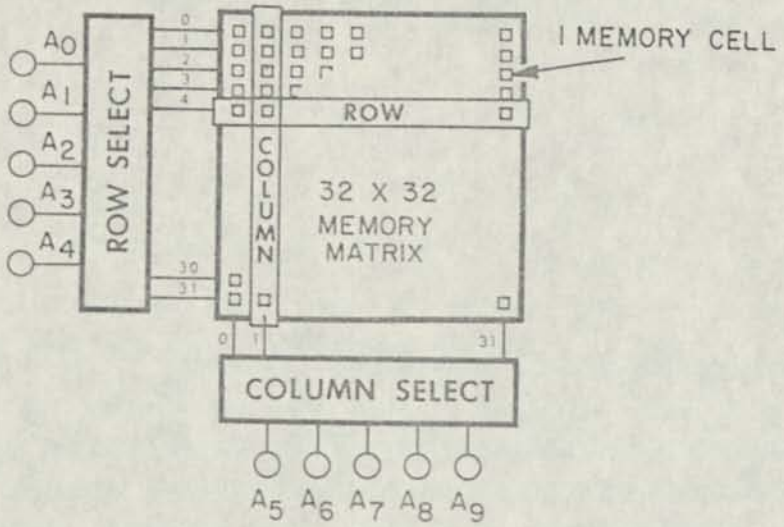
There is another way of permanently storing some types of instructions and data using a type of semiconductor memory called read only memory (ROM). This memory, which has the program "burned-in" by the manufacturer, is used to store the BASIC language interpreter program in many microcomputers. Data stored in this manner is instantly available after power-on.

Units of microcomputer memory are labeled by numbers called ADDRESSES. A memory address is much like the street address of a house. A BLOCK of semiconductor memory (either RAM or ROM) is a group of successive storage addresses. Analogously, a city block contains a group of successive house addresses. A manufacturer may offer 12K BASIC on ROM. This means that his system contains blocks of ROM totalling 12×1024 or 12,288 bytes of storage. There is one byte per address. See Figure 1-17.

The MEMORY SPACE in a microcomputer is the total number of addresses it can access. Most microcomputers can directly address up to 64K of memory. A system with 12K of ROM has 64K less 12K or 52K of space remaining, which can be filled with RAM as the user's needs grow. Usually, a BASIC interpreter in ROM requires some RAM for its operation. This RAM stores the user's program in the PROGRAM BUFFER AREA and also temporarily stores variables and other data. A system with 4K of RAM really has less than 4096 bytes of storage available for programs. The exact amount depends on the nature of the interpreter. RAM is generally added to a microcomputer system in multiples of 4K or 16K.

Typically, BASIC programs require about 2K of RAM per 100 lines of program statements or data. Often, programs have less than 400 lines of statements and need only about 8K

MICROCOMPUTER STATIC RAM MEMORY



1K BITS = 1024 BITS

4K BITS = 4096 BITS

8K BITS = 8192 BITS

16K BITS = 16,384 BITS

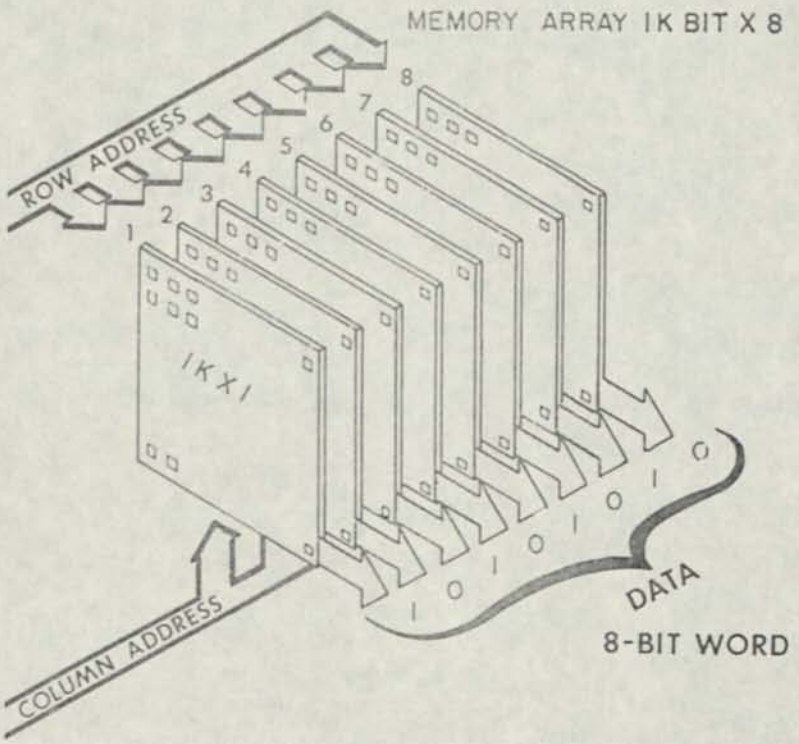


Figure 1-17. Address selection in static RAM. Ten bits are required to address 1K of memory. Division of address bits into row and column bits occurs inside each 1K memory chip.

RAM. However, some large programs for accounting or inventory control or even some games such as Star Trek may require much more RAM because of the need to store large quantities of data. For small business applications, 32K to 48K RAM is usually necessary.

Microcomputer systems frequently use data storage media other than RAM and ROM. Cassette tape and floppy disks can store large quantities of data, but the access time is significantly more than that for RAM or ROM. A floppy disk can provide from 80K to 500K of external memory at less cost than for an equivalent amount of RAM. Bulk storage media are not addressed in the same way as semiconductor memory. So there is no upper limit on the amount of external memory accessible to the CPU as there is a limit for RAM. Typically, a microcomputer can use up to four disk drives for a total storage capacity of up to 2 million bytes. However, disk storage is not quite as easily accessed as RAM. We will learn more about mass data storage peripherals in Chapter 3.

MICROCOMPUTER BUSES AND COMPATIBILITY

A microcomputer bus, which is a set of parallel data paths, allows the different circuit boards in a microcomputer to exchange data with each other. There are many different bus systems used by different microcomputers. As a result of this lack of standardization, circuit boards designed for one microcomputer cannot easily be adapted for use in another microcomputer. One of the earliest buses was the Altair bus, commonly known as the S-100 bus. Microcomputers using this bus standard are sometimes referred to as S-100 machines. Many microcomputers make boards that plug into this type of microcomputer. For instance, there are at least 25 manufacturers who make S-100 compatible memory boards and several others who offer video display circuit boards. In addition, many other types of S-100 circuit boards are available. These include input/output circuit boards, real-time clocks, graphics circuit boards, printer controllers, floppy disk controllers, and process control interface circuit boards. All S-100 microcomputers use either the 8080A or the Z-80 microprocessor. The Altair, IMSAI, and Cromemco microcomputers are S-100 machines.

Most microcomputer manufacturers employ a bus standard that is unique to their machines. Microcomputer components (with the exception of those made for S-100 machines) usually cannot be interchanged between systems made by different manufacturers. Bus interface adapters are available for some microcomputers. These let you use circuit boards designed for one type microcomputer in another machine. In general, these interfaces are not offered by the manufacturer of the microcomputer, but rather, by an independent firm. Often it is not possible to interface a microcomputer bus of one type to another type bus because of differences in timing of signals or the unavailability of certain necessary signals.

The IEEE-488 bus standard is not an internal microcomputer bus at all. Instead, it is a bus standard used to interface with external peripherals. It is commonly used in scientific data-gathering systems to connect instruments and other equipment to a computer or advanced desk-top calculator. Some microcomputer manufacturers include this bus so that their machines can be used with digital voltmeters, signal generators, and so on.

MICROCOMPUTER INTERFACES

A microcomputer communicates with the outside world by using peripheral devices. Examples of commonly used microcomputer peripherals are video displays with keyboards, printers that give hardcopies of data, and mass memory devices. Also available are numerous special peripherals such as analog-to-digital converters that permit a microcomputer to measure light, sound, and other quantities. A peripheral is even available that permits some microcomputers to talk.

All peripherals communicate with a microcomputer using special types of circuits called INTERFACES. These circuits require special software called I/O DRIVERS. The two main types of interface in common use are the PARALLEL interface and the SERIAL interface. The parallel interface is used with parallel data transmission. In this technique eight data bits are transmitted in parallel all at the same time. Parallel data transmission can be very fast. It is most often used to com-

municate with devices close to the microcomputer. It is commonly used with keyboards and small printers. Figure 1-18 shows the Heath H8-2 parallel interface circuit board.

For some applications data must be transmitted over distances greater than 15 or 20 feet. For instance, a microcomputer may need to communicate with a remote printer or keyboard. Then, the many wires used for parallel data transmission between the microcomputer and the peripheral become overly expensive and sensitive to noise. Serial data transmission is used to lower the cost and to reduce the susceptibility to noise interference. The technique of serial data transmission sends data one bit at a time over one line. It is usually a somewhat slower technique than parallel data transmission. Figure 1-19 shows the Heath H8-5 serial input/output circuit board, which includes a cassette tape interface.

The unit of data transmission speed is the BAUD. Roughly speaking, it is the "number of bits of data transmitted per second." A tape interface rated at 300 baud is relatively slow; one rated at 1200 baud is much faster. The difference between these two tape interfaces can be great when loading a tape full of

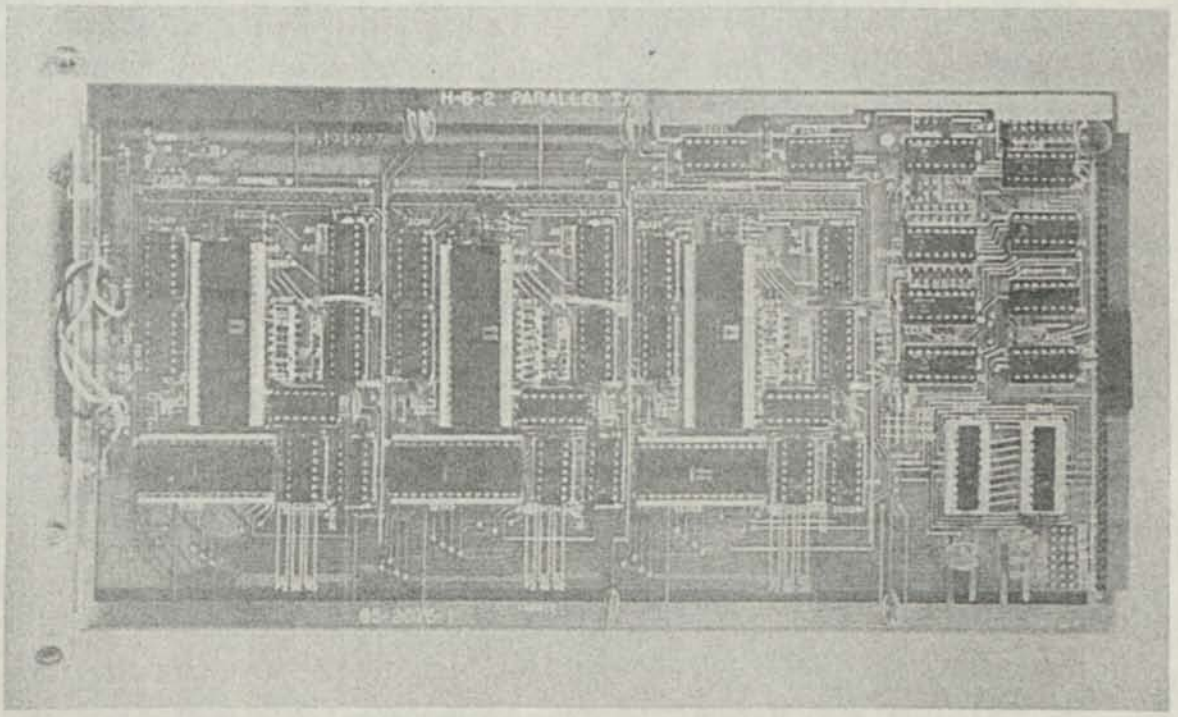


Figure 1-18. The Heath H8-2 three-port parallel interface circuit board.

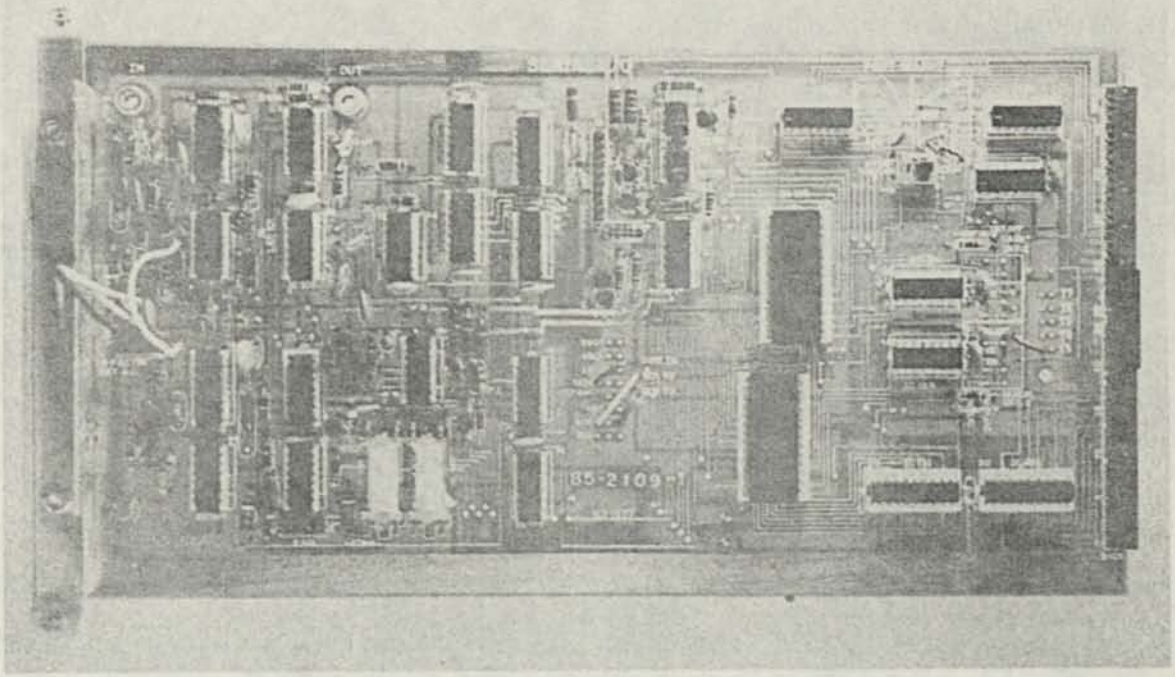


Figure 1-19. The Heath H8-5 serial I/O and cassette interface circuit board.

data. For the 300 baud interface, it could require 15 minutes, but the 1200 baud interface might require less than 4 minutes. For most hobby applications, a 300 baud interface is adequate. For most business purposes and other serious applications, this low data transfer rate is not very useful. For these applications the much greater data transfer rate of a floppy disk drive is required. Floppy disk drives can provide data transfer rates of 250,000 bits per second.

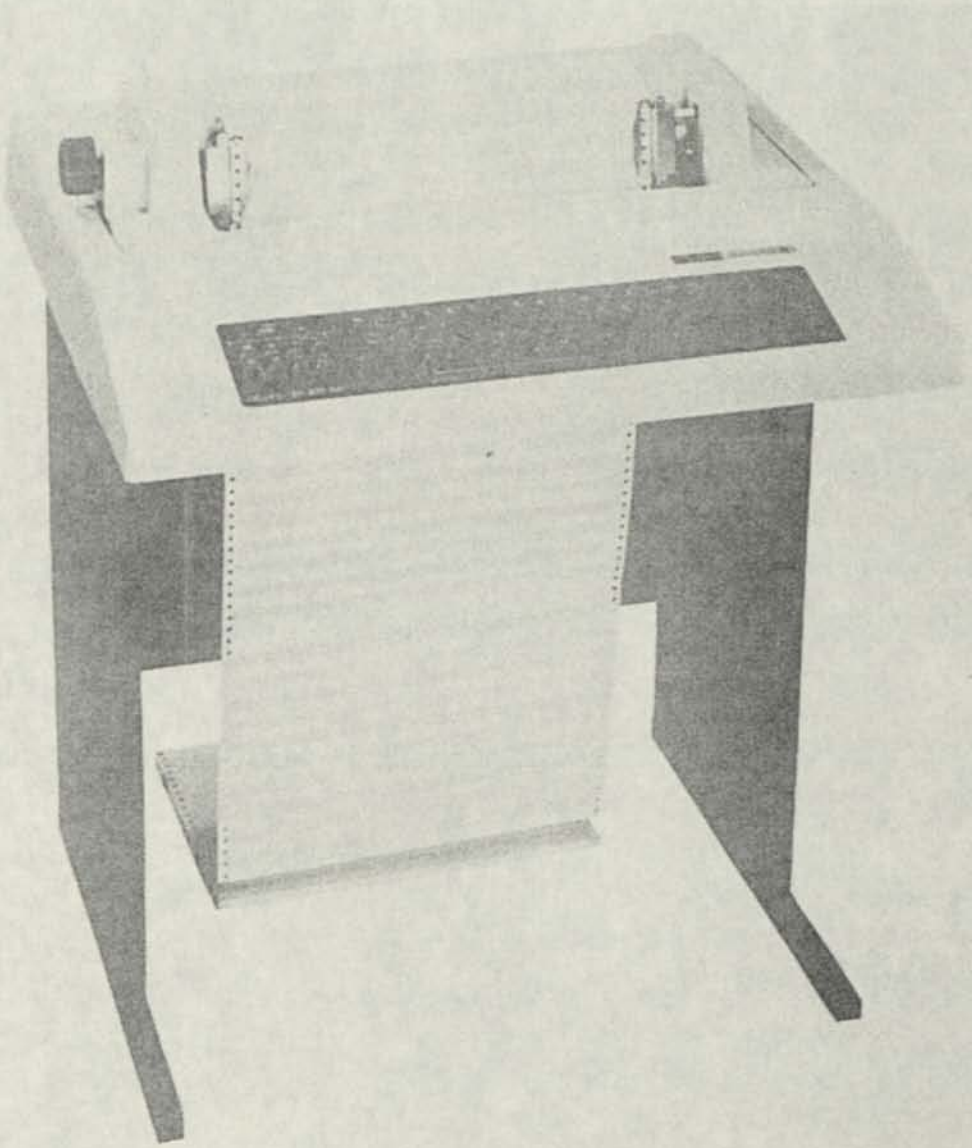
One other type of interface, only briefly mentioned before, is the PROCESS CONTROL INTERFACE. It can be used to control temperature or to turn lights or machines on or off. A special type of interface, the ANALOG-TO-DIGITAL CONVERTER, translates continuously variable voltages into digital form. It can convert the voltage from a pH sensor or temperature sensor into a digital value that can be understood and used by a microcomputer. Many microcomputers are equipped with game paddles. The position of the game paddle is converted by a special interface to a digital form understood by the microcomputer. A game paddle permits the user to communicate with the microcomputer using means other than numbers. Another type of interface is used by the microcomputer to open

or close relays. With this type of interface the microcomputer can control electrical devices such as motors. Finally, there is a type of interface called a real-time clock. It generates precise time "ticks" or provides the time of day. This capability can be used by an applications program for process control or for logging events. Some of these special applications are discussed in more detail in Chapter 10.

SUMMARY

Although microcomputers use the most advanced technology, they do not have to be viewed as mysterious boxes with blinking lights. They are quite comprehensible if you only take a little time to learn how they work. This chapter is just a brief introduction. In the following chapters we will explore the microcomputer in greater depth, and we will see how it is used to solve practical problems.

2



SOME MICROCOMPUTER PERIPHERALS

HOW TO TALK TO YOUR MICROCOMPUTER

You must be able to communicate with your microcomputer in order to use it. Today a wide range of I/O (input/output) peripherals are available. Without these devices the microcomputer would not be a practical tool for most people.

In this chapter we will take a look at the common types of I/O devices: the keyboard, the CRT or video display terminal, and the printer. Keyboards are used to enter data and to control microcomputer operation. Video monitors or complete CRT terminals are used to display data. They can show what has been typed in or display the results of computations. Printers give a HARDCOPY (a paper copy) of information. They are essential for most business applications, and they are very useful for many other microcomputer applications.

The choice of I/O peripherals is much like the choice of high fidelity components; there is a wide range of features and prices. It is easier to evaluate microcomputer systems if you know what peripherals exist and what your needs are. Some microcomputer systems easily interface with common peripherals; others do not. The wise buyer is aware of this. He estimates his future needs and keeps in mind the problem of compatibility when planning his microcomputer system.

KEYBOARDS

Many microcomputers now include a keyboard as standard equipment. Others require the user to furnish a complete CRT terminal with built-in keyboard. Let's examine the differences between a microcomputer keyboard and that of a regular typewriter. Because of these differences, some skill adjustment must be made by the user who is familiar with a standard typewriter keyboard. However, even a "hunt-and-peck" typist can use a microcomputer.

Let's start with the features on a standard electric typewriter keyboard, shown in Figure 2-1. It contains the complete alphabet, with both lower case and upper case letters, plus all of the numerals, punctuation marks, and symbols used for business or personal correspondence. There is a SHIFT key to change from lower to upper case letters or from numbers to symbols. The RETURN key moves the typing point to the left margin. The BACKSPACE key permits motion to the left—one character at a time. On this typewriter there is an INDEX key that moves the typed page upward one line each time it is pressed.

Now consider the Radio Shack TRS-80 keyboard shown in Figure 1-7. At first glance both keyboards seem identical.

Figure 2-1. A standard electric typewriter keyboard.

However, like most general-purpose microcomputer keyboards, the Radio Shack keyboard is not equipped to handle lower case letters even though it has a shift key. Except for word-processing systems, most microcomputers only accept and display upper case letters. The shift key only allows choice between numerals and special symbols. Instead of a return key, the TRS-80 keyboard has a key marked ENTER. When pressed, it transmits the current line of data to the microcomputer. The microcomputer accepts the data and returns the cursor on the screen to the start of the next line. The BREAK key, when pressed, interrupts the microcomputer, if busy, and gains its attention. A key labeled CLEAR erases all data from the video display. Most punctuation marks have been relocated from their customary positions on a typewriter keyboard. This change may cause typing mistakes until the user adjusts to the new locations.

In addition to these keys, there are several new keys with special functions. The ARROW keys move the cursor up, down, left, or right one position. On the TRS-80, the left-pointing arrow serves as a backspace key. The up-pointing arrow is just like the index key on a standard electric typewriter; it scrolls the page up one line. Two new symbols appear on this keyboard. They are the GREATER THAN (>) and the LESS THAN (<) comparison symbols, which are useful for advanced programming.

The Heath H9 video terminal, shown in Figure 2-2, has extra function keys on the keyboard and also in a row above the keyboard. All cursor movement keys are grouped at the right side of the keyboard. This terminal features a HOME key that causes the cursor to return to the first position on the first line of the page. The CTRL, or CONTROL key, shown at the left edge of the keyboard, is used together with other keys to provide unique control code functions. For instance, the Benton Harbor BASIC software contains 5 CTRL codes used with the Text Editor software.

One other type of data entry device is the stand-alone keyboard. It is a keyboard mounted in an enclosure. A parallel interface is included, or else a serial interface if the keyboard is located far away from the microcomputer. Such a keyboard might be used at a sales counter.

Figure 2-2. The Heath H9 video terminal. Photo courtesy of the Heath Company.

VIDEO MONITORS AND CRT TERMINALS

The two most practical ways to get data out of a microcomputer are the CRT display and the hardcopy printer. The video display is widely used for its speed, silence, economy of operation, and ability to show graphic information. There are basically two kinds of video displays: the video monitor and the more-expensive full CRT terminal.

A video monitor is a simple cathode ray tube display that shows data from the video display generator of a microcomputer. The monitor converts the signal into readable information on the screen. Video monitors contain no memory circuits, and the displayed data must be continually refreshed in order to be

retained on the screen. Video monitors are available with screen sizes from 9 inches up to 19 inches and produce displays in black-and-white or full color. They range in price from about $100 to several hundred dollars. The Radio Shack TRS-80 12-inch black-and-white video monitor is shown in Figure 2-3.

The alternative to buying a monitor is to use a home television set as a monitor. In order to do this, the user must connect a VIDEO MODULATOR between the microcomputer's video output and the antenna terminals of the television receiver. A video monitor is basically a very low power television transmitter used to transmit data from the microcomputer to the TV. The signal is received just like the signal from a television broadcast station, and the data is processed in the same way as a normal TV signal. The Apple-II microcomputer is designed to be used with a video modulator such as the one shown in Figure 9-2. This microcomputer produces both alphanumeric and graphic displays in full color. If desired, the Apple-II can be connected directly to a black-and-white or color monitor.

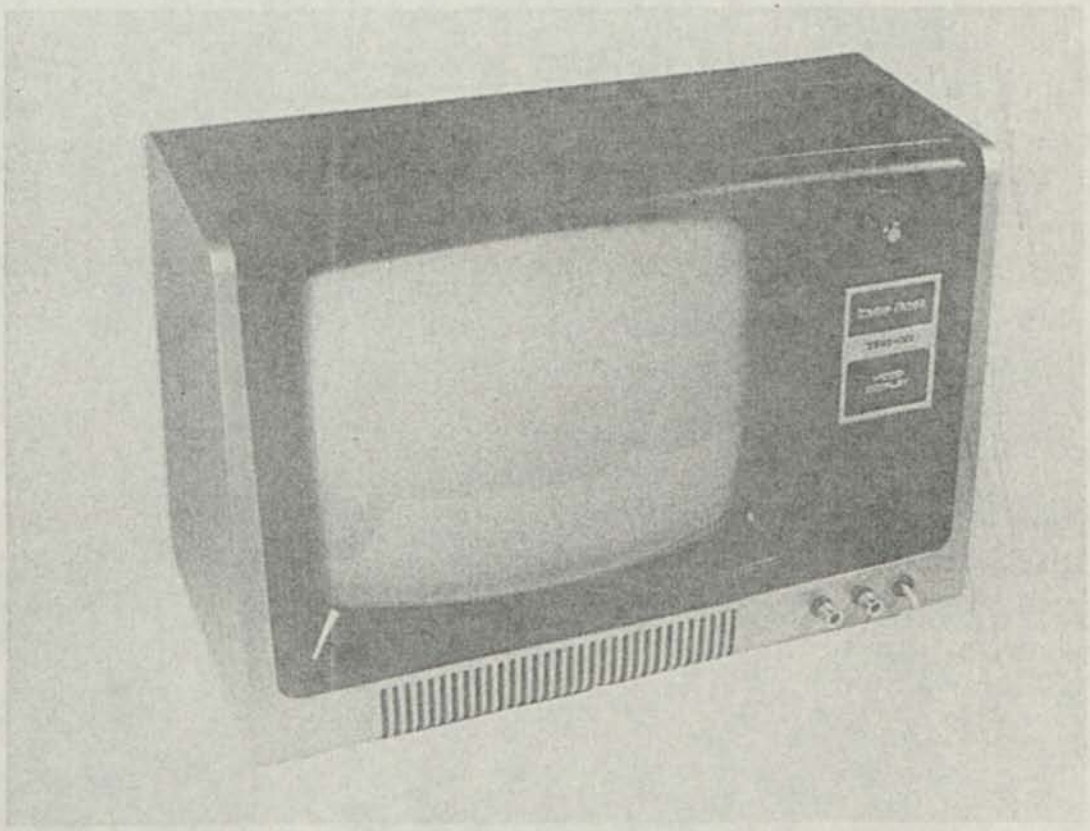


Figure 2-3. The Radio Shack TRS-80 video display. Photo courtesy of the Radio Shack International Headquarters.

Although use of a modulator with a home TV is less expensive than any other method of display, the character quality may not be particularly good. If used for long periods of time at high display intensity, the TV screen phosphor may become worn at the character positions. This is called phosphor etch. When it occurs, the TV can no longer be used as a regular television receiver without the appearance of "ghost" characters over the regular picture.

If a microcomputer does not have a video display generator, a CRT terminal must be used. A CRT terminal contains not only a video monitor, but also a complete video display generator, a keyboard, and supporting electronic circuitry. Many terminals can store a full page of data and at a command send it through an interface to a microcomputer. Terminals generally have screens about 9 inches to 12 inches measured diagonally. They range in price from under $600 to over $2000. Because a CRT terminal is a commonly used peripheral, let's learn more about its major features.

All CRT terminals have keyboards. In addition to the features mentioned in the section on keyboards, many terminals offer extra capabilties. For instance, a numeric keypad is often extremely useful for business applications such as the entry of accounting data. The numeric keypad is a small group of numeric keys placed at the right side of the keyboard separate from the main keys. A numeric keypad can be used to enter numbers independently of the main keyboard. This is more efficient for data entry than using the row of numeric keys at the top of a standard typewriter keyboard. A terminal with a numeric keypad is shown in Figure 9-17.

Another important consideration is the quality of the keyboard itself. Legends may be engraved on the keys or molded into the keys. The keyboard touch varies widely among different terminals. Some have a "good" feel much like an expensive electronic typewriter. This aids the typist in error-free data entry. Others may feel "mushy" or lack adequate tactile sensation.

The sharpness and clarity of the display on the monitor screen is very important. If the characters are not clear and well-defined, the operator may fatigue easily. Many different colors

of phosphor are available. The standard is generally a bluish-white, although green and yellow-green are also popular and easy on the eye. It is important to survey the different types of displays and select the one that looks best.

Terminals differ in the number of characters per line and the number of lines they can display. The least expensive terminals are limited in both areas. Professional terminals can display 80 characters per line and up to 24 lines. They may also offer reverse video (black on white) and underlining.

The reliability and serviceability of the terminal are also important. Some manufacturers have nationwide service networks and others don't. If the unit breaks down, what will you,

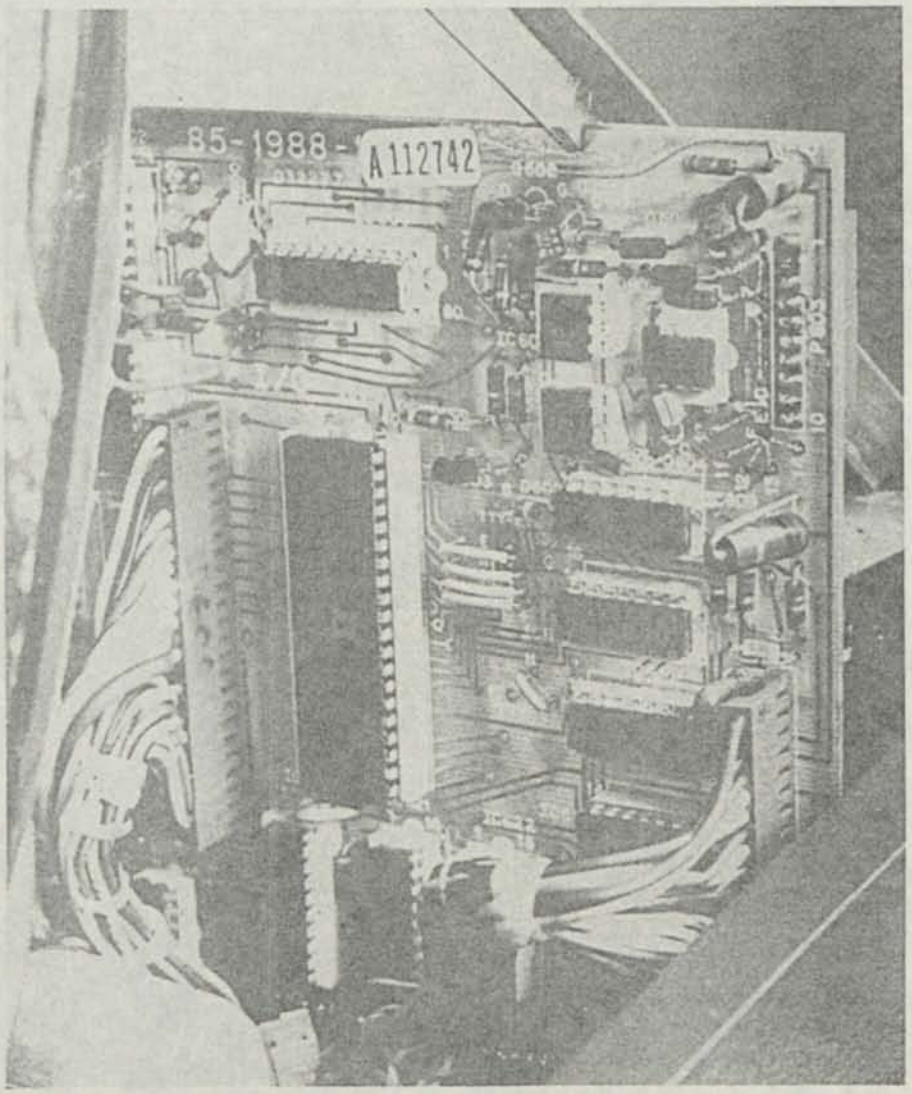


Figure 2-4. The Heath H9 serial-and-parallel I/O port.

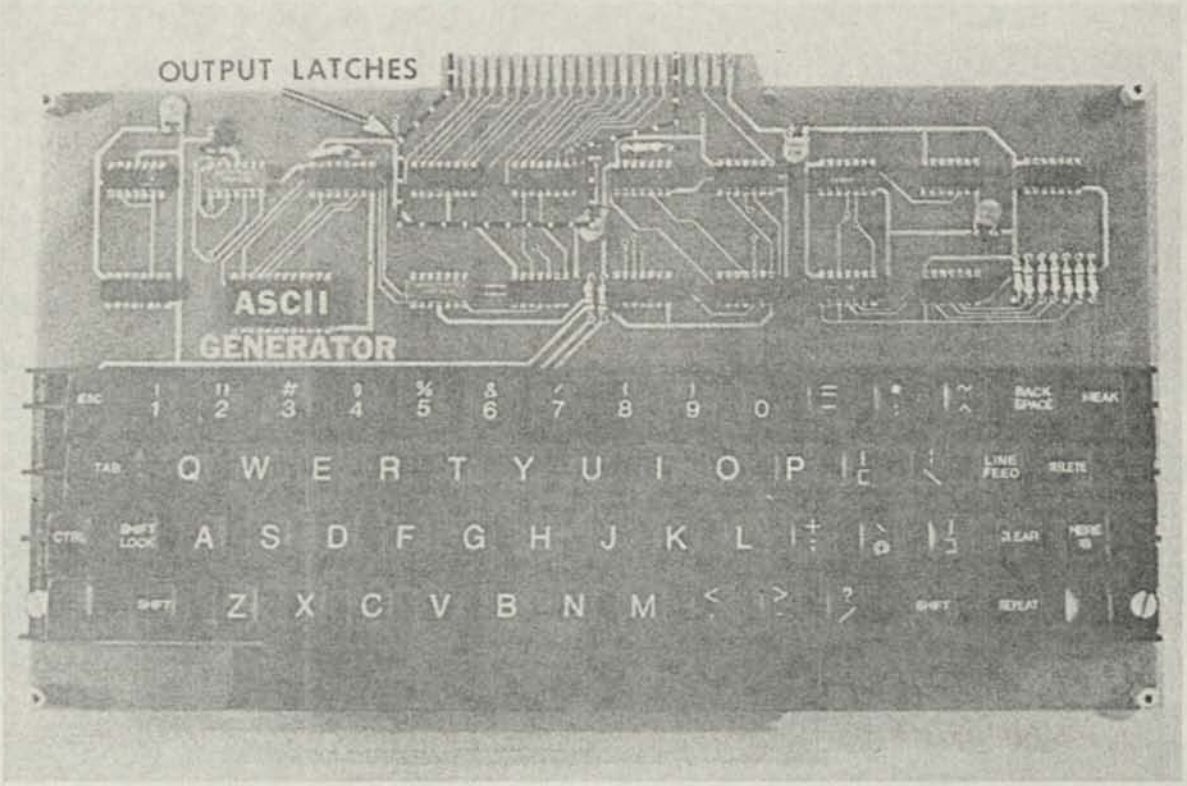


Figure 2-5. A microcomputer keyboard with ASCII generator and output latch units used to place the ASCII code on the ASCII bus.

the user, do? Check out the warranty and verify dealer and factory service support before you make your purchase.

Terminals can be located some distance away from the microcomputer. A remote terminal is connected through an internal RS-232C serial interface to cables that run to the serial interface of the microcomputer. The data transfer rate is the rate at which data can be transmitted back and forth along the cable. It is expressed in baud. If the data transfer rate is low, it may take many seconds for the microcomputer to fill the screen with data. For instance, at 250 baud it would take as much as 30 seconds for the microcomputer to fill the display screen. This is a definite disadvantage when using graphics such as charts or simulated business forms. A rate of 300 baud is relatively slow; 1200 baud is useful; higher rates are in use. Figure 2-4 shows the serial interface in the Heath H9 video terminal, which offers preset switch-selectable data transfer rates.

The Heath H9 is a moderately priced unit that can be used not only with Heath microcomputers but also with any other microcomputer requiring a terminal. It can accept serial

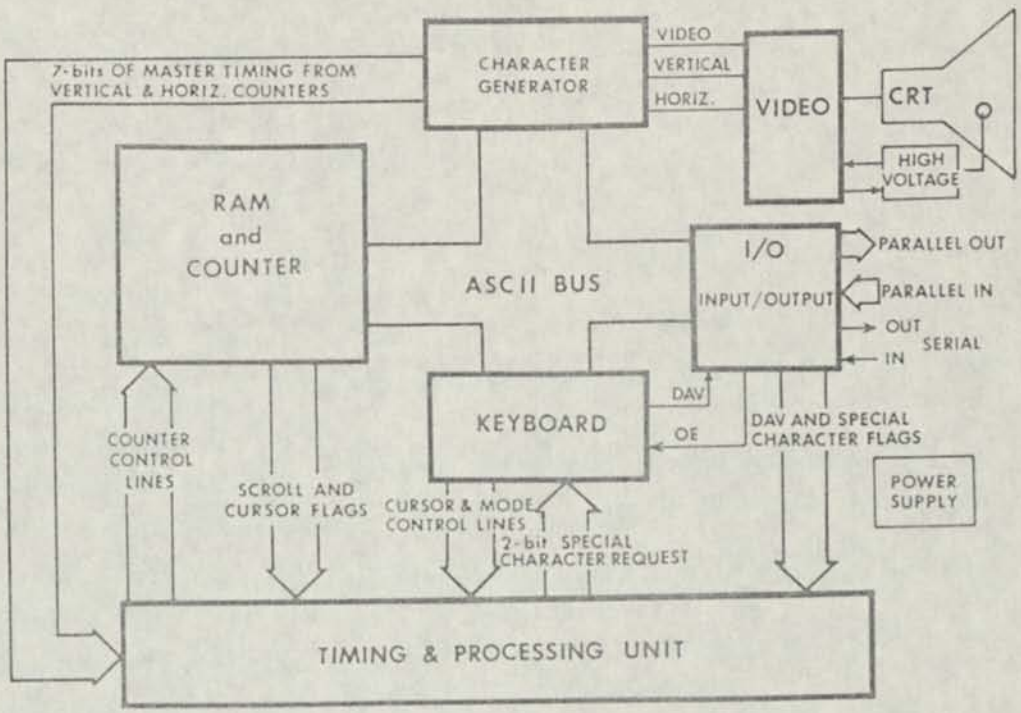


Figure 2-6. The Heathkit H9 video terminal block diagram.

or parallel data transmission, and it offers the choice of data transfer rates from 300 to 9600 baud. In addition, it offers the choice between a long-form display (twelve 80-character lines) and a short-form display (forty-eight 20-character lines). Its keyboard is shown in Figure 2-5. Figure 2-6 is a block diagram of the Heath H9 video terminal. The Heath H9 is available factory assembled or in kit form. The Heathkit assembly/instruction manuals are very explicit and easy to follow. Figure 2-7 shows a user-built circuit board from the H9.

HARDCOPY PRINTERS

Many microcomputer users will want to be able to print out the results produced by their microcomputer. A paper printout (called a hardcopy) is a permanent record that can be read without access to a microcomputer. A hardcopy capability is essential for business applications requiring communications within your business and with outside vendors and customers. A hardcopy printout is the only convenient way to examine large quantities of data.

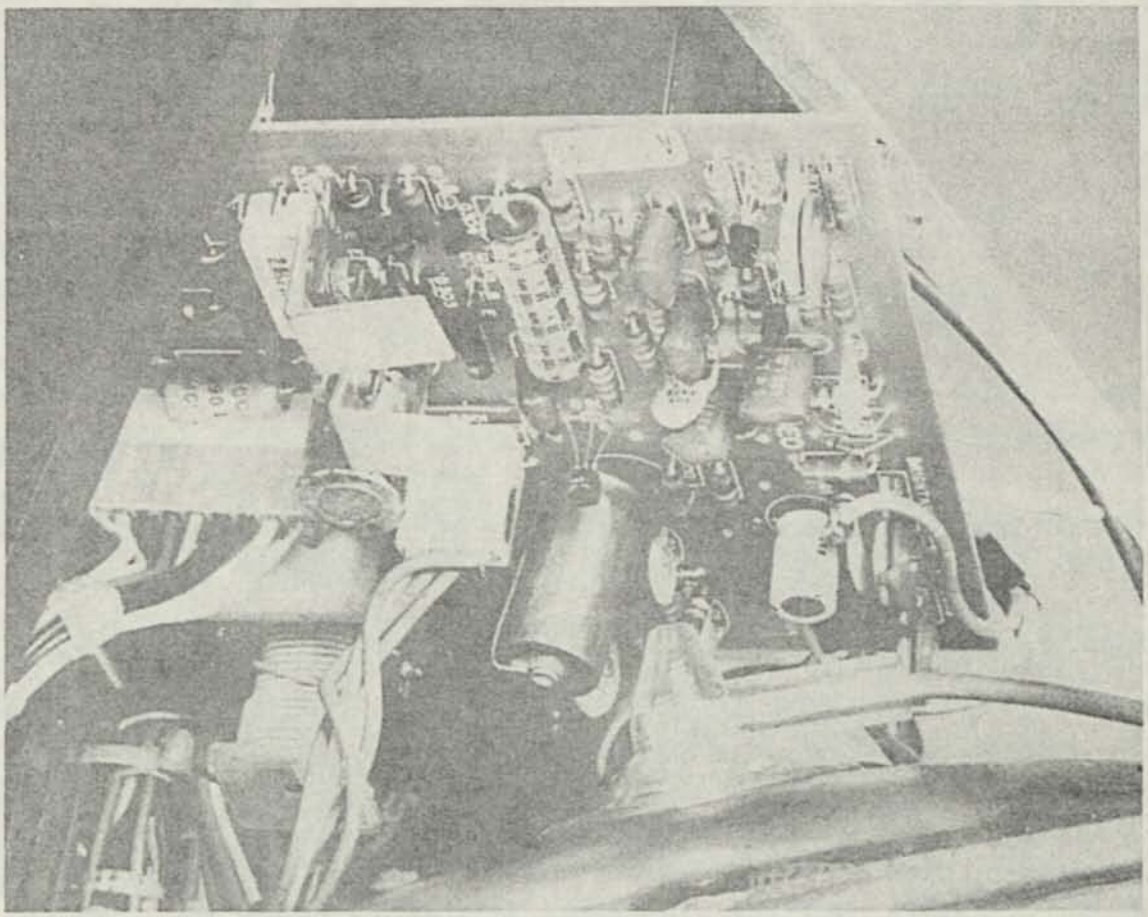


Figure 2-7. The Heath H9 video circuit board.

As a microcomputer user, you can choose between a large number of different printers. In this section we will discuss the various factors that might influence your choice. There are great differences in price, printing speed, character quality and typeface, type of paper used, type of ribbon used, quietness of operation, and maintainability.

In the early days of microcomputing, a user had to make do with whatever type of hardcopy printer he could obtain inexpensively. Many people used a Teletype, which is an electromechanical printing terminal with a keyboard. At 10 characters per second it was slow, it printed only upper case letters, it was extremely noisy, and it required frequent preventive maintenance. The only alternative was a surplus large-computer printer. While these were fast, they were extremely large and totally unsuitable for home or small business use. In contrast, today there are many small, fast, quiet printers no bigger than a business typewriter available at reasonable cost.

The speed of a printer is a large factor in its cost. Printers can be divided into two main types: the character printer and the line printer. The true line printer is expensive but very fast. It prints a whole line at one time at a speed of many lines per minute. The character printer, on the other hand, prints only one character at a time, but it costs less than a line printer. A printer speed of at least 30 characters per second is the minimum acceptable for serious business applications, and a printer speed of 45 to 55 characters per second or more is highly desirable.

Some character printers print not just from left to right but also from right to left. These bidirectional printers save the time normally used for a carriage return. Other printers can skip over blank character positions. This feature increases the effective printing speed for tabular material such as accounting reports. Other printers can move the paper up and down. This feature is useful for generating graphics.

Mechanisms used for movement of paper in printers fall into two categories: tractor feed and friction feed. Printers equipped with tractor feed have spiked wheels that engage holes in the edges of the paper. Either lined or unlined paper or preprinted business forms can be used. These are available in continuous rolls. Multipage printouts can be prepared automatically without an operator to feed each sheet of paper. Perforations between the sheets allow the finished printout to be separated from the unused paper. In contrast, friction feed holds and feeds paper by pinching it between rollers just like a regular typewriter. Letterhead stationary and preprinted business forms can be used by a printer with friction feed.

Character print quality is a major factor in the choice of a printer. There are basically two techniques used to print characters: DOT-MATRIX printing and CHARACTER printing. The dot-matrix printer creates each character out of a matrix of dots. Typical dot-matrix formats are 5 x 7 and 9 x 12. This means that, for example, each character can be formed using up to 5 rows of 7 dots each. The dot-matrix technique permits high printing speeds. It also allows much flexibility in choice of character size and shape. The dots can be formed by two different methods. Needles can force an inked ribbon against the paper, or an electric discharge can blacken aluminized paper. Dot-matrix impact printers can produce multiple copies in one

printing using special carbon paper forms. In contrast, electric discharge printers, although fast and inexpensive, are limited to single copies. Figure 2-11 shows a sample of dot-matrix printing.

A character printer can offer better print quality than a dot-matrix printer, but the printing speed may be somewhat slower. Character printers employ impact printing using typeballs, petal-wheels, or moving belts to produce characters, and the user has a selection of typefonts. Often an inked ribbon or a carbon ribbon is used for letter-quality copy. A character printer is usually more expensive than a dot-matrix printer.

Printer noise is another important factor. In an office or home environment a quiet printer is highly desirable. Printers vary widely in the amount of noise they make. The quietest are electric discharge printers, while character printers are noisier as they use impact printing. Line printers are noisiest of all.

The Expandor Model 123P Black Box printer, a character printer, is shown in Figure 2-8. It can print 10 characters per second using friction feed of standard typewriter paper and a regular typewriter ribbon. Physically, it is quite small. Its price is about $400, which is fairly low for this type of peripheral.

The "daisy wheel" or "thimble wheel" printer is more expensive. It is so named because it employs as a printing element a rotating wheel with many radial arms. One character is on the tip of each arm. The wheel rotates to place the correct character over the paper, and a hammer strikes it. This presses the petal against the ribbon and prints the character on the paper. Since the printing quality is very good, these printers are used extensively in word-processing applications. Printing speeds range from 45 to 55 characters per second. Manufacturers of this printer type include Diablo/Xerox, Qume, and NEC. Prices are high ranging from $2000 to $3500.

The Radio Shack TRS-80 screen printer, shown in Figure 2-9, is a type of dot-matrix printer. It prints whatever is on the screen of the TRS-80 video display including graphics. It uses a 4-inch-wide electrostatic paper and has an effective printing speed of 2200 characters per second! This incredible rate is made possible by a printing mechanism that actually burns away dots of material from the surface of the paper using an electrode. This printer can be used with any TRS-80 system regardless of the

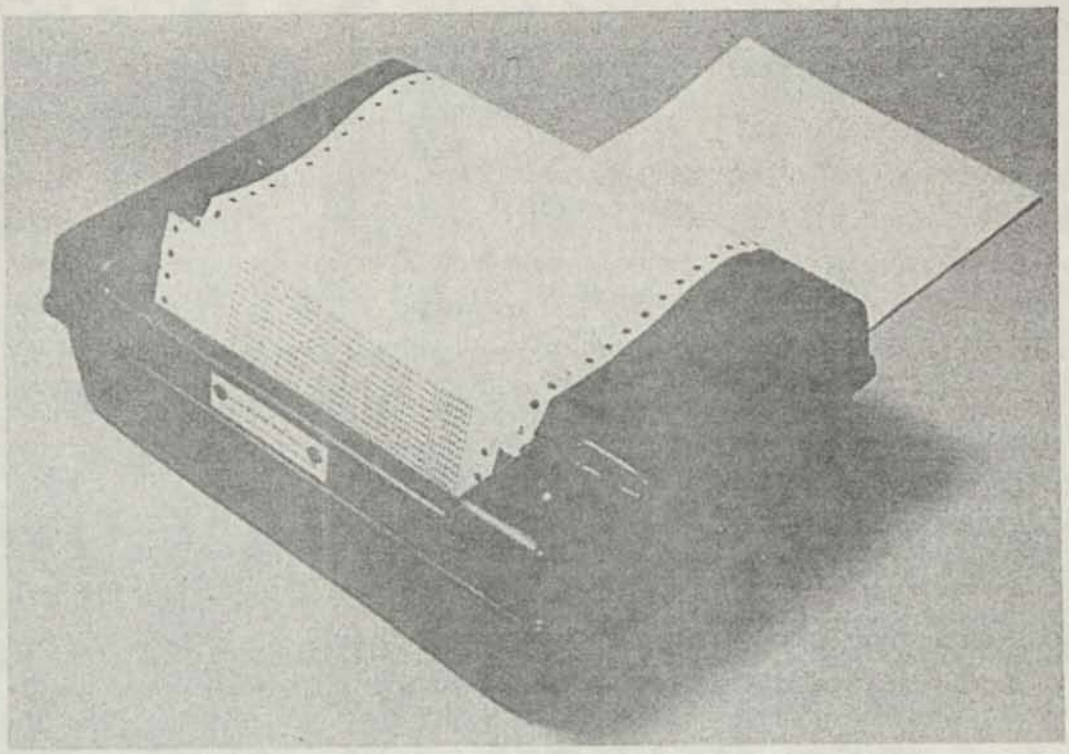


Figure 2-8. The Expandor Model 123P Black Box printer with cover housing in place.

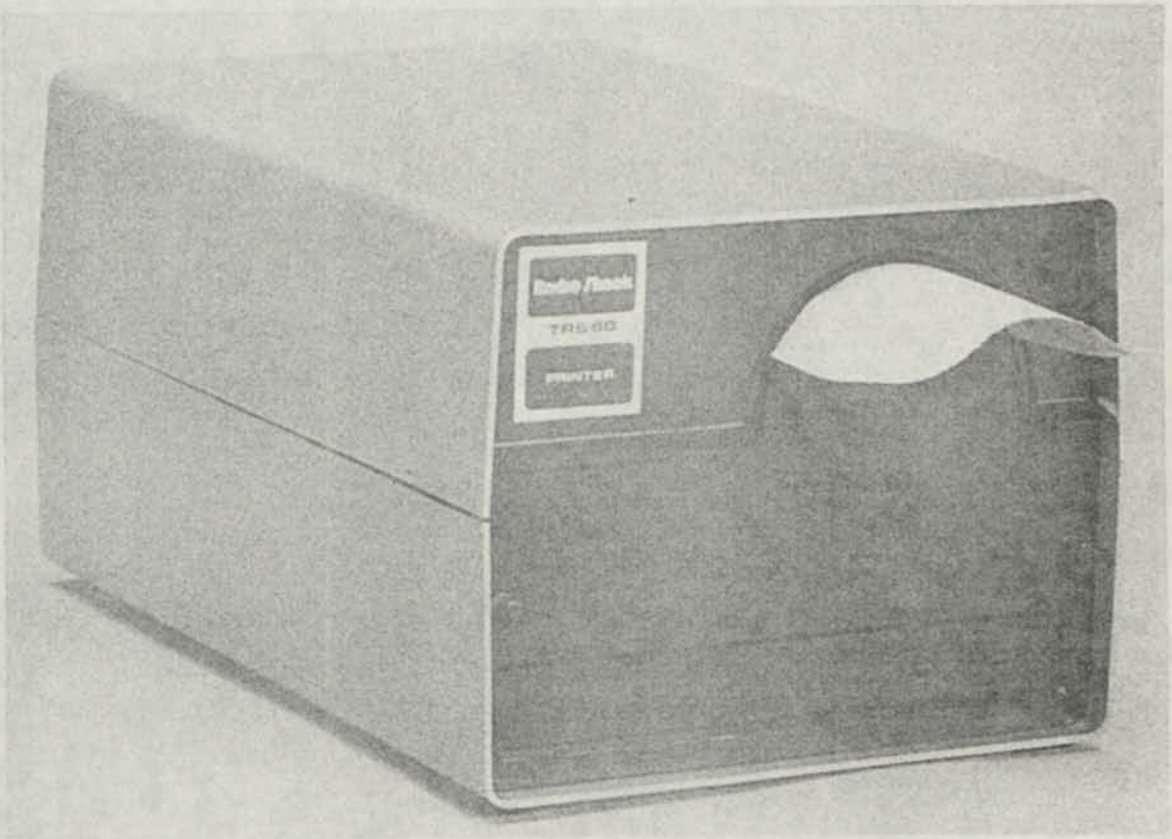


Figure 2-9. The Radio Shack TRS-80 screen printer.

amount of RAM or the level of BASIC used. The price of about $600 is phenomenal for its performance.

The Integral Data Systems IP-125 impact printer, shown in Figure 2-10, offers a choice of 10 or 12 characters per inch. It uses ordinary single-sheet, fanfold, or roll paper up to 8½ inches wide. The average printing speed is 50 characters per second. For short bursts it can hit a top speed of 100 characters per second. Characters are formed from a 7 x 7 dot matrix, and the printer can make multiple copies without special adjustment. A sample printout from the IP-125 is shown in Figure 2-11. The printer costs under $1000.

The DECwriter II printing terminal is shown in the chapter heading photograph. It features a 7 x 7 matrix and prints at speeds to 30 characters per second at 10 characters per inch. It offers both upper and lower case letters and has the abil-

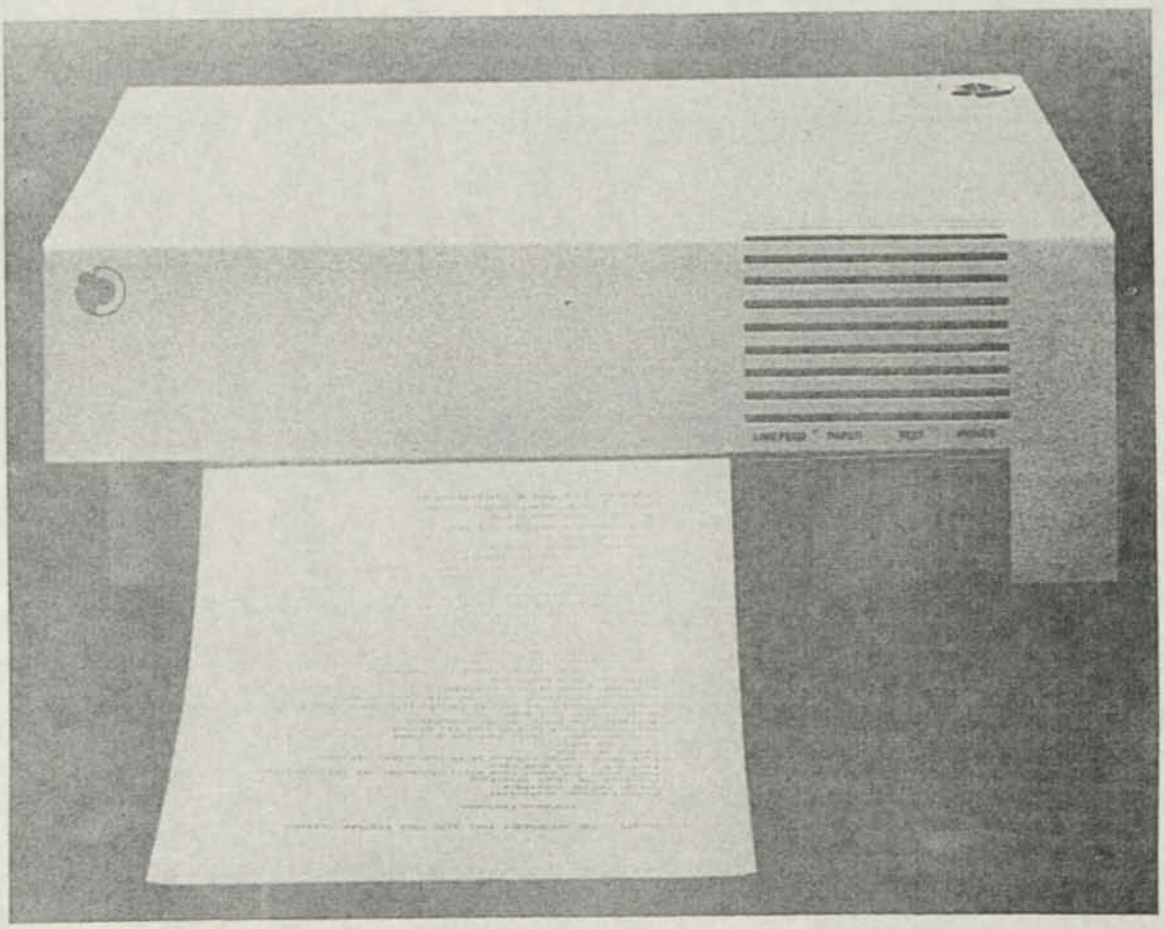


Figure 2-10. The Integral Data Systems Model IP-125 impact printer. Photo courtesy of Integral Data Systems.

```
 1 INTEGER C,I
10 DIM N$(40),A$(40
20 INPUT"TYPE 1 TO
30 ON X GOTO 40,160
40   FOR I=1 TO 25
50   PRINT
60   NEXT I
70 CREATE"B:NAME.FI
80 INPUT"ENTER THE
```

Figure 2-11. Dot-matrix printing produced by the Integral Data Systems IP-125 impact printer.

ity to handle forms ranging from 3 inches to 14.9 inches wide. Its keyboard can be used for data entry into a microcomputer. Priced at approximately $1500, it is a thoroughly professional unit backed by a manufacturer with an excellent reputation and nationwide service.

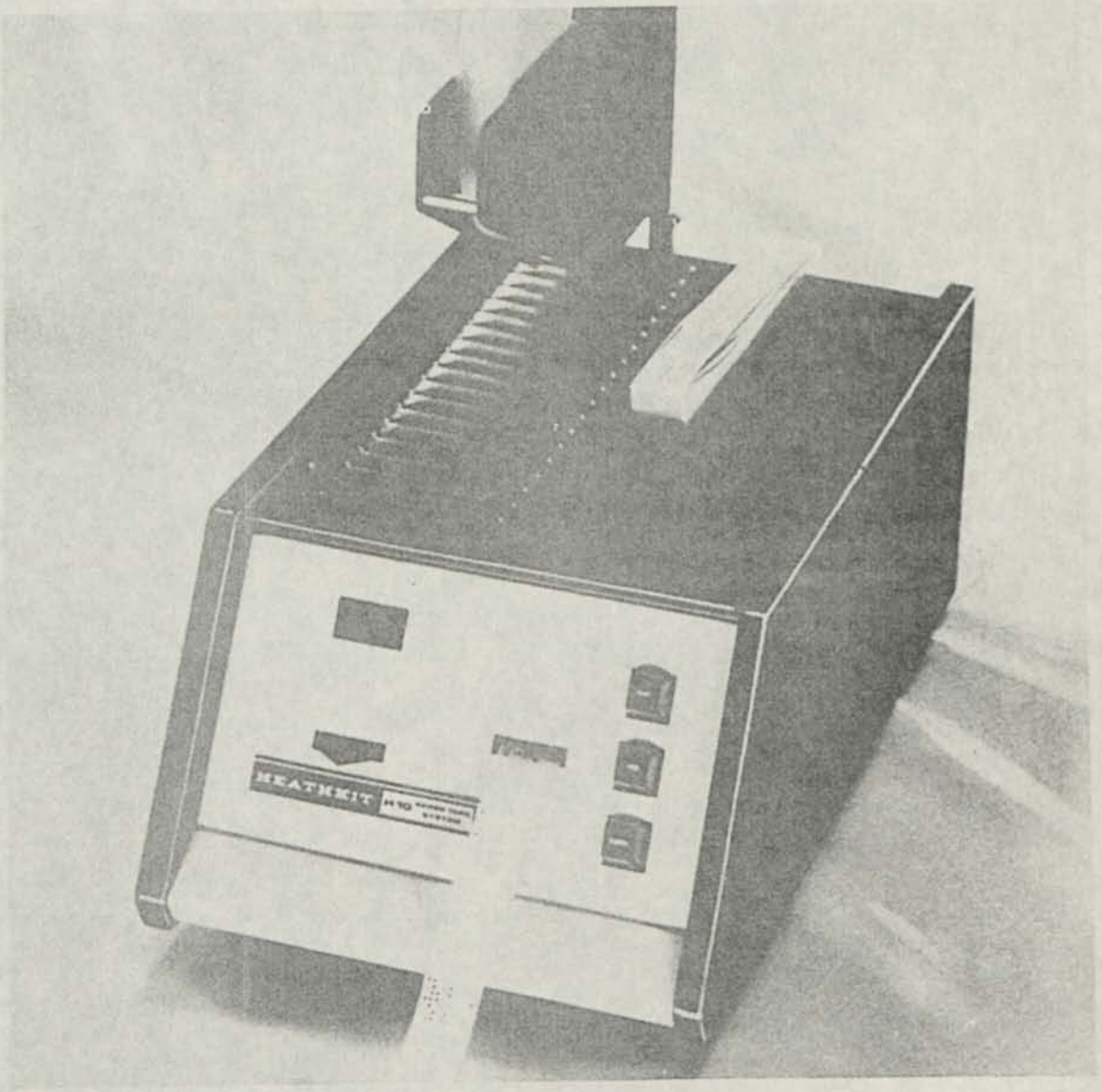
The Malibu 160 is a true line printer. It prints at 160 characters per second with 132 characters per line. The print mechanism is a bidirectional dot-matrix device. The Malibu printer offers many special features such as expandable character widths for emphasis, graphics capability, multi-part form capability, and modular electronics for easy servicing. In addition, the Malibu Design Group offers an S-100 interface

card for microcomputers such as the Altair 8800 and IMSAI 8080. The Malibu 160 costs approximately $2000.

The Futra Company offers the Model 10 desk-top line printer. It prints a minimum of 150 lines per minute with 80 characters per line at 10 characters per inch. It uses a 64 character printing belt. With the expanded set of 96 characters, the speed drops slightly to a range of 84 to 110 lines per minute. The Model 10 is available with either friction feed or tractor feed. It is priced at about $2600.

The peripherals presented in this chapter and the next were chosen to be representative of the many available on the market. The potential buyer should evaluate peripherals in terms of his intended application, cost, reliability, availability of service, and of course compatibility with his microcomputer system.

3



MASS DATA STORAGE PERIPHERALS

Many microcomputer applications require the capability to store and retrieve large quantities of data. It is impractical to store data in semiconductor RAM for long periods of time as the data is lost if the power is turned off or even temporarily interrupted. In addition, most microcomputers are at present limited to a maximum of 64K of semiconductor memory. This is insufficient for many applications.

The solution to the problem of storage of large amounts of data is the mass memory peripheral device. Such a device can store much more data than is practical with semiconductor random access memory, but data retrieval is slower. For example, a cassette tape can hold hundreds of thousands of bytes of data. A multiple-drive floppy disk system can store megabytes of data. For both of these data storage media the cost per byte of storage is considerably less than that for semiconductor RAM.

A mass memory device is often used to load a programming language such as BASIC or FORTRAN into a microcomputer. Data storage peripherals are also used to load commercially available applications software and to save user-written programs. Mass memory devices are required for business applications that require storage of large files of accounts or other financial information.

In this chapter we will look at three of the most commonly used methods for mass data storage. They are

punched tape, magnetic cassette tape, and the floppy disk. Each method is best in certain data storage applications.

PUNCHED TAPE

Punched paper tape was the first medium used for mass data storage by microcomputer owners due to the availability of inexpensive used Teletypes equipped with a tape reader/punch. Punched tape is still used as a medium for exchange of data and programs, and much minicomputer software is available on punched tape. However, except under special circumstances, it is not a practical means of data storage. In particular, it is unsuitable for most business applications.

Physically, punched paper tape is a ribbon of paper about an inch wide with round holes punched in rows extending from one edge to the other (see Figure 3-1). Each row represents one character using the Teletype code. The small holes running the length of the tape are sprocket holes used by the drive mechanism to move the tape through the reader/punch. Sometimes Mylar plastic tape is used instead of paper tape because of its greater durability.

The chapter heading photograph shows the Heath H10 paper tape reader/punch, which is available fully assembled or in kit form. The H10 can be used with either the Heath H8 or H11 microcomputer as a mass data storage peripheral. It also enables owners of the Heath H11 microcomputer to exchange programs with other owners of a H11 or LSI-11 microcomputer.

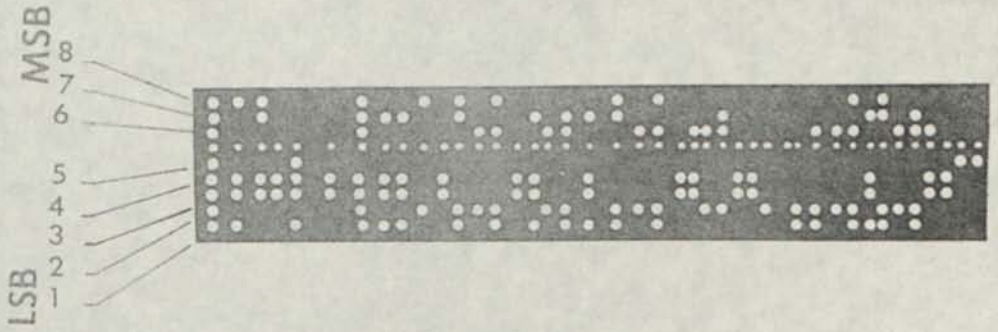


Figure 3-1. A length of punched paper tape with least significant bit (LSB) to most significant bit (MSB) labeled.

The Heath H10 reads tape at a maximum rate of 50 characters per second and punches tape at a maximum rate of 10 characters per second. Figure 3-2 shows the H10's punch mechanism, which is driven by a bank of solenoids. Figure 3-3 shows a close-up view of the phototransistor tape read head, which is located below a lamp. As the paper tape moves between the read head and the lamp, light from the lamp passes through the holes in the tape to the elements of the read head. In this way the data recorded on the paper tape as a pattern of holes is converted into electrical impulses.

One limitation of punched tape is that is not reusable. Once data is punched into the tape, it is there permanently. Sometimes this is an advantage since it is not subject to accidental erasure and loss of data. A more serious limitation is that data transfer from punched tape is much too slow for most applications. For instance, it may take 20 minutes to load 12K

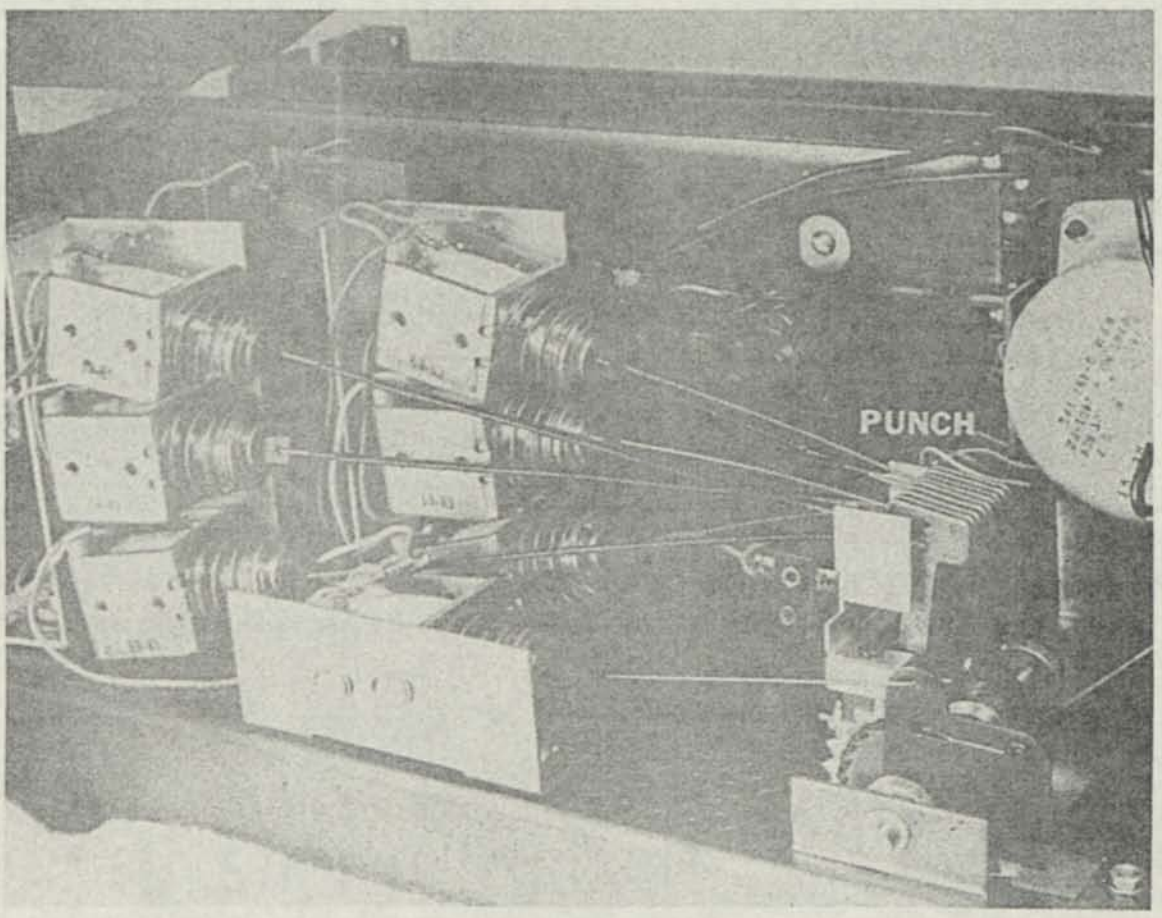


Figure 3-2. Heath H10 paper tape punch mechanism. Solenoid bank is visible at left.

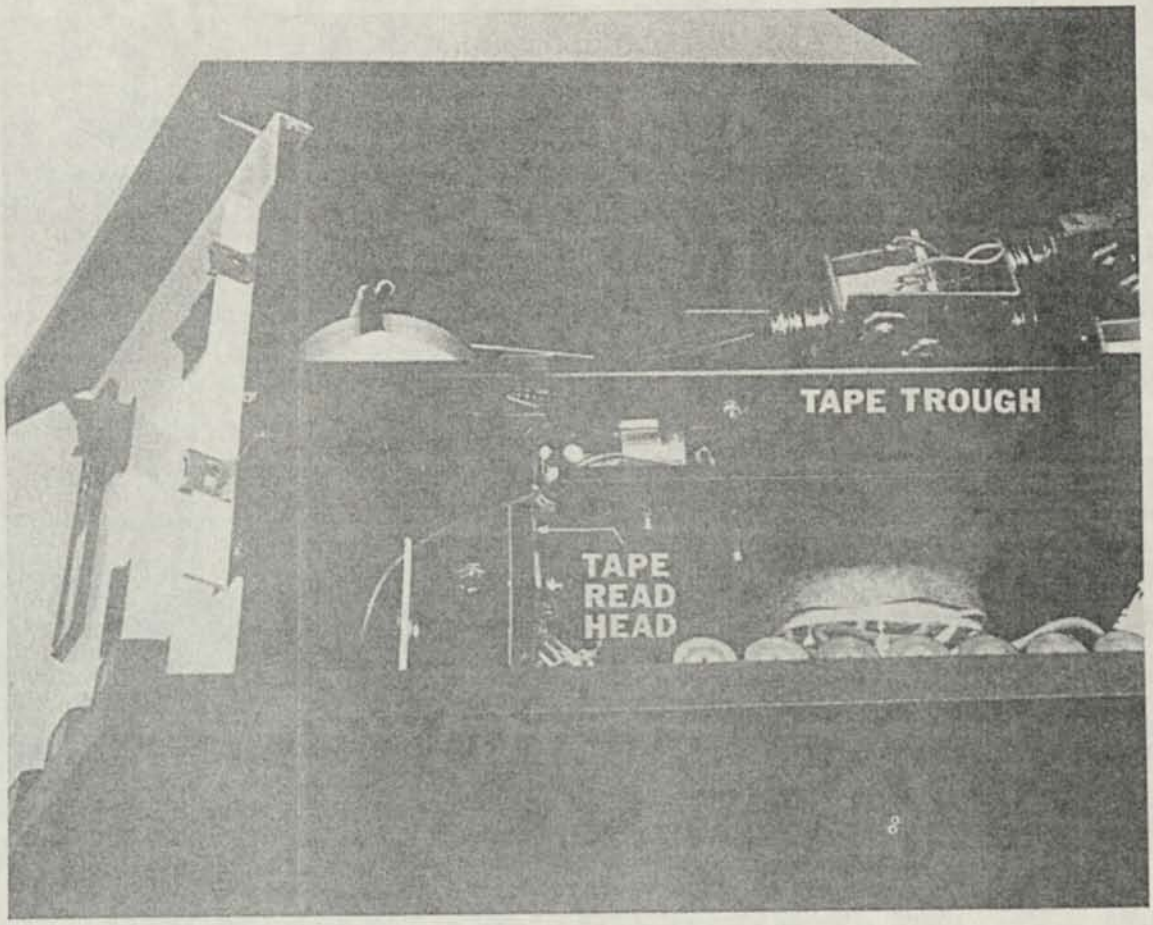


Figure 3-3. The Heath H10 tape read mechanism. Optical detector and excitation lamp are visible in the tape read head.

extended BASIC into some microcomputers. Even though faster readers are available, punched tape is not a practical mass data storage medium for most microcomputer users.

CASSETTE TAPE

At present the most economical mass data storage medium for the hobbyist is cassette tape. Cassette tapes are easy to handle and store, and cassette tape drives are relatively inexpensive. A cassette tape interface is required to load data from tape into a microcomputer, but the interface is not very complex and data transfer rates are adequate for most hobby applications. A wide variety of software is available on prerecorded cassette tapes for microcomputers such as the TRS-80, the Apple-II, and others. A representative selection of tape cassettes is shown in Figure 3-4.

Figure 3-4. Typical audio tape cassettes used with microcomputers.

There are two types of cassette tapes and drives commonly used with microcomputers. The most popular and inexpensive is the audio cassette. The second type is the digital cassette. Although a digital cassette system offers greater storage capacity per tape, it is much more expensive than an audio cassette system, and so it is not widely used at present.

Most microcomputer systems that can use cassette tapes (such as the TRS-80 and the Apple-II) use commonly available audio tape cassettes and tape cassette recorders. The Commodore PET also uses ordinary audio cassettes, but it features a built-in cassette drive.

A cassette tape device offers a data transfer rate that is significantly greater than that for punched tape but less than that for a floppy disk. While a punched tape device operating at 10 characters per second would require at least 20 minutes to load extended BASIC into a microcomputer, the audio tape cassette version would load in a few minutes and the floppy disk version would load in seconds.

CASSETTE TAPE INTERFACES

Microcomputer data is stored on magnetic tape in much the same way that audio signals are stored on tape. As the magnetic tape moves past the tape head, a varying magnetic field

generated by the head alters the magnetic properties of the tape. The process of data recording and playback is handled by special circuitry in the microcomputer, known as the tape interface, which is controlled by software. Let's examine some of the commonly used types of tape interfaces.

The Kansas City Standard is a popular interface technique that represents data as short bursts of audio frequency tones. A binary one is coded as a 2400 Hertz tone burst, while a zero is coded as a 1200 Hertz tone burst. On playback the microcomputer interface recognizes the high and low tones and assigns to them either a value of one or zero. The Kansas City Standard is relatively slow, offering a data transmission rate of only 300 baud.

The Apple-II tape interface features a fast data transfer rate of 1500 bits per second. It permits quick and reliable program loading. There are many prerecorded tapes available for the Apple-II microcomputer including such programs as Star Wars, Apple Talker (which allows the Apple to speak through its built-in loudspeaker), Chess, Bridge, Electronic Filecards, Mailing Lists, and others.

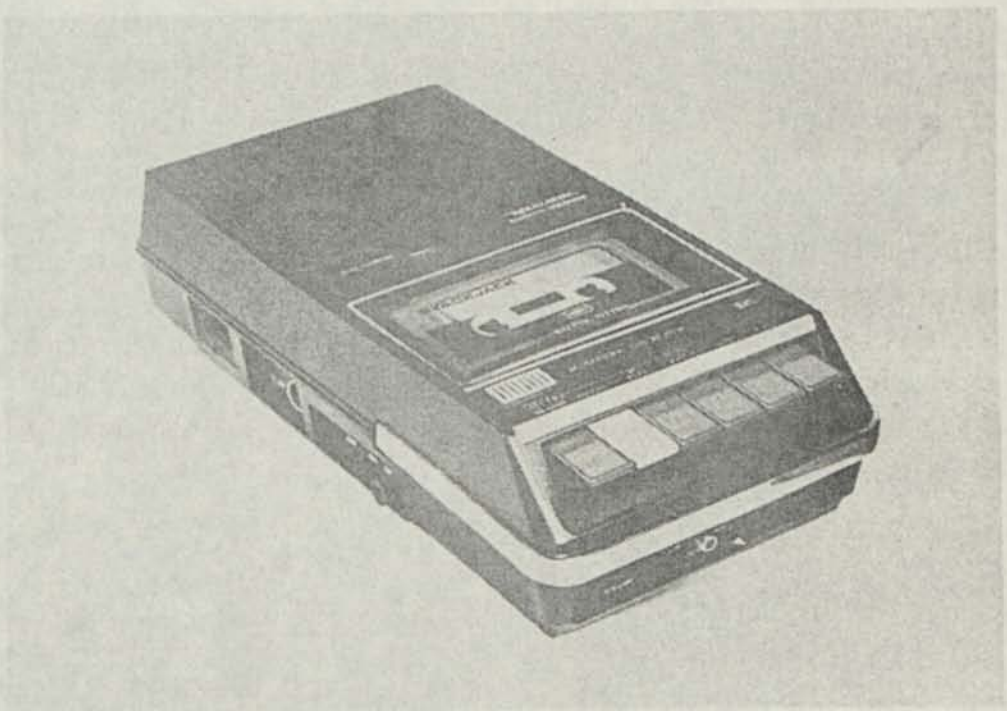


Figure 3-5. The CTR-41 Realistic Data Cassette Recorder for microcomputer mass data storage.

The TRS-80 Level-I machine has a tape cassette data transfer rate of 250 baud, while the rate for the Level-II version is twice as fast. Level-I tapes are not directly compatible with Level-II machines, but can be converted into Level-II tapes with reformatting programs furnished by Radio Shack. A wide variety of programs are available on tape cassette. These include chess, Star Trek, bowling league statistics, inventory control, Battleship, business applications such as a journal/ledger program, and more. The TRS-80 uses the Radio Shack CTR-41 cassette recorder, shown in Figure 3-5.

The Tarbell Interface Board is offered for S-100 microcomputers. It uses a phase-encoding technique with ordinary audio tape, and it achieves a data transfer rate of approximately 1500 bits per second. The Tarbell board is available either assembled or as a kit. It comes with complete 8080 software for program loading and dumping to tape. It is an extremely reliable unit that works well with an inexpensive tape recorder such as the J.C. Penney unit recommended by Tarbell.

SOME TAPE HANDLING TIPS

Although an ordinary audio tape cassette is used for magnetic tape data storage, the tape cassette should be handled with more care than is ordinarily given to cassettes used to record music or speech. This is because the techniques used to record microcomputer data on tape cassette are more sensitive to flaws in the magnetic tape than the technique used to record music or speech. For instance, loss of data can be caused by dust, dirt, cigarette smoke particles or ash, or pencil erasings contaminating the surface of the tape. So, tape cassettes should be kept in a clean environment. They should always be stored in a closed container such as a plastic cassette holder.

Do not rewind magnetic tape prior to storage. The fast motion will create stresses in the tape that may in time cause it to stretch. Instead, rewind the tape only before use. Also magnetic tape should be kept away from magnetic fields such as those generated by speakers, transformers, and radios or by magnetized objects such as screwdrivers. A magnetic field can create a small erasure on the tape that would ruin a data tape

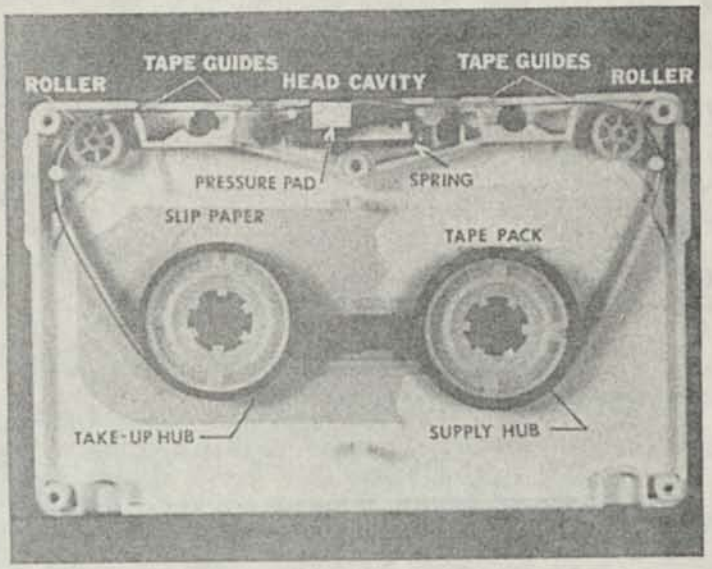


Figure 3-6. Inside the audio tape cassette.

although the same erasure would hardly affect a tape with music recorded on it.

Always use the type of tape cassette recommended by the microcomputer interface manufacturer; or if none is recommended, use a medium to high quality tape cassette. Better cassettes have smoother tape surfaces and therefore fewer drop-outs, which are losses of the recorded signal caused by tape imperfections. Sometimes it is necessary to experiment with different brands to find the one most reliable.

As a guide to the selection and use of tape cassettes, let's look at what's inside a typical tape cassette (see Figure 3-6). Here are descriptions of some of the parts labeled in the photograph:

ROLLER	A circular tape guide that rotates with the movement of the tape. It is designed to prevent skewing of the tape and to keep it in alignment with the recording and playback heads.
SHELL	The molded plastic casing of the cassette. It must be rigid to protect the tape and to prevent skewing. The shell must be molded to ANSI standards for use with most tape cassette machines.

SHELL CLOSURE SCREWS	Removable screws that permit the shells to be assembled as a rigid package and yet be opened for inspection or repair of the damaged tape.
SLIP PAPER	A low-friction cassette liner used for reduction of tape abrasion. By reducing friction it minimizes static electricity that may cause tape demagnetization or may generate noise on the tape.
SUPPLY HUB	The hub from which the tape unwinds to record or playback as it moves through the recorder/player.
TAKE-UP HUB	The driven hub takes up the magnetic tape after it has moved through the head cavity.
TAPE GUIDES	Precision molded partitions on both shells that control the path of the magnetic tape as it moves from the supply hub to the take-up hub. Tape guides minimize skew and maintain tape alignment with the recording/playback head.
RECORD ENABLE TAB	The cassette shells contain two cavities on the rear side that have removable plastic tabs. These tabs must be in place in order to record onto the magnetic tape. Once recorded, removal of the record enable tabs prevents accidental recording over data intended to be retained. Once the tabs are removed, gummed tape can be placed over the cavities to once more record on the magnetic tape.
PRESSURE PAD	The pressure pad located behind the magnetic tape in the head cavity assures a uniform pressure of the tape against the record or playback head.

When selecting cassettes, choose units with screws joining the cassette half-shells together. Then the tape can be easily repaired or spliced if it is damaged. Some inexpensive cassette tapes drag or hang-up. This changes tape speed and causes distortion of data. Quality cassettes contain slip-paper on both inner shells to prevent the tape from dragging against the plastic shells. The slip-papers also prevent the build-up of static electricity, which can interfere with data recording and playback.

CASSETTE RECORDERS

For a better understanding of the functions of a cassette recorder, a typical cassette recorder drive mechanism is shown in Figure 3-7. The tape take-up hub drive spindle and the rewind hub drive spindle are visible at the top. The capstan, which is visible at the right, passes through the capstan hole in the tape

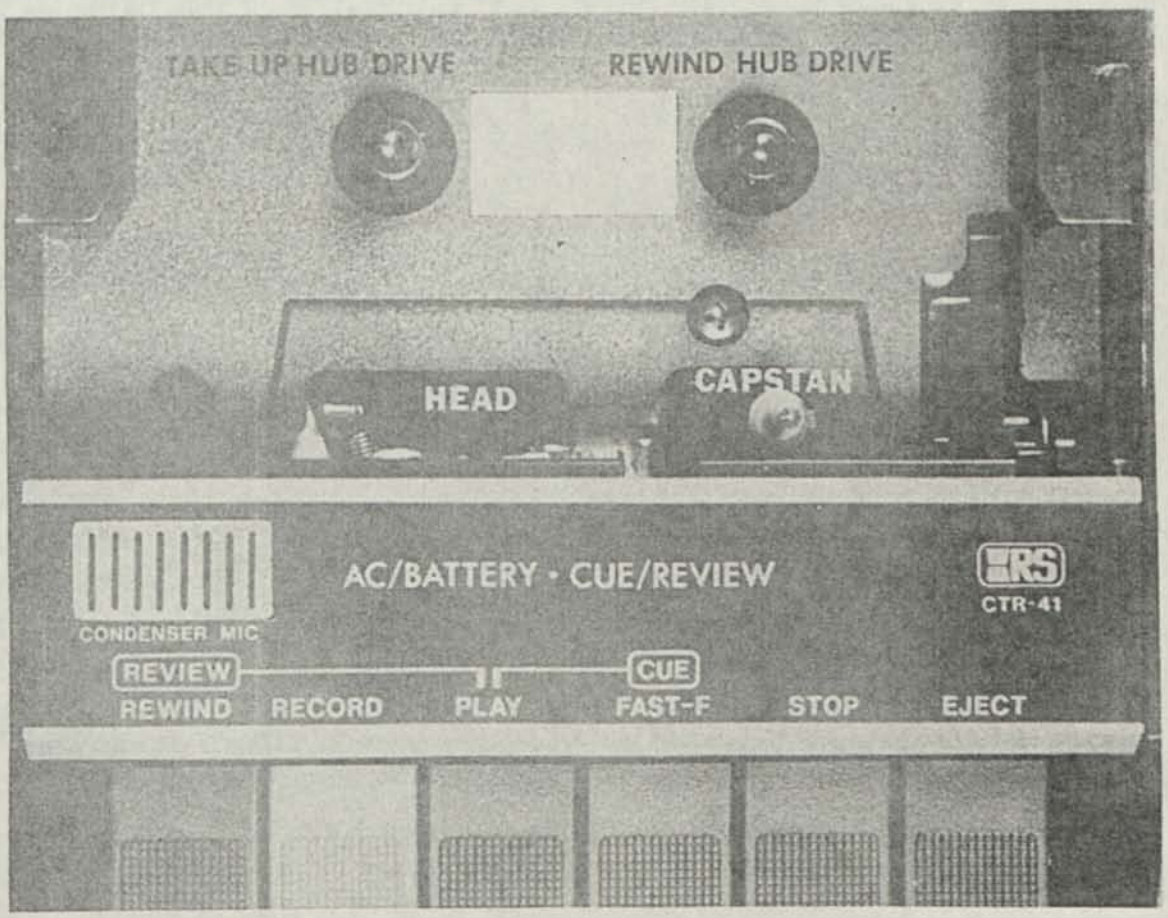


Figure 3-7. Drive features of a typical audio cassette recorder/player.

cassette to drive the tape at a constant speed. In the record or playback mode the capstan follower wheel, which is not visible in Figure 3-7, extends out and pinches the recording tape between itself and the capstan. To ensure the precise alignment of the cassette with the capstan and the tape heads, a pilot spindle extends through another hole in the tape cassette. Unless the play or record key is pressed, the heads, capstan follower wheel, and a mechanical end-of-tape sensor retract under the nameplate in order to permit unobstructed loading and unloading of the cassette and to prevent damage to the heads.

Usually a microcomputer manufacturer will supply or recommend a brand of recorder suitable for use with his microcomputer systems. However, if you choose one separately, you should be sure that the cassette recorder/player under consideration will work with your microcomputer before buying it. From the many different cassette data rates required by different microcomputers, you should be able to see the complete lack of industry standardization in this field. This situation should emphasize the need for you to fully understand your microcomputer, its mass data storage peripherals, and your overall software requirements in order to be completely sure of full compatibility.

On the side or front of your tape cassette recorder is a row of jacks. Be sure to choose one with an auxiliary input. Not all cassette recorders have an auxiliary input, and an attempt to enter data from your microcomputer through the microphone input may produce severe distortion by overmodulating the recording amplifiers. When connecting your microcomputer to your cassette recorder, care must be exercised to be sure that the microcomputer's INPUT connection is inserted in the cassette unit's EARPLUG connection and that the microcomputer's OUTPUT connection is inserted into the recorder's AUXILIARY connection. These two miniature plugs are the same size and can be incorrectly inserted in reverse order. The remote control plug is a special subminiature plug and cannot be interchanged.

For maximum reliability of your cassette recorder, you should take certain precautions. The recorder must be kept free of both ordinary dust and dirt and free of the magnetic oxide dust from the magnetic tape. Follow the manufacturer's

instructions on periodic maintenance. Also, the tape heads should be occasionally cleaned and demagnetized with a standard audio tape head demagnetizer. Care should be taken not to damage nearby tapes with the demagnetizer.

In general, cassette tape is the optimum low-cost mass memory medium for the hobbyist and the small system user. However, if faster access time, more powerful system software, or greater data storage capacity is required, a floppy disk system must be used.

MAGNETIC DISKS

Both paper tape and cassette tape the same limitation: they are sequential storage media. They store data serially, and to reach desired data, one may have to move past much data to reach the required data. This is a slow process. Is it possible to jump over the intervening data to reach the desired data? The answer is yes, and the medium used is a floppy disk.

Floppy disks are sometimes called diskettes to distinguish them from the multimegabyte fixed hard disks used with large computer systems. We will use the terms "floppy" and "diskette" interchangeably.

A floppy disk is a flexible plastic disk coated with magnetic oxide, sealed within a square envelope. It is like a magnetic tape, but the shape is different. The floppy disk drive clamps onto the diskette through a hole in the envelope and spins it within the envelope. The drive employs a magnetic head that can be positioned along a radius of the diskette (see Figure 3-8). Each position of the head along the radius is called a track. As the diskette spins, different sectors of the track pass beneath the head. In this way data stored on the magnetic surface of the disk is read (see Figure 3-9). The floppy disk drive can access data anywhere on the diskette usually within a fraction of a second. Even the smallest floppy disk can store 90 kilobytes of data. The larger ones using advanced recording techniques can store one megabyte of data or more. Because of their superior performance, floppy disk drives are included in many business and professional microcomputer systems.

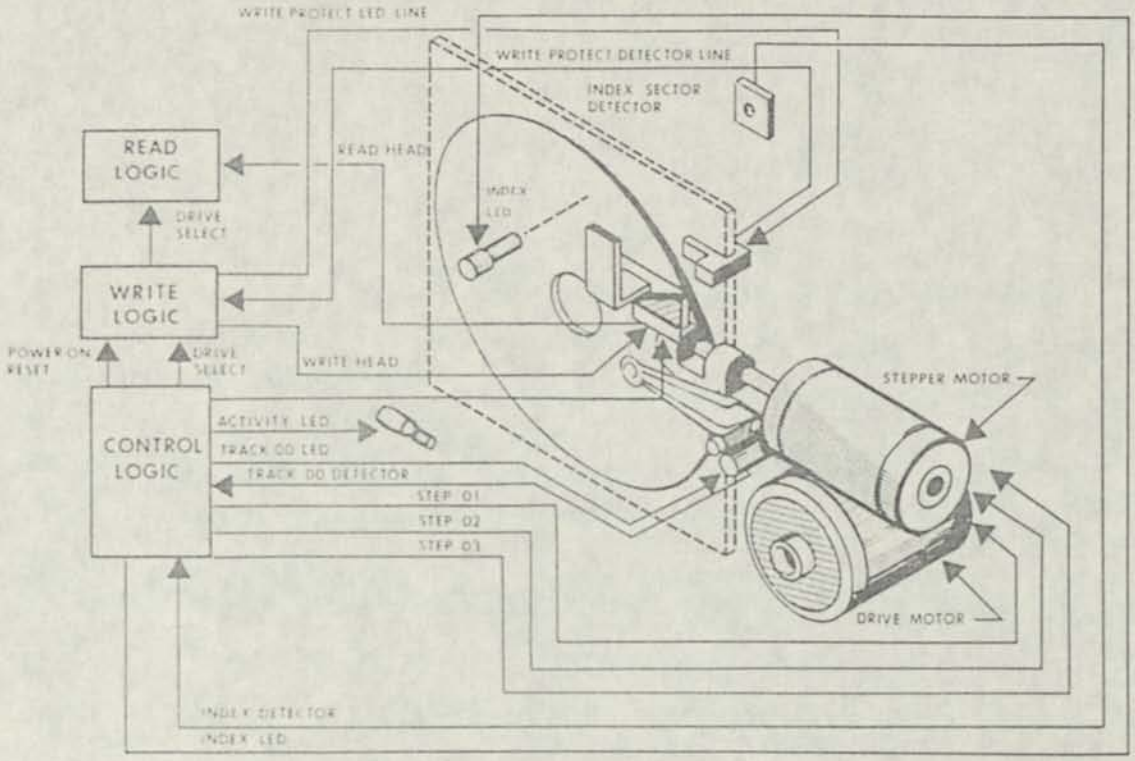


Figure 3-8. Functional diagram of a floppy disk drive unit.

THE FLOPPY JUNGLE

There are many different types of floppy disks, drives, and controller/interfaces presently on the market, and more are released every month. Approximately 32 different kinds of disks are available commercially. With the many possibilities available, choice of the right one may be difficult. To guide the reader in understanding the options open to him, we will outline the floppy disk field.

Owners of some microcomputers can only use the floppy disk systems sold by the manufacturers of their microcomputers. Others, such as owners of microcomputers using the S-100 standard, have a wide variety of choices. At the present time a microcomputer owner has the choice between two principal types of floppy disks and accompanying drives. The first type is commonly called a minifloppy disk drive, and it uses disks that are 5-1/4 inches in diameter. These are referred to as 5-inch disks. A soft-sectored single-density minifloppy disk typically

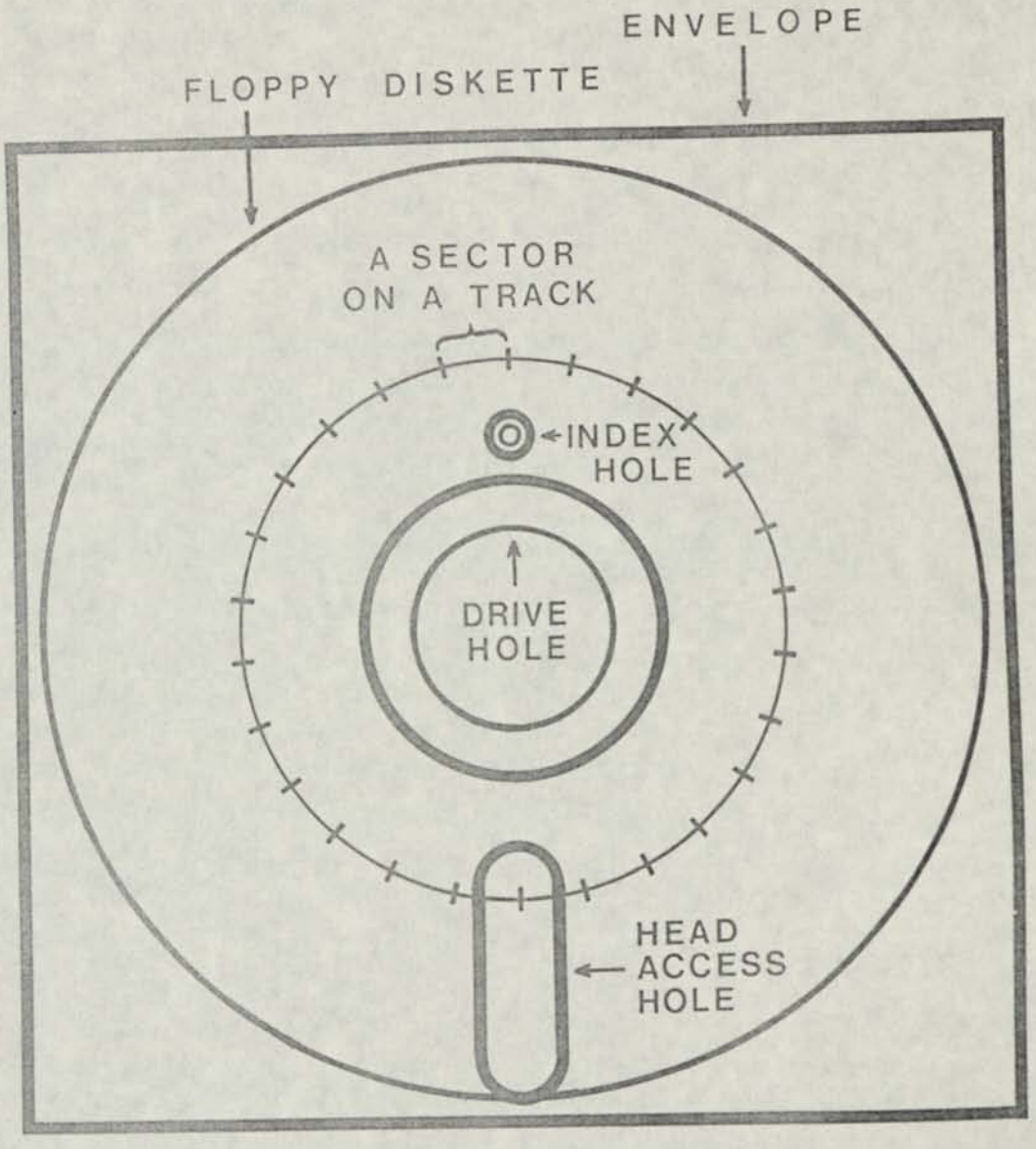


Figure 3-9. A floppy diskette in its protective envelope. The diskette is drawn with light lines. Its protective envelope is drawn with heavy lines. One track is shown divided into sectors. The innermost track is designated Track 77 and the outermost track is designated Track 0.

holds a maximum of 90 kilobytes of data. The second type is simply called a floppy disk drive, and it uses disks that are 7-7/8 inches in diameter. These are referred to as 8-inch disks. A soft-sectored single-density single-sided floppy disk typically holds a maximum of 240K of data. (The terminology connected with disks is explained in more detail below.) Unfortunately, each type of disk is physically incompatible with the other type, and each requires its own drive. Typical minifloppy disk drives are in

the price range of $400 to $600; drives for floppy disks are $700 to $1000. For business applications two disk drives are necessary for reasons that will be discussed later. All in all, a complete floppy disk system represents a substantial investment costing from $1000 to $3500.

In addition to a disk drive, the user must have a drive controller/interface, a power supply, and disk-oriented system software. The controller translates requests for data from the microcomputer into commands to the disk drive to move the head to perform read or write operations. The controller acts as an interface that performs tasks that are either too fast for the microcomputer itself to perform or too slow and nonproductive. For example, a seek track command may take 30 milliseconds or more. This is a long time to tie up a microcomputer, and so the controller handles this operation instead. We will discuss some popular controllers later.

A disk operating system (DOS) is a sophisticated piece of software that allows the user to store and reload data and programs (called files on a disk system) without consciously having to keep track of their actual location on the disk. In addition a good DOS offers many utility programs that make the job of writing programs or handling data much easier.

Now we can discuss some of the different types of floppy disk drives and disks. The SOFT-SECTORED diskette is the standard for interchange of programs. It contains one index hole, which is a small hole used to sense the start of each revolution of the disk. The HARD-SECTORED diskette is not compatible with the other type. It contains multiple holes used to identify the location of each sector of data. Drives for the two types are not compatible.

There are SINGLE-SIDED diskettes (floppies) and diskettes with magnetic oxide on both sides (Flippies or DUAL-SIDED diskettes). The dual-sided floppy, when used in a dual head drive, can store information on both sides, rather than the single side the standard floppy is limited to.

Finally, there are SINGLE-DENSITY drives and diskettes, and DOUBLE-DENSITY (also known as DUAL-DENSITY) diskettes that store twice as much information but require their own special drive and controller.

In addition, there are some variants even with these categories. For example, there are hard-sectored minifloppies with 35 tracks and some with 40 tracks, and there are some with 10 sectors, 16 sectors, or 18 sectors of data per track.

Choosing between all these different formats is difficult. One must weigh off data packing density versus program interchangeability. For instance, although a hard-sectored dual-density diskette may store a lot of data (420K bytes), the user may not be able to exchange software with owners of soft-sectored single-density machines. The popular choices are the 5-inch diskette (used by Radio Shack, Apple, North Star, Micropolis, and others) and the 8-inch diskette (used by owners of many business systems and users of the popular CP/M disk operating system). The 5-inch diskettes are not readily interchangeable between the different types of disk drives, whereas the 8-inch CP/M diskettes are often interchangeable.

DATA RELIABILITY

When using a floppy disk drive in a business application, reliability and integrity of the data are essential. Although a floppy disk is designed for long life, after a time stray dust may adhere to the surface of the disk, or wear caused by the rotation of the disk within its envelope may damage the oxide coating. When these things happen, data may be lost. For this reason, in applications where absolute data integrity is essential, two disk drives are needed. Then, the diskette in use is periodically copied to one or more backup diskettes that are preserved in safe places.

Double-density and double-sided diskettes use technologies that are relatively new. The double-density diskette packs data onto its surface using a different coding scheme than the single-density diskette. At present different manufacturers use different coding schemes, and it remains to be seen which one will offer the greatest reliability in the small computer market. Also, the double-sided diskette used in a two-headed disk drive is an emerging but not yet thoroughly tested concept. Only time will show which manufacturers can succeed in making completely reliable units.

SOME REPRESENTATIVE DISK SYSTEMS

Here are some of the commonly used minifloppy and full-sized floppy disk systems. Figure 3-10 shows the Southwest Technical Products Corporation MF-68 dual minifloppy disk system for their Motorola 6800-based microcomputer. This system includes a controller, a disk operating system, and disk BASIC. The system can be expanded with the SWTPC MF-6F expansion kit to increase the number of disk drives to four. The MF-68 is available factory assembled or in kit form. The price is in the vicinity of $1000.

Figure 3-11 shows the Altair Minidisk unit for their Altair 8800b or the Altair 680b. The Altair Minidisk offers 71,680 bytes of memory per disk and a data transfer rate of 125 kilobits per second. It includes a controller and interconnecting cable. Software support is good.

The Altair Model 88-DCDD hard-sectored floppy disk unit is shown in Figure 3-12. It offers 300K bytes per disk and the standard data transfer rate of 250K bits per second. Like other modern disk drives, it is very reliable, featuring error rates of only one soft error (recoverable data) per billion bits and only

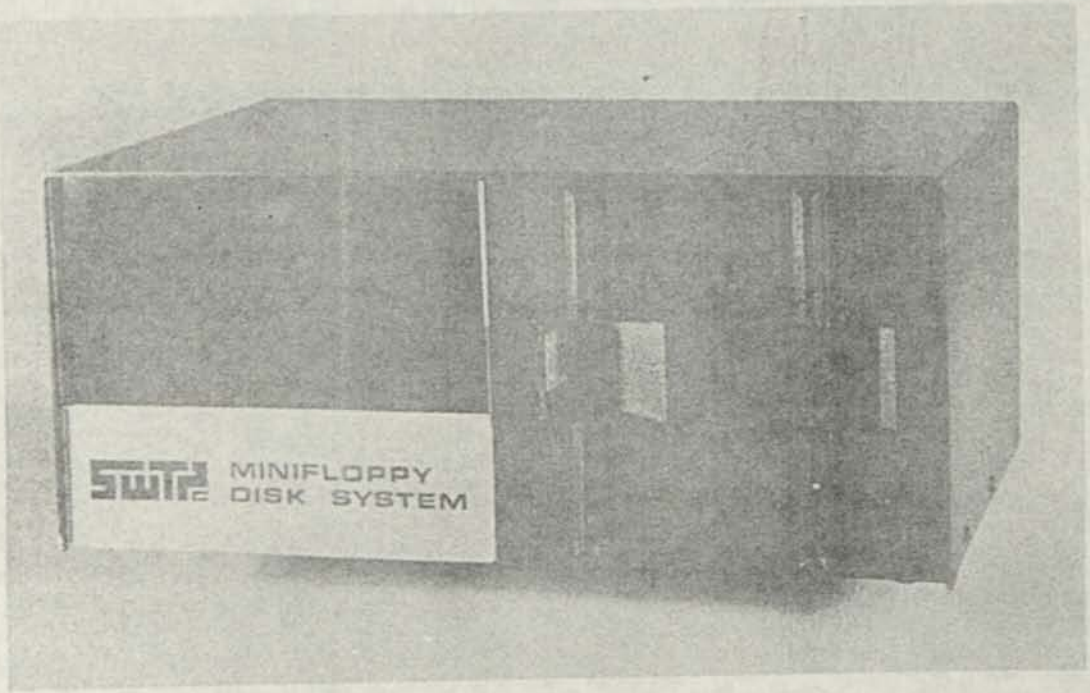


Figure 3-10. The SWTPC MF-68 minifloppy disk system.

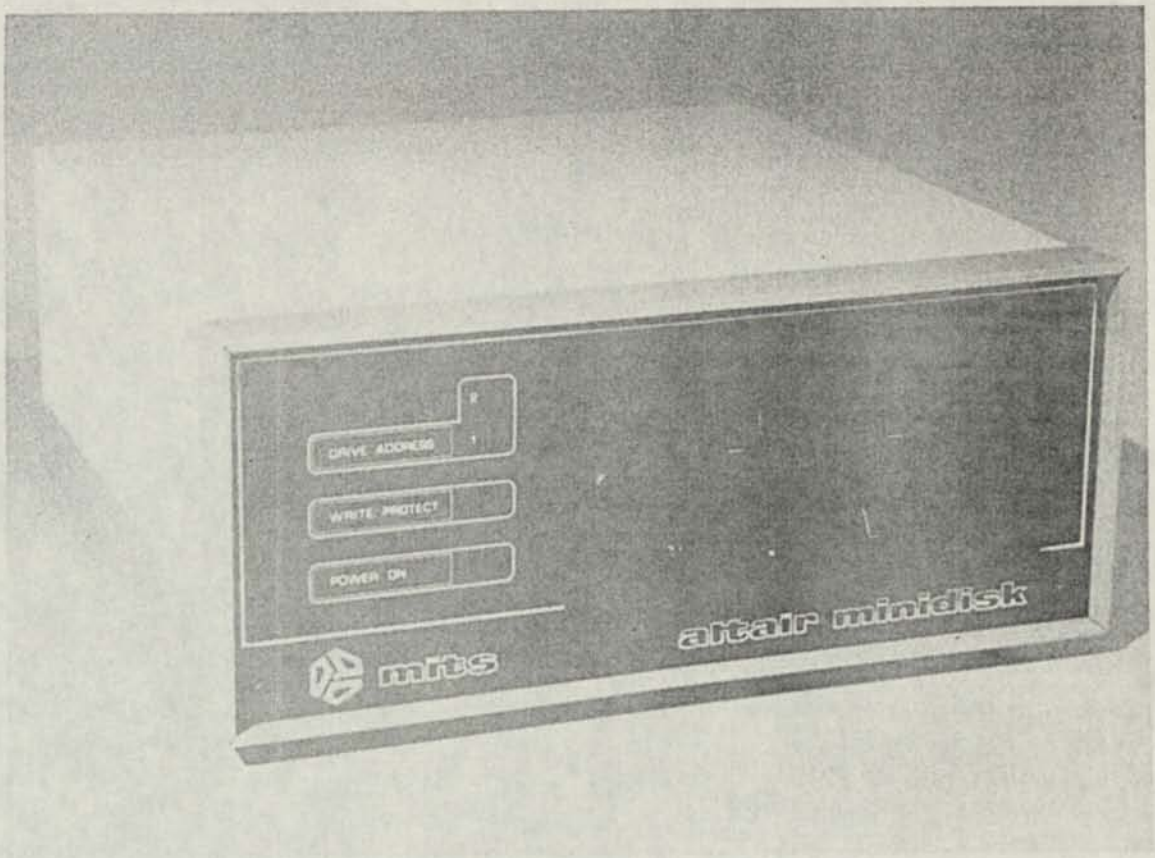


Figure 3-11. The Altair minifloppy disk unit.

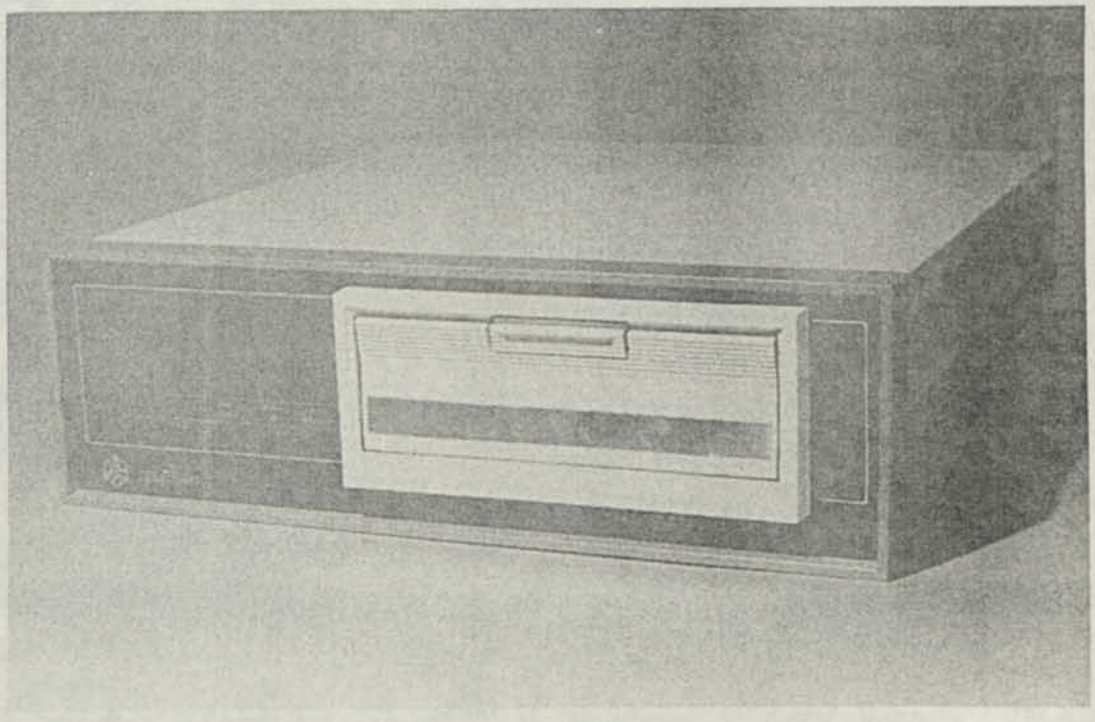


Figure 3-12. The Altair Model 88-DCDD floppy disk system.

one hard error (non-recoverable data) per trillion (10^{12}) bits. The hard-sectored ferric oxide coated disk used in this system is shown in Figure 3-13. The multiple holes near the center of the disk are the sector identification holes.

The Radio Shack TRS-80 Mini-Disk System is shown in Figure 3-14. It uses the very reliable industry standard Shugart SA-400 minifloppy 5-inch drive. It can hold 89K bytes of data. Like other minifloppy disk drives, average access time for data is

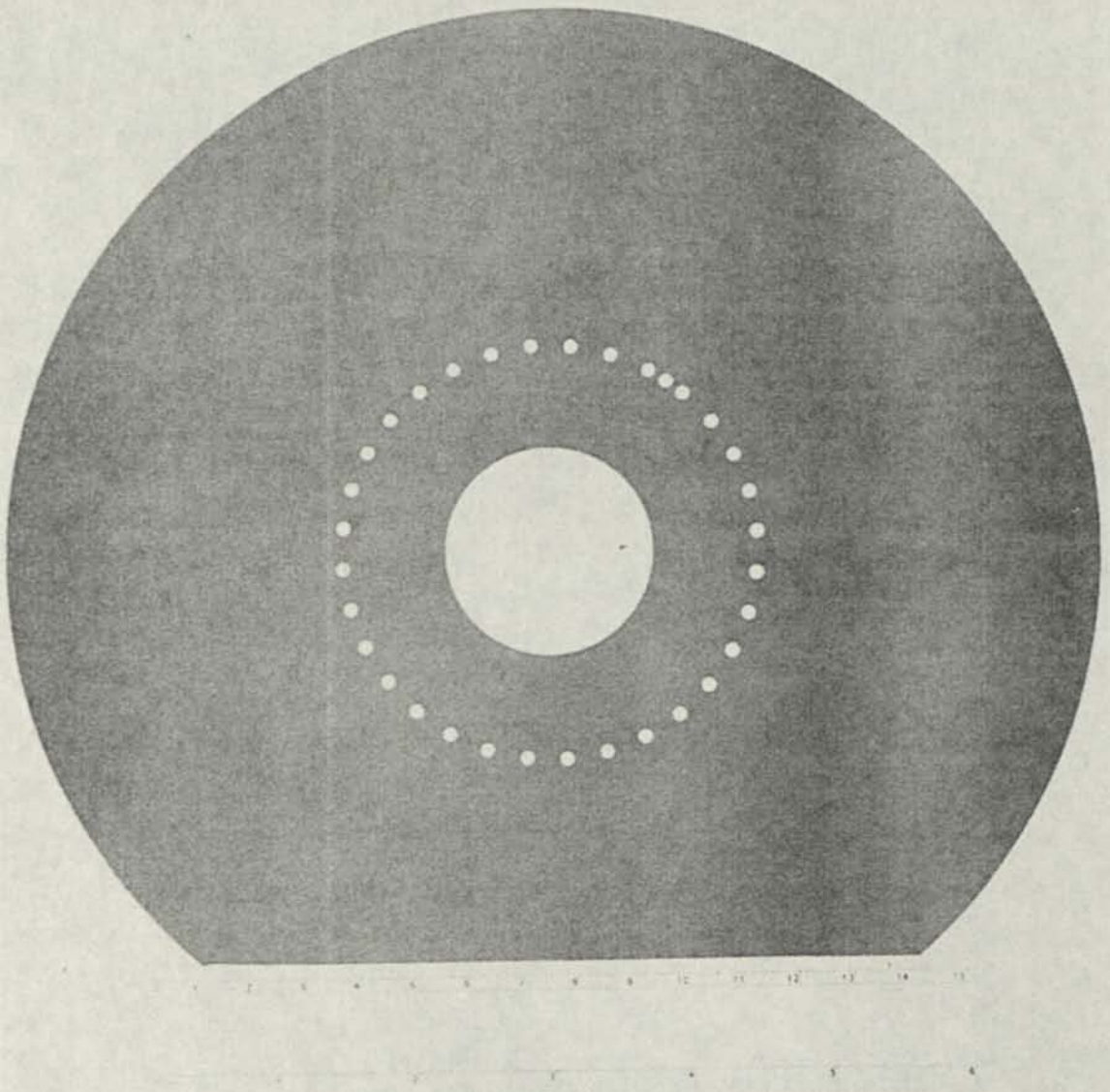


Figure 3-13. The ferric oxide coated disk used with the Altair floppy disk unit.

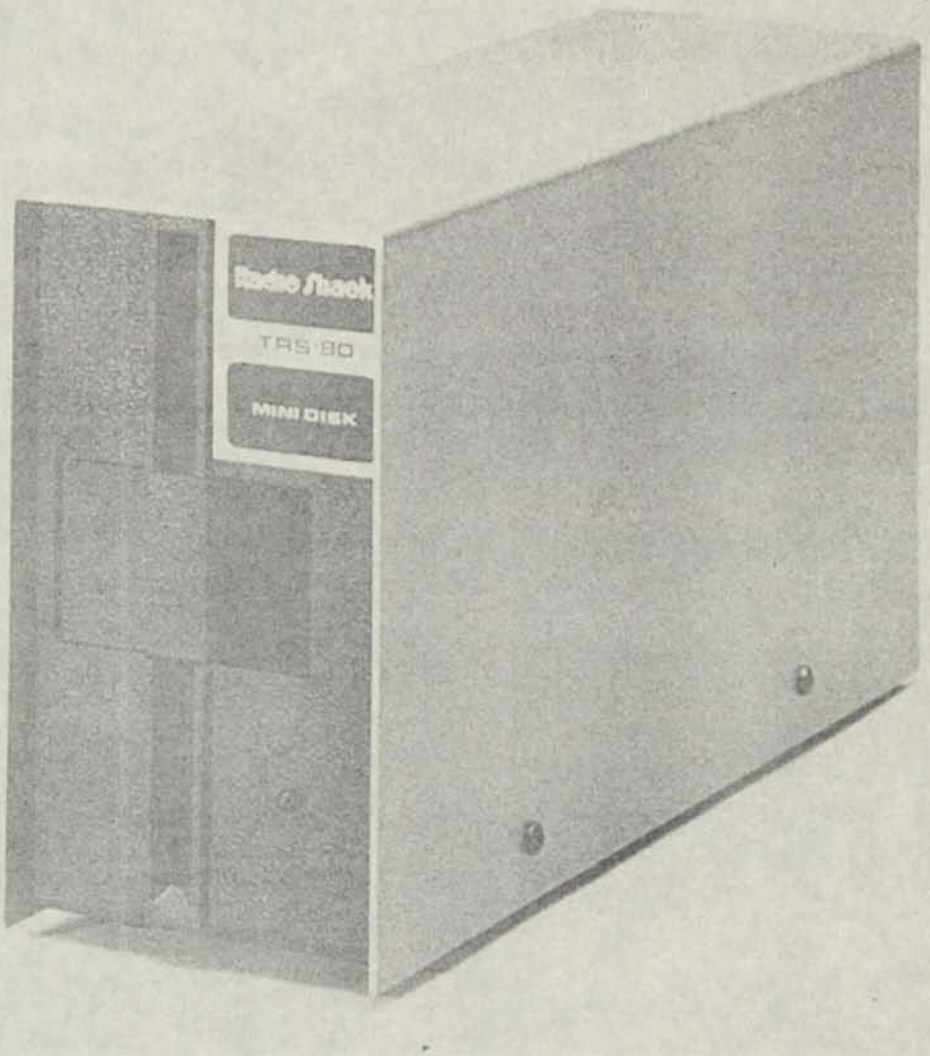


Figure 3-14. The Radio Shack TRS-80 Mini-Disk System.

about 500 milliseconds, which is much slower than the average 83 milliseconds access time on 8-inch diskettes. For a complete disk system, 16K RAM, Level-II BASIC, and the Radio Shack Expansion Interface are required. The Expansion Interface is shown in Figure 3-15.

The Heath Company offers a fully assembled WH-17 floppy disk system for use with its H8 microcomputer. This unit employs the Wangco Model 82 disk drive. The controller/interface and power supply are included. The system uses 5-inch hard-sectored diskettes with 40 tracks and ten sectors per track. Total storage capability is 102K bytes per diskette. Access time is typically 350 milliseconds or less. The Heath WH-17 is shown in Figure 3-16. It is available in single and dual-drive versions.

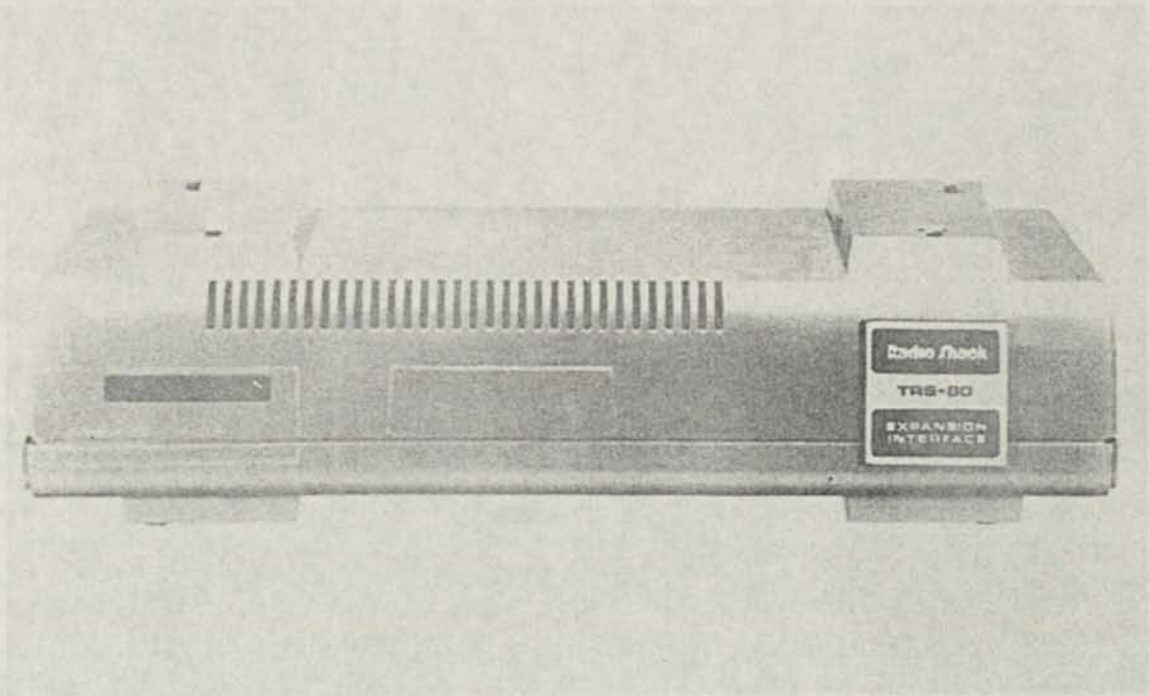


Figure 3-15. The Radio Shack TRS-80 expansion interface. Photo courtesy of Radio Shack International Headquarters.

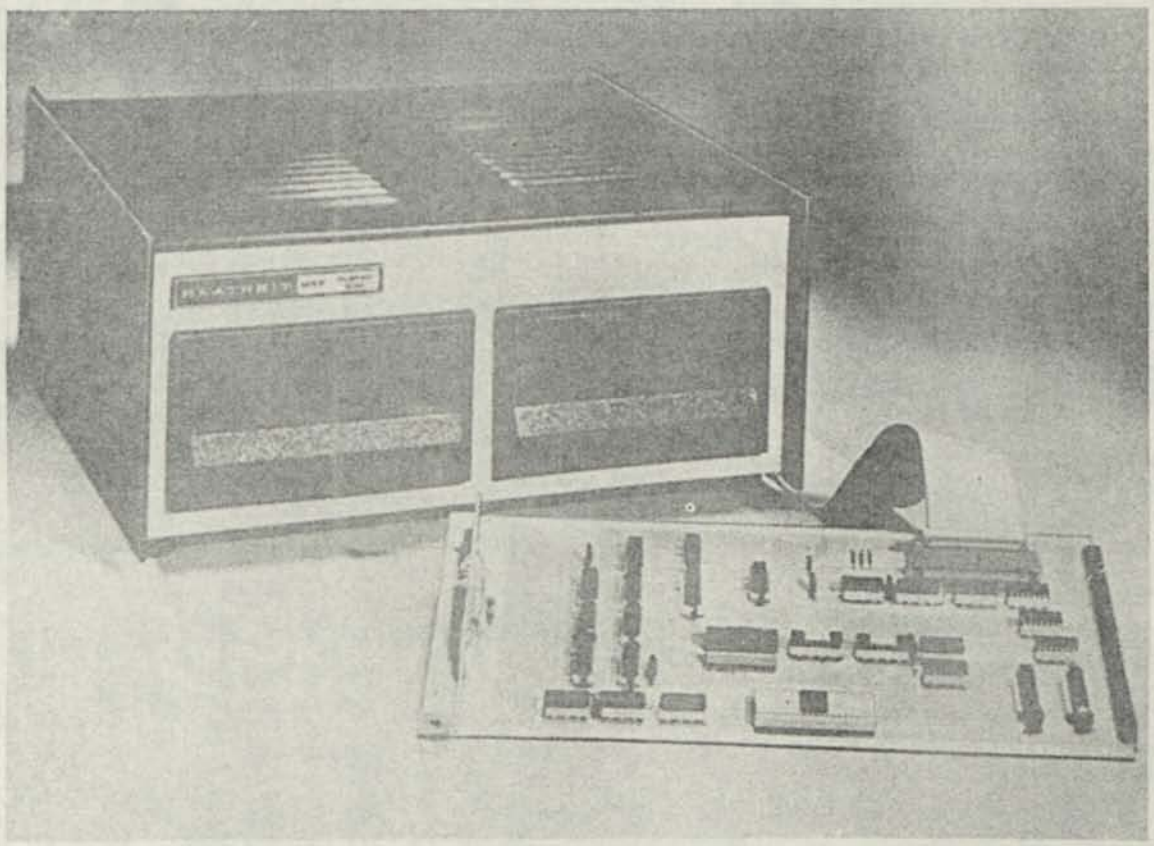


Figure 3-16. The Heath WH-17 dual floppy disk system and controller interface. Photo courtesy of the Heath Company.

CONTROLLERS

A controller is an interface between the microcomputer and the floppy disk drive. In all but S-100 machines, the owner of a microcomputer is almost always restricted to using the controller and drives offered by the manufacturer of his system. However, the owner of a S-100 system has the choice of buying from the vendor of his machine or buying separate drives, controller, power supply, and software. Two popular disk controllers are the Tarbell floppy disk interface and the SD Systems Versafloppy floppy disk controller. Both are available in kit form or assembled. The Tarbell interface is primarily intended for 8080-based machines and preferably those with static memory. It will control most of the popular 8-inch drives including the Shugart SA800/801, the Persci 270 and 70, the Calcomp 140, the Pertec 400, and others. The SD Systems Versafloppy will work with either the 8080 or Z80 microprocessor, and it will control minifloppy disk drives such as the 5-inch Shugart SA400 or any of the popular 8-inch drives. Both of these controllers use CP/M as the disk operating system software. CP/M is the industry standard DOS. Its user's group software library includes more than 24 diskettes containing a vast number of programs.

Although a microcomputer user can save large amounts of money by putting together his own floppy disk system, it is a task for the person experienced with digital electronics, and it is not a task to be undertaken lightly by a newcomer to the field.

SUMMARY

Of the three main types of mass memory devices, paper tape is the slowest and floppy disks the fastest. Unfortunately, price is directly proportional to speed. Perhaps the best overall memory medium for the hobbyist is cassette tape, while floppy disks are better for the businessman. However, any type of mass memory is much better than none at all.

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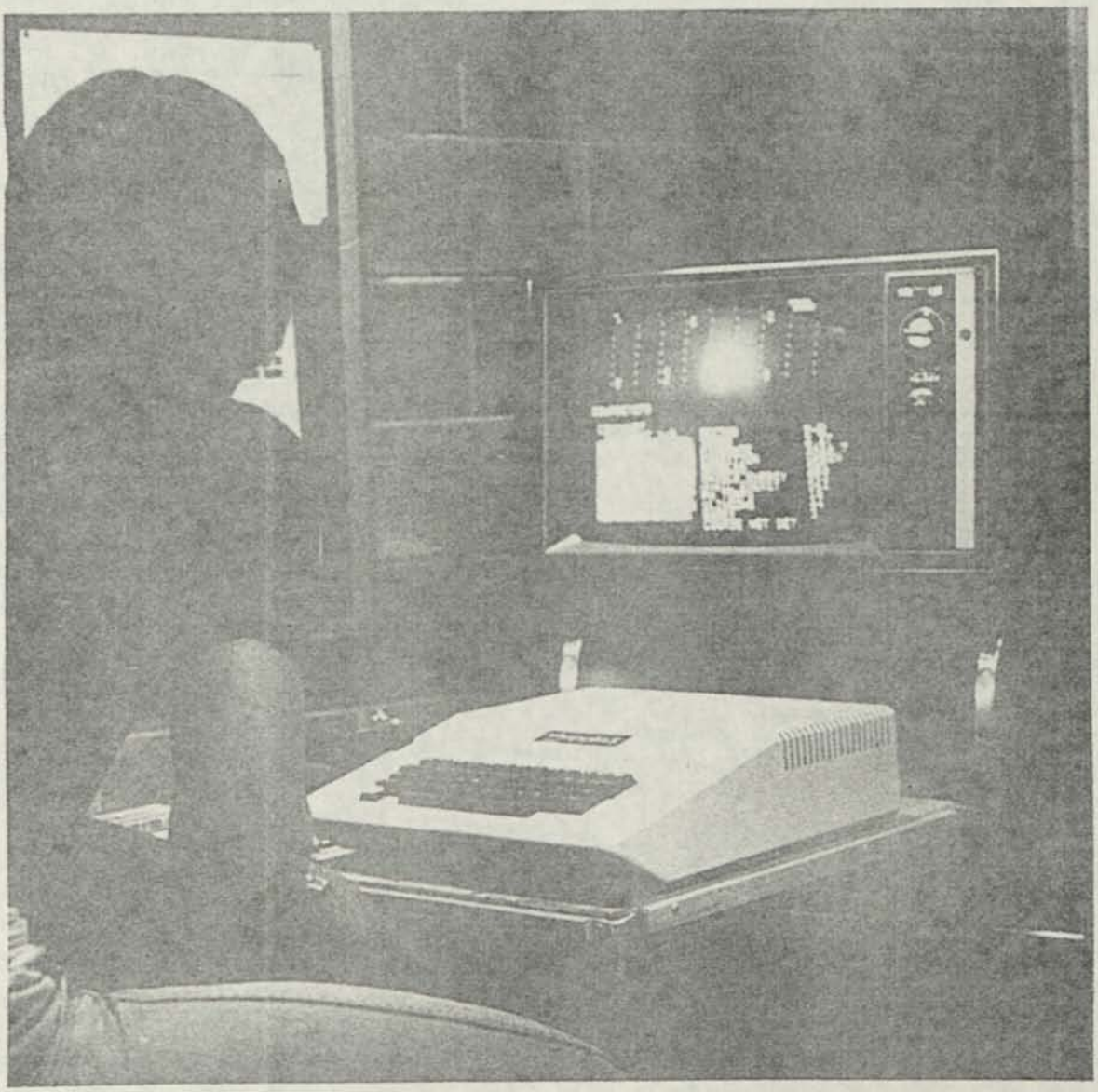

THINGS YOU CAN DO WITH A MICROCOMPUTER

There is something fascinating about a microcomputer. Just watching one conveys something of its power and versatility. Figure 4-1 seems to capture our mental image of a home microcomputer. Here it is being used to calculate a home budget. A microcomputer is extremely flexible and is capable of a large number of home applications ranging from games to menu planning to personal finance. A home microcomputer is now a novelty, but the day will come when almost every home will have one.

After you purchase your microcomputer, at first you may use the programs provided with it. Then you may purchase commercially available programs. Eventually you may want to write your own programs. Microcomputer programming is not hard, but is cannot be mastered without some effort. In this respect it is like learning to play a musical instrument. Let's look at some of the things you can do with a microcomputer.

THE BEGINNER

You have just laid your hard cash on the line and bought a microcomputer after months of deliberation. You hurry home to try it out. Like a kid with a new toy, you open the cartons, plug in the connecting cables, push together the connectors, jam in the power cord, and flip on the power switch and nothing happens . . . or still worse you blow a fuse. This is a classic

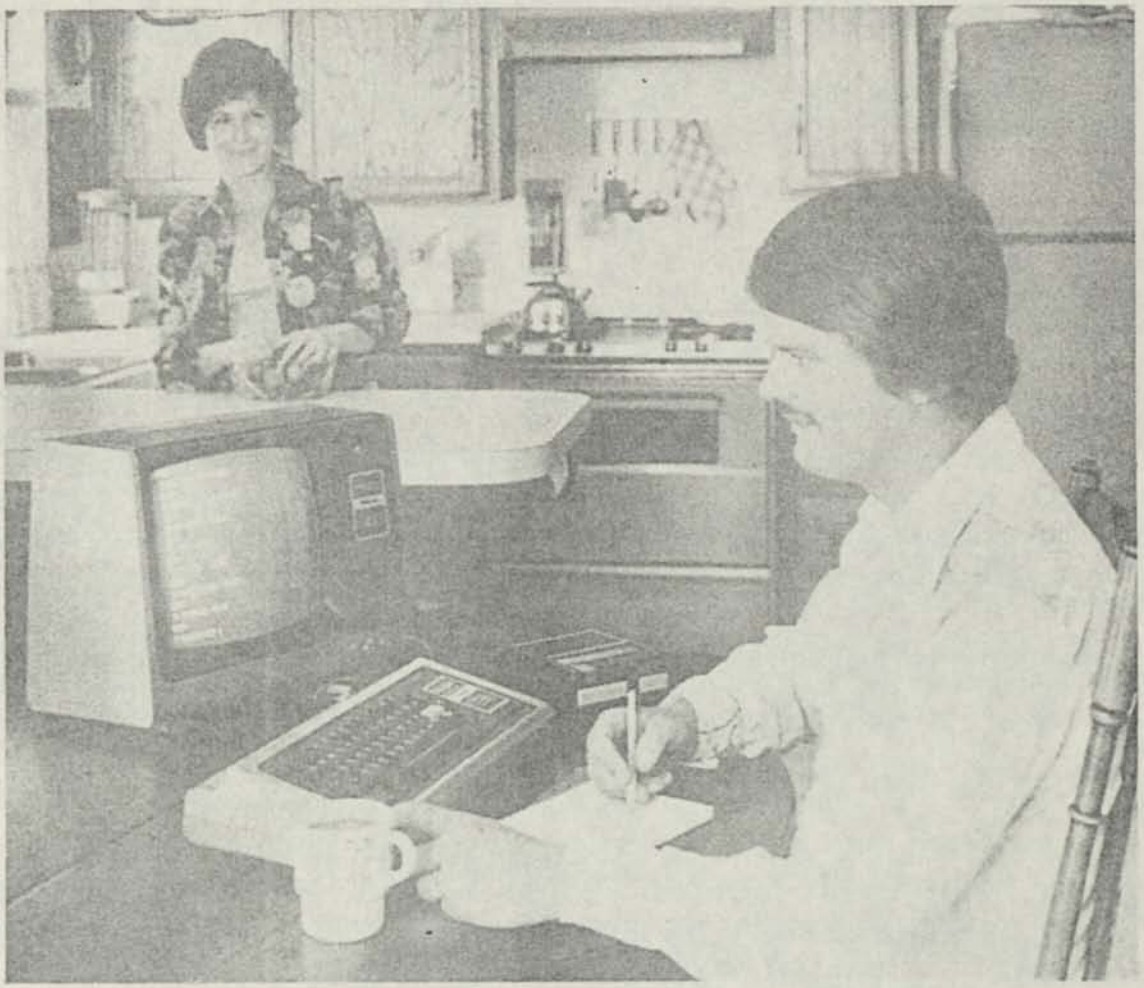

Figure 4-1. A home microcomputer in use. Photo courtesy of Radio Shack International Headquarters.

example of how *not* to assemble the components of your microcomputer. Don't damage your expensive investment! *Rule number one:* Read your instruction manual first, and then begin assembly. Proceed step-by-step as instructed by the manual. It's a good idea to check off each step as you proceed in order not to overlook a critical installation step.

Fortunately, most microcomputers are almost indestructible. No matter what you type into the keyboard, you can't physically damage the microcomputer. However, if you have entered a program into the microcomputer, you may lose it. Some systems require more care. This particularly true of those with floppy disk drives. For instance, if power is cut off while a disk drive has a disk in it, the disk may be damaged. Learn the correct operating procedures for your microcomputer system early in the game.

After you have completed the assembly of your microcomputer and have connected it to the household power, you are ready to turn it on. If your microcomputer has a BASIC language interpreter stored in ROM, the first indication that it is working will be the appearance on the video display of a small asterisk, a flashing white block, or perhaps the word "READY" with a white arrow below it. All these are signals from your microcomputer telling you that it is ready to receive your instructions. Try typing "HI COMPUTER" on the keyboard. Then enter it. What happens? The microcomputer responds with something like "WHAT?" or "SYNTAX ERROR." Both mean that the microcomputer did not know what you wanted or that you made a typing mistake (see Figure 4-2). Most microcomputers respond only to a limited vocabulary of commands.

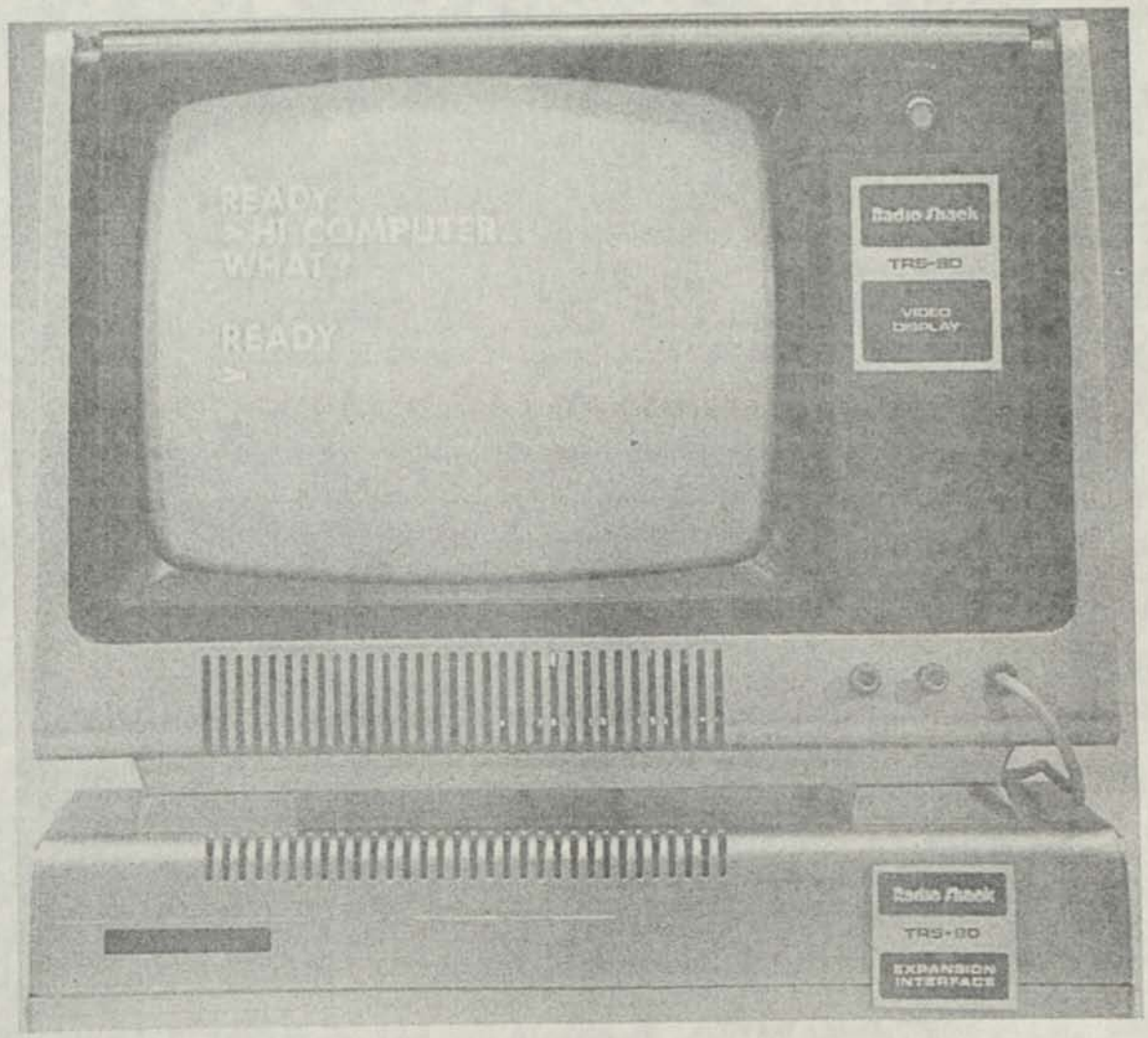

Figure 4-2. Getting nowhere fast with your first microcomputer programming attempt.

Your microcomputer needs instructions to tell it what to do. Collectively these instructions form a program. Many microcomputer programs are written in the BASIC language (Beginner's All-purpose Symbolic Instruction Code). A program can be as short as one statement. For instance, suppose you type "2*3" on your microcomputer keyboard. (The "*" stands for the multiplication operation.) But nothing happens. Your microcomputer did multiply 2 by 3, but you did not tell it what to do with the answer. Try it again, but this time type in "PRINT 2*3." Your microcomputer will display the correct answer 6. This time you instructed your microcomputer to display the answer. Remember, the microcomputer must be told what to do.

Here are some things you will be able to do as soon as you get your microcomputer system home:

- Load and run programs prerecorded on cassette tape
- Play games using programs recorded on cassette tape
- Solve simple arithmetic problems

A number of manufacturers offer programs to run on their machines. All you do is place the prerecorded tape into the cassette device and load the program into your microcomputer. For instance, Radio Shack offers Blackjack for its TRS-80. The user doesn't do any programming, but follows the program's instructions displayed on the screen (see Figure 4-3). By entering a number the player instructs the machine that he wishes to hit, stand, double, or review the cards.

Figure 4-4 shows the video display for Star Trek, a game that allows the player to pilot his own spaceship. There are many game programs offered for each different type of microcomputer. None of these games requires advanced computer skills, and as the player uses his microcomputer, he gradually learns about its capabilities.

Many ready-to-use programs other than games are available for your microcomputer. There are programs for doing the household budget, balancing a checkbook, calculating interest or doing more complicated financial computations, teaching

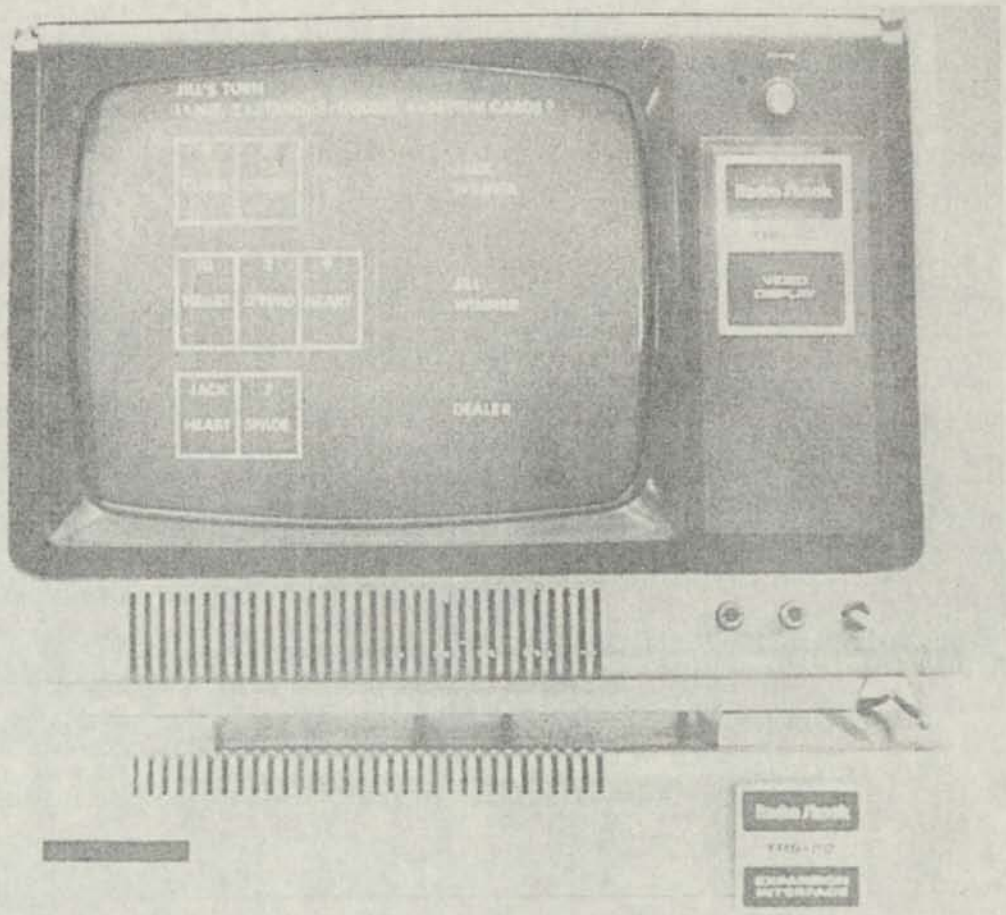

Figure 4-3. Two people can play Blackjack on a microcomputer.

arithmetic skills to children, drawing graphic displays, keeping electronic notecards, and much more. These programs can be used without a detailed knowledge of the workings of your microcomputer. We will discuss these applications and others in a subsequent section.

THE INTERMEDIATE MICROCOMPUTER USER

Eventually you may want programs for your microcomputer that are not available commercially. One solution is to learn a programming language such as BASIC. The BASIC language is easy to learn and simple to use. Most microcomputer manufacturers offer interactive BASIC interpreters for their machines. Many supply a beginning programming manual with exercises and instructions. Eventually you may want to purchase

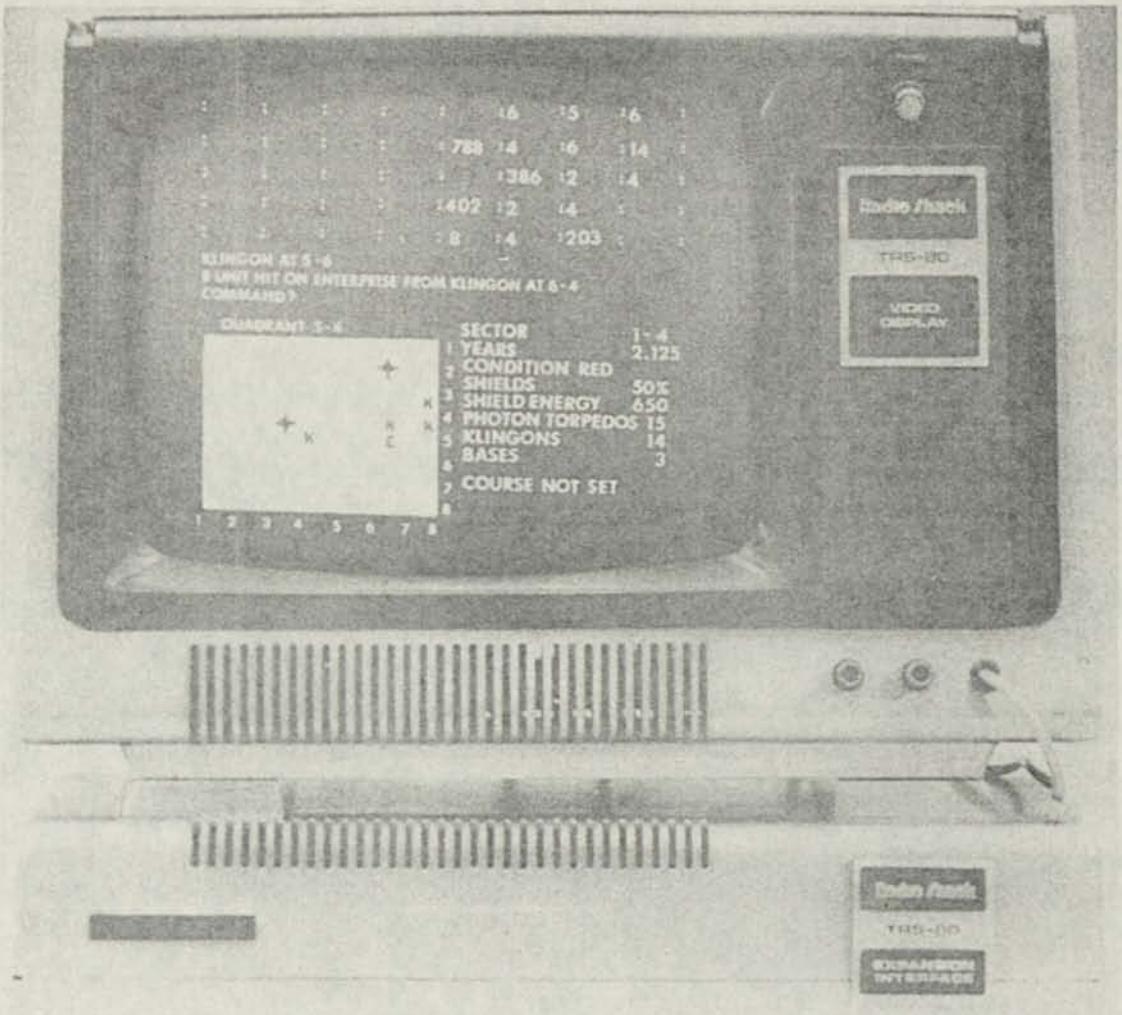

Figure 4-4. The Star Trek game can provide hours of fun.

one of the many books available on BASIC programming. For practice try a few of the simple programs in the book and write some of your own. Run them on your microcomputer and study the results. It is almost impossible to damage your microcomputer by typing on the keyboard, so you can feel free to experiment and learn. Soon you will be able to write programs for specific applications. Figure 4-5 shows the results of a program written to perform a simple calculation.

THE ADVANCED MICROCOMPUTER USER

Eventually your programming skills may grow to the point where you can confidently write your own programs and

can understand those written by other people. With these skills you can use your microcomputer for a large number of applications. You can write programs to do things such as keep memos, address files, or recipe files, teach arithmetic or music theory, and handle business applications to mention but a few.

Usually an advanced program requires more microcomputer memory than a simple one, and so you may want to add more RAM as your programming skills increase. You may also want to add microcomputer peripherals such as printers and floppy disk drives. A printer can give a printed copy of data, and it is essential for most serious business applications. A floppy disk drive can store large quantities of data that cannot be economically stored in RAM. It is useful for applications requiring the permanent storage of large data files. Much microcomputer

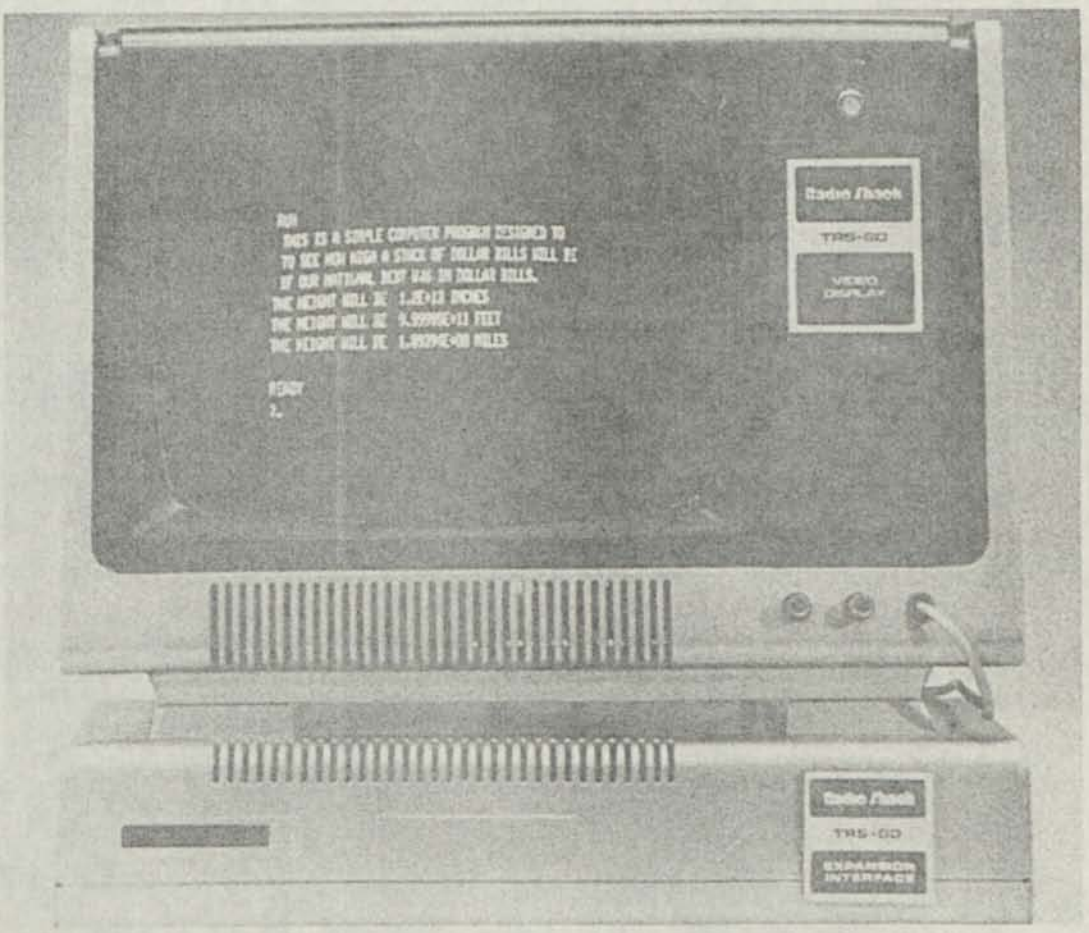

Figure 4-5. The results of a microcomputer program written to solve a mathematical problem.

software such as accounting, inventory, and payroll programs is available only on floppy disk. Because of the large size of these programs, the fast data transfer rate of a floppy disk drive is essential in order to reduce program loading time to a reasonable amount.

SOME MICROCOMPUTER APPLICATIONS

Possible applications of a microcomputer system range from the very simple to the very complex. Prerecorded software is available commercially for many of these applications. For others you may have to write your own software.

1. Education

Did you know your microcomputer can help your children achieve better grades? Special microcomputer mathematics programs can serve as a tireless tutor for your children. In school the microcomputer can serve as a useful teaching aid. Figure 4-6 shows how a microcomputer can be used in classroom instruction replacing the time-honored chalkboard for mathematical problem solving.

Your microcomputer is useful for other types of tutoring. It can be used for memory drills on spelling, word meanings, state capitals, names and dates, and even foreign language vocabularies. It can be used in music studies to teach scales.

In the typical educational application the microcomputer asks a question requiring a simple, factual answer. If the user correctly answers the question, he receives praise. If not, the microcomputer tells him of his mistake and gives him another try. It may even give him a hint. At the end of each session, the microcomputer shows the score (the number of questions answered correctly).

2. Record Keeping

With the appropriate software your microcomputer can remind you of important events. For instance, you could enter

Figure 4-6. The microcomputer can be used as a teaching aid in public schools. Photo courtesy of Radio Shack International Headquarters.

important dates into the machine. Then, each morning you would check it. It might say "CHANGE OIL IN CAR TODAY" or "RENEW INSURANCE ON BOAT TODAY." Your microcomputer can also serve as a message center for your home or office. Each person would type in their name, and the microcomputer would display the messages for that person.

Your microcomputer can serve as a filing system. You can use your microcomputer to hold lists of names, addresses, and telephone numbers. The microcomputer can serve as a table of contents for your regular filing system. You simply record the contents of each file in the microcomputer. With the appropriate software your microcomputer could even search the table of contents and list all files containing information on a specified subject. This is an area where many special applications are possible.

3. Health Applications

You can use your microcomputer to plan your diet and tell you whether or not you are receiving all the proper nutrients, vitamins, and minerals. You would enter what you actually eat into the microcomputer, and it would refer to nutritional tables stored in its memory. Then it would add up the total amount of each nutrient, vitamin, and mineral consumed. This way you would know whether or not you are eating a balanced diet. A microcomputer can also keep track of your exercise and your weight. It might even motivate you to stay on a diet: "YOUR WEIGHT LOSS LAST MONTH WAS 5 POUNDS; SO FAR THIS MONTH YOU HAVE GAINED ONE POUND."

4. Household Applications

Your microcomputer can be used in your kitchen to plan menus, and it can serve as a file for recipes. You can enter a recipe into your microcomputer, and it will calculate the amounts of ingredients needed to serve any specified number of people. The microcomputer can also keep inventory of your foodstuffs.

You can use your microcomputer for household word processing. Imagine having your microcomputer print out mailing labels for Christmas cards. You can use a word processing system to write routine letters. The microcomputer keeps track of frequently used names and addresses and also paragraphs and phrases. It prints these out as directed, and you add any additional text as desired. A small activities group or club can use such a system to send out routine mailings. The microcomputer can also keep the membership list.

5. Home Security and Energy Control

A microcomputer can monitor the security of your home. Using intrusion detectors and smoke detectors, it can be programmed to issue a warning if anything is amiss. When you are away, it can cycle the lights to give the impression that your home is occupied. A home microcomputer can also be used for energy conservation. It can control temperature, lighting, and electrical power. For instance, room temperatures can be auto-

matically varied to match the time of day. Certain rooms can be unheated at night in order to save money. The microcomputer can control temperature not only by controlling the heater, but also by opening or closing windows and vents and by moving drapes to block heat loss. The microcomputer can also control a solar heating system. These applications are discussed in more detail in Chapter 10.

6. Business and Administrative Applications

The small businessman can benefit greatly from the microcomputer. It can make his business more flexible, more efficient, and better able to meet the competition. Microcomputer business systems are available to meet the needs of the professional man, the manufacturer, the contractor, and the serviceman by making available to him powerful accounting and record keeping procedures. A microcomputer can keep business records for state and federal income tax returns. Budgeting becomes a simple task. Figure 4-7 shows how a microcomputer

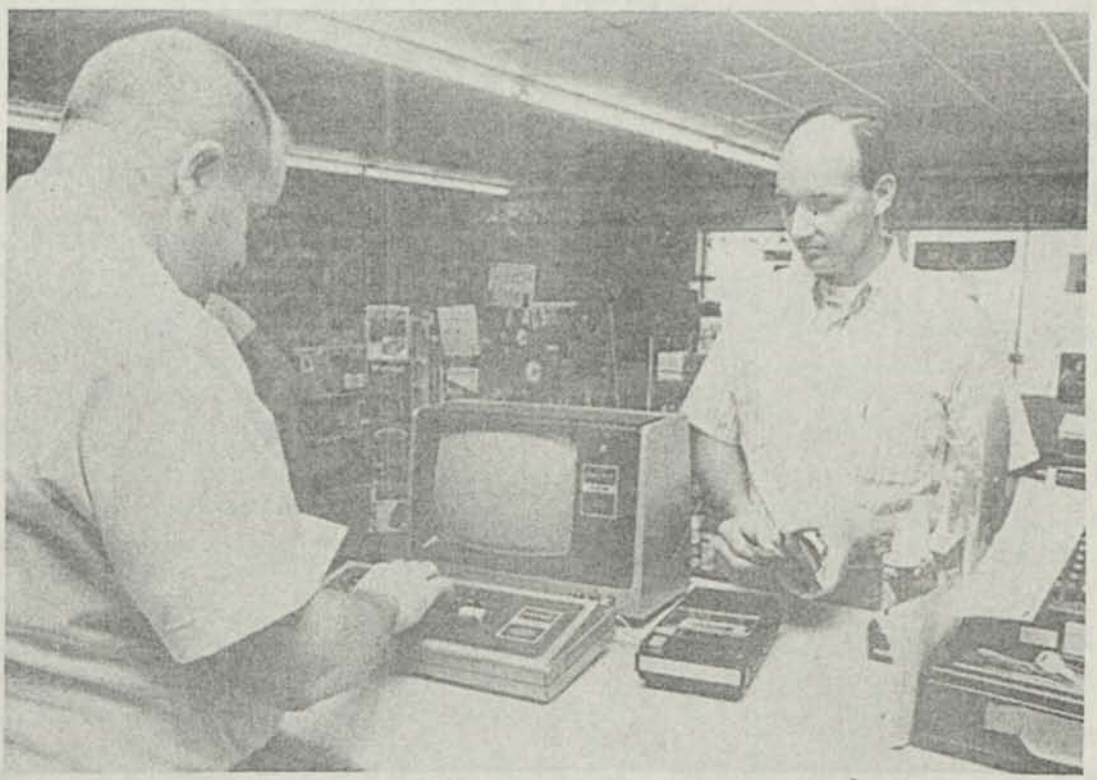

Figure 4-7. Businessmen can use a microcomputer to record and process daily sales transactions. Photo courtesy of Radio Shack International Headquarters.

system might be used in a retail parts store. These applications are discussed in more detail in Chapters 11 and 12.

School administration can successfully apply the microcomputer to class scheduling. Calculation of grades and ranking of students become simple tasks and no longer require hours of calculator computations. Small school budgets can be established in seconds with the aid of accounting software. Report cards can be printed at a speed of 50 to 110 characters per second. Student records can be stored on a microcomputer floppy disk system and retrieved in 30 seconds or less simplifying a tiresome task for the teacher.

As microcomputer systems become more and more common, software packages will be offered for special applications. Software packages are already available for medical offices, for legal offices, and for pharmacies to mention but a few businesses with special needs. Soon software packages will be available that are tailored to the needs of construction firms, real estate offices, insurance sales offices, advertising agencies, newspapers, retail stores, and many others. Then the business microcomputer will become as common as the typewriter is today.

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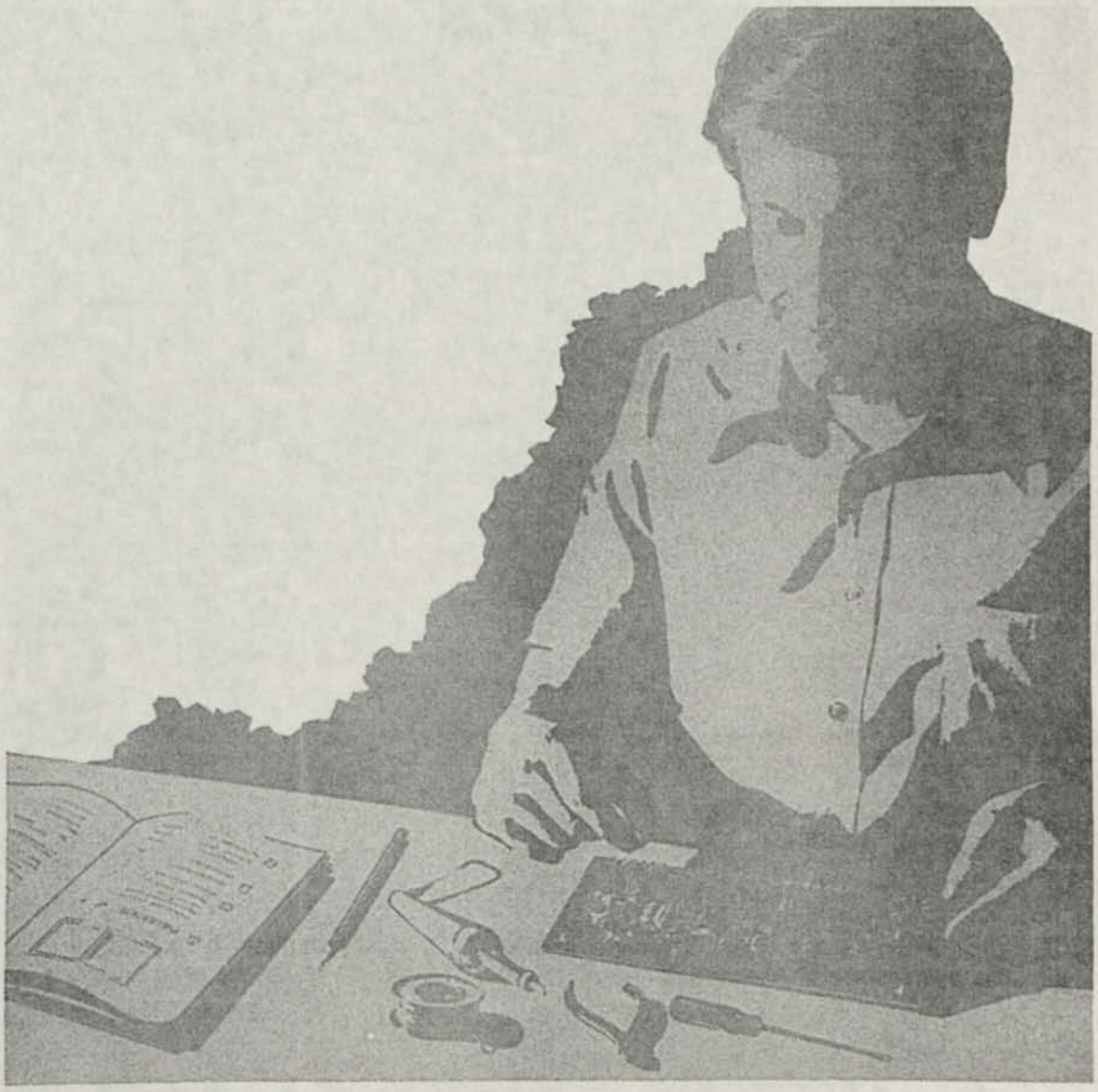


HOW TO BUILD YOUR OWN MICROCOMPUTER

WHY BUILD A KIT?

Today a wide range of microcomputers and microcomputer components are available in kit form. Just open any microcomputer magazine and look at the ads. A good kit usually includes all necessary electronic parts, mounting hardware, enclosure if needed, circuit diagram, and detailed assembly instructions. Using simple tools the purchaser solders the parts into place, performs mechanical assembly, and tests the finished device. Involved mechanical operations such as drilling, punching, and milling are not necessary. By assembling your own microcomputer from a kit, you can save as much as 50% of the cost of the assembled item. In addition, you will become familiar with the equipment and its operation, and you will be able to perform many repairs yourself thus saving still more money.

Micro Instrumentation Telemetry Systems (MITS) was the first company to offer a microcomputer in kit form. They also offered technical and software support to the customer. Now the recognized world leader in do-it-yourself electronic kits, the Heath Company, has entered the microcomputer field with not one but two microcomputer kit systems. Heath offers assembly instructions of unsurpassed simplicity, extensive technical assistance and service, and substantial software support for their microcomputer products.

Should you assemble a microcomputer system from kits? The answer depends on your own capabilities and the quality of

the kits. Keep in mind that the present generation of microcomputers began as kits and that thousands of people with nontechnical backgrounds have successfully assembled microcomputer systems from kits. If you have average mechanical dexterity and can follow detailed instructions, you probably can assemble a kit without any significant problems. Much will depend on the quality of the instructions accompanying the kit and the degree of technical support offered by the factory. All too frequently microcomputer kit manufacturers assume a considerable degree of technical knowledge on the part of the purchaser, and sometimes errors creep into instruction manuals.

If you are considering purchase of a microcomputer kit, it is good advice to first purchase a complete set of assembly manuals and technical documentation. Then you will be able to judge the quality of the kit and decide whether or not kit assembly is within your capabilities. The cost of a complete set of manuals will run from $5 to $25 for each component of the microcomputer system. It would be wise to ascertain the availability of service and software support and also the availability of technical assistance should you encounter difficulties. When choosing a microcomputer system either factory assembled or in kit form, consider the availability of compatible peripherals such as printers and disk drives.

In summary, if you decide to build a microcomputer from a kit, here are a few tips:

- Examine the product manuals before making your purchase.
- Verify factory service and software support.
- Make sure your microcomputer can easily accommodate future peripherals.
- Have the time to assemble the kit without rushing.
- Be sure you have appropriate tools for the job.

WHAT DO YOU NEED TO BUILD A KIT?

Figure 5-1 shows some of the hand tools useful in the assembly of an electronics kit. At the top is a pair of tongs useful

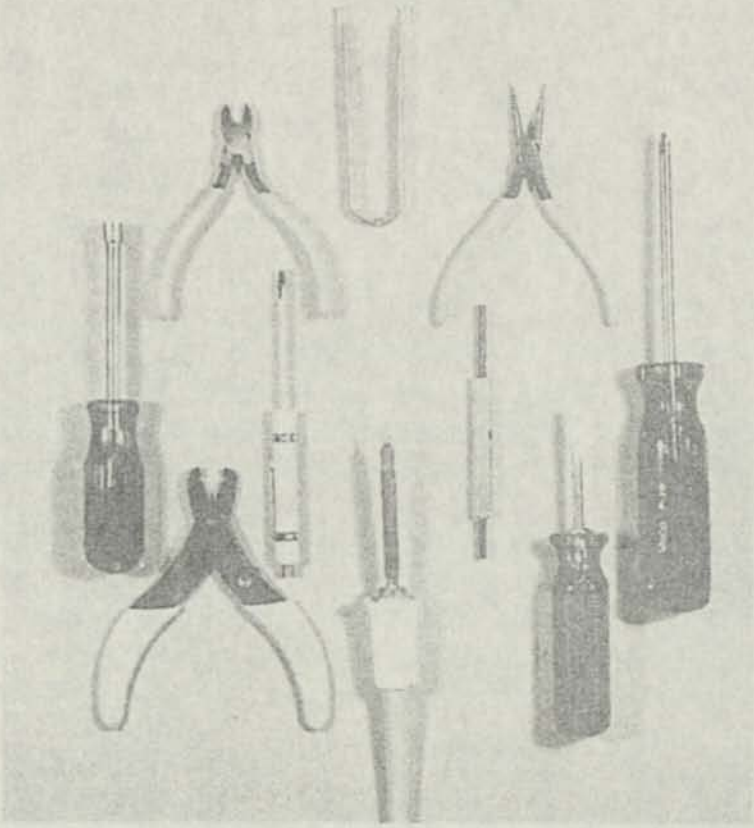


Figure 5-1. Hand tools useful for kit construction.

in soldering. In the next row from the left are 4-inch side-cutting pliers and 4-inch needle-nose pliers. In the center row from the left are a nut driver, small screwdriver, wire-wrapping tool, and Phillips screwdriver. In the bottom row from the left are an adjustable wire stripper, the Ungar Princess 18-watt soldering iron, and a flat-blade screwdriver. A miniature tip-cutting nipper for trimming the leads on IC's may also be useful.

A major part of the assembly of any electronics kit is the soldering of numerous electrical connections. Soldering in a microcomputer kit is particularly demanding. Printed circuit boards can be easily damaged by excessive heat, and low-wattage soldering equipment is essential. The Ungar Princess soldering iron is a good choice. Ungar offers the Microchisel soldering tip shown in Figure 5-2. It is particularly useful for the close tolerance soldering necessary with sockets for integrated

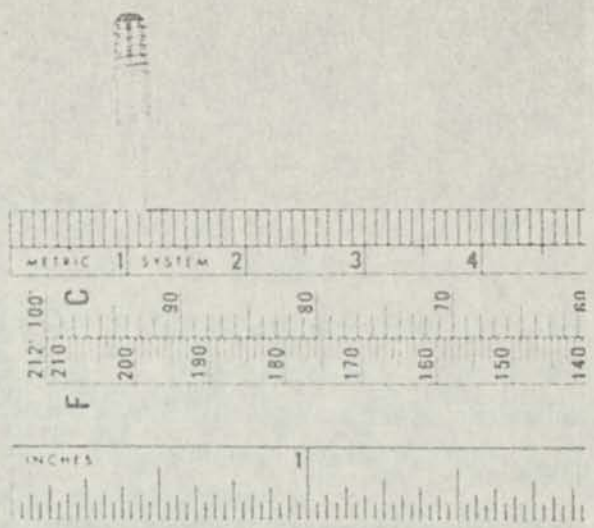


Figure 5-2. The Ungar Princess Microchisel solder tip.

circuits. For some applications higher wattage soldering irons are desirable. For instance, 25 watt, 55 watt, and 100 watt soldering irons are frequently used in electronic assembly. The 100 watt size is used primarily to solder heavy wires to terminals. The smaller sizes are used for soldering on printed circuit boards.

Most people who assemble electronics kits find it advisable to have the basic electronic test instruments for troubleshooting circuit problems. The Heathkit assembly manuals identify voltage test points for each circuit board. Detailed troubleshooting instructions are available when incorrect voltages are found. A meter that can read AC voltage, DC voltage, and resistance is extremely useful. It can be a volt-ohm meter (VOM), a vacuum tube volt meter (VTVM), or a transistorized digital volt meter (DVM). The last two are more useful because their high input impedance matches the high impedance of digital circuitry. This means that these meters load the measured circuit less, and so the measured voltages are more accurate. A digital logic probe is ideal for testing digital integrated circuits. The probe can be used with an IC test clip to make voltage measurements easy and to eliminate the accidental shorting of IC pins by the probe tip. A small oscilloscope is useful for observing clock waveforms and data pulses. It can be used for rapid

fault tracing. Test equipment need not be elaborate or expensive, but it should have reasonable accuracy.

HOW TO SUCCESSFULLY BUILD A HEATHKIT MICROCOMPUTER SYSTEM

The Heath Company offers two microcomputer systems in kit form: the Heathkit H8 and the Heath/DEC H11. Just how difficult is the assembly of a Heath microcomputer? If you have the proper tools and can follow simple instructions, you can put together the Heath H8 in just six evenings. High school students ranging in age from 15 to 17 years old do it routinely. Figure 5-3 shows a student installing circuit boards in a Heath H9 video terminal he is assembling.

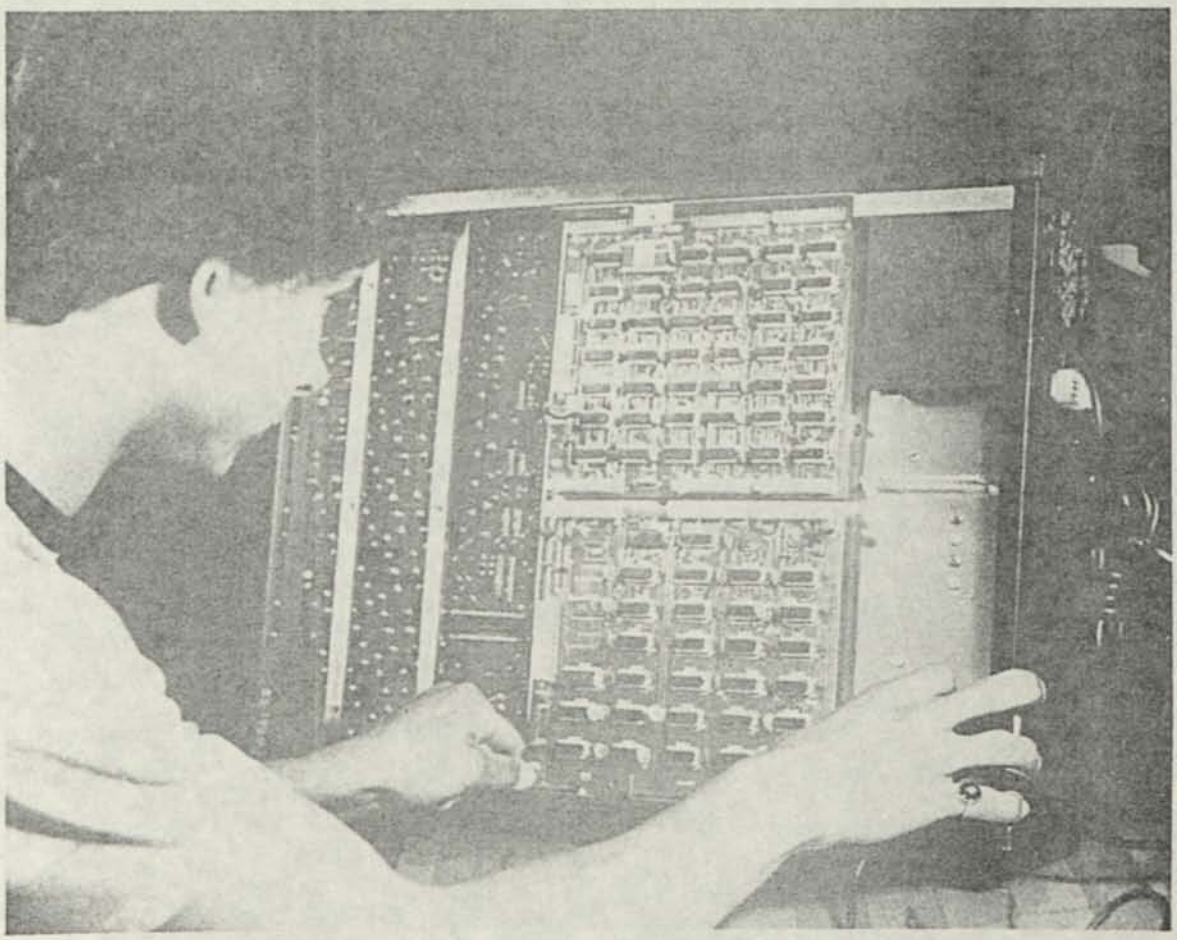


Figure 5-3. A student installs circuit boards in the Heathkit H9 video terminal.

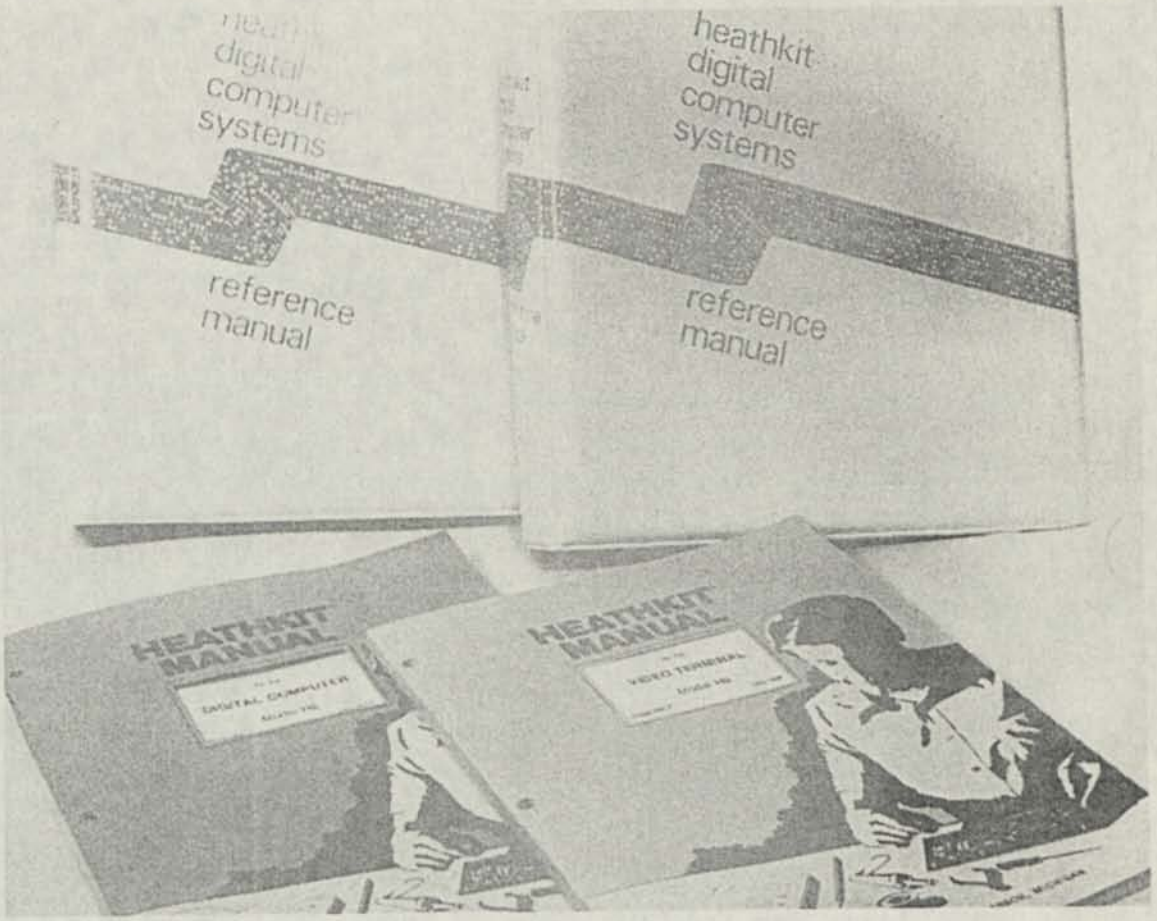


Figure 5-4. Assembly and reference manuals for the Heathkit H8 microcomputer and the H9 video terminal.

Kits manufactured by the Heath Company are set apart from all other kits by the quality of their instruction manuals. Those for the H8 microcomputer are depicted in Figure 5-4. The Heathkit instruction manuals assume no knowledge of electronics on the part of the purchaser. Each manual starts by recommending hand tools to assemble the kit. Then the electronic parts in the kit are identified. For instance, the kit purchaser is taught how to read the resistor color code and identify the values of the resistors in his kit. Likewise, he is taught how to read the values of capacitors. Then the instruction manual discusses the techniques for assembly of the kit. Pictorial diagrams show him how to mount resistors, capacitors, transistors, and integrated circuits on circuit boards.

Next each instruction manual shows the kit purchaser how to make good electrical solder connections. Soldering is

perhaps the single most important skill involved in kit construction. A bad solder joint usually means a bad electrical connection. Here are some typical soldering errors:

- Use of improper soldering iron and tip.
- Cold solder joints caused by the use of too little heat and the failure of the solder to flow.
- Solder bridges between conductors on circuit boards. Solder bridges are usually caused by too much solder.
- Poor electrical connections between component leads and the circuit board. This is usually caused by oxidation of the metal conductors or by burned rosin. Clean the metal conductors before you solder them.
- Solder connections overlooked by the assembler.
- Circuit board pads and paths lifted from the surface of the circuit board by excessive heat from soldering equipment. Use the appropriate wattage equipment for your soldering application and keep the soldering tip clean and bright.

The Heath service department reports that the majority of all customer repairs stems from poor soldering techniques. After you finish assembly of your kit, inspect each solder joint as in Figure 5-5 and redo any that look suspicious.

The Heathkit instruction manuals provide diagrams of all circuit boards showing the location of all components and identifying them by number. The parts list links the part number to a description of the part. Detailed pictorial diagrams show the installation of all mechanical and electrical components (see Figure 5-6). Heathkit instructions are engineered for simplicity and assume absolutely no technical knowledge on the part of the customer. Every step from the attachment of a metal clamp to the installation of nuts and bolts is fully illustrated to assure no mistake. Multiwire cables and harnesses are diagrammed to identify each wire by color or color stripe. Prefabricated wiring harnesses eliminate much of the individual circuit wiring and greatly speed assembly. Where hand wiring is required, large

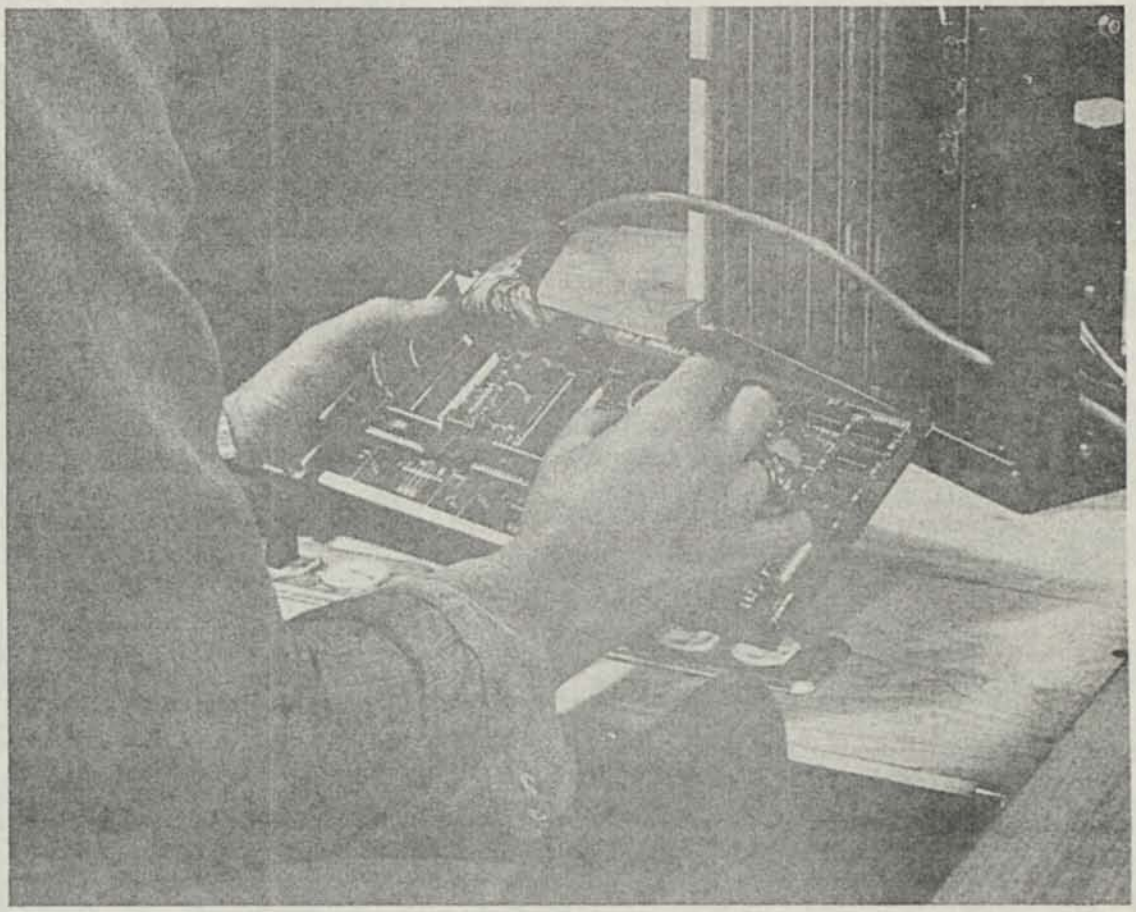
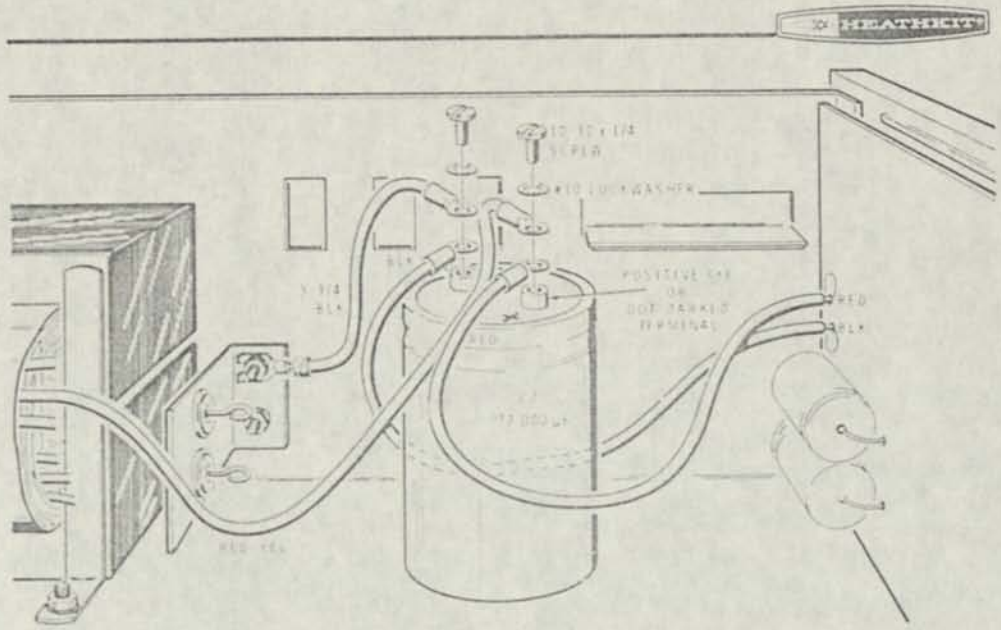


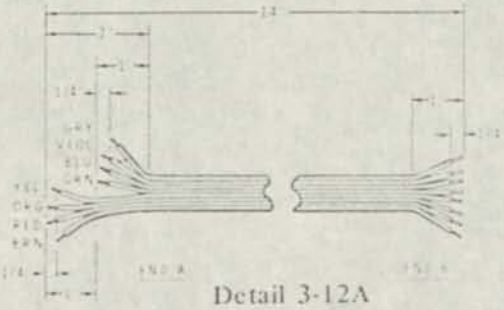
Figure 5-5. A student uses a magnifying lens to check for solder bridges on the Heathkit H8-2 parallel interface circuit board.

pictorial diagrams show how to route the wires. Check-off blocks aid point-to-point hand wiring and minimize mistakes.

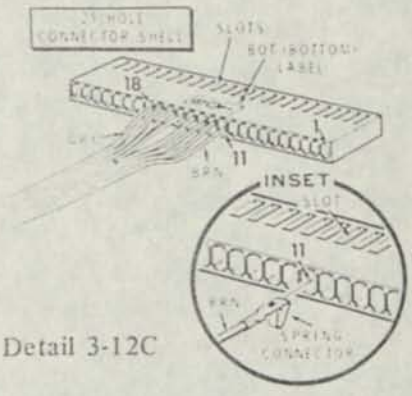
In cases of difficulty the step-by-step troubleshooting diagrams included in the Heathkit manuals are invaluable (see Figure 5-7). By making yes-no decisions that are detailed on the troubleshooting diagrams, the kit assembler can quickly identify the problem in most cases. When all troubleshooting efforts fail, Heathkit purchasers have a free consulting service as near as their telephone (see Appendix II). If the difficulty still cannot be located, the Heath Company maintains a well-trained customer service department where the unit can be returned for repair at minimal cost. Heathkit H8 circuit boards can be repaired in the 90-day warranty period for a nominal fee. With each repair the customer receives a full service report identifying the problem and giving the test results on the repaired unit.



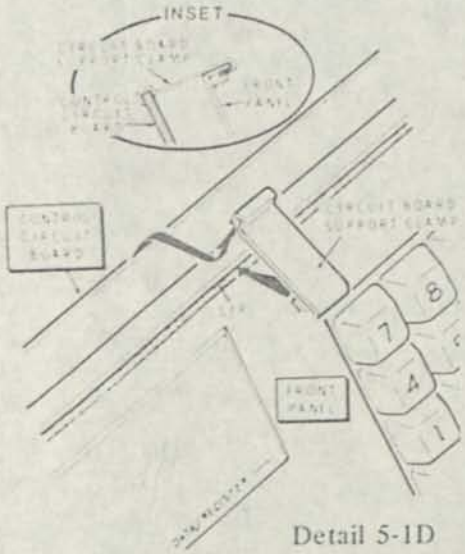
Detail 2-7F



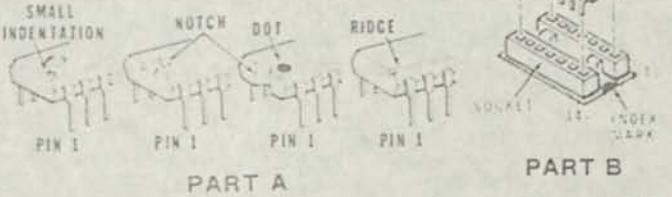
Detail 3-12A



Detail 3-12C



Detail 5-1D



Detail 3-18B

Figure 5-6. Detailed pictorial diagrams in the Heathkit assembly manuals aid kit construction. Courtesy of the Heath Company.

TROUBLESHOOTING CHARTS

CHART 1

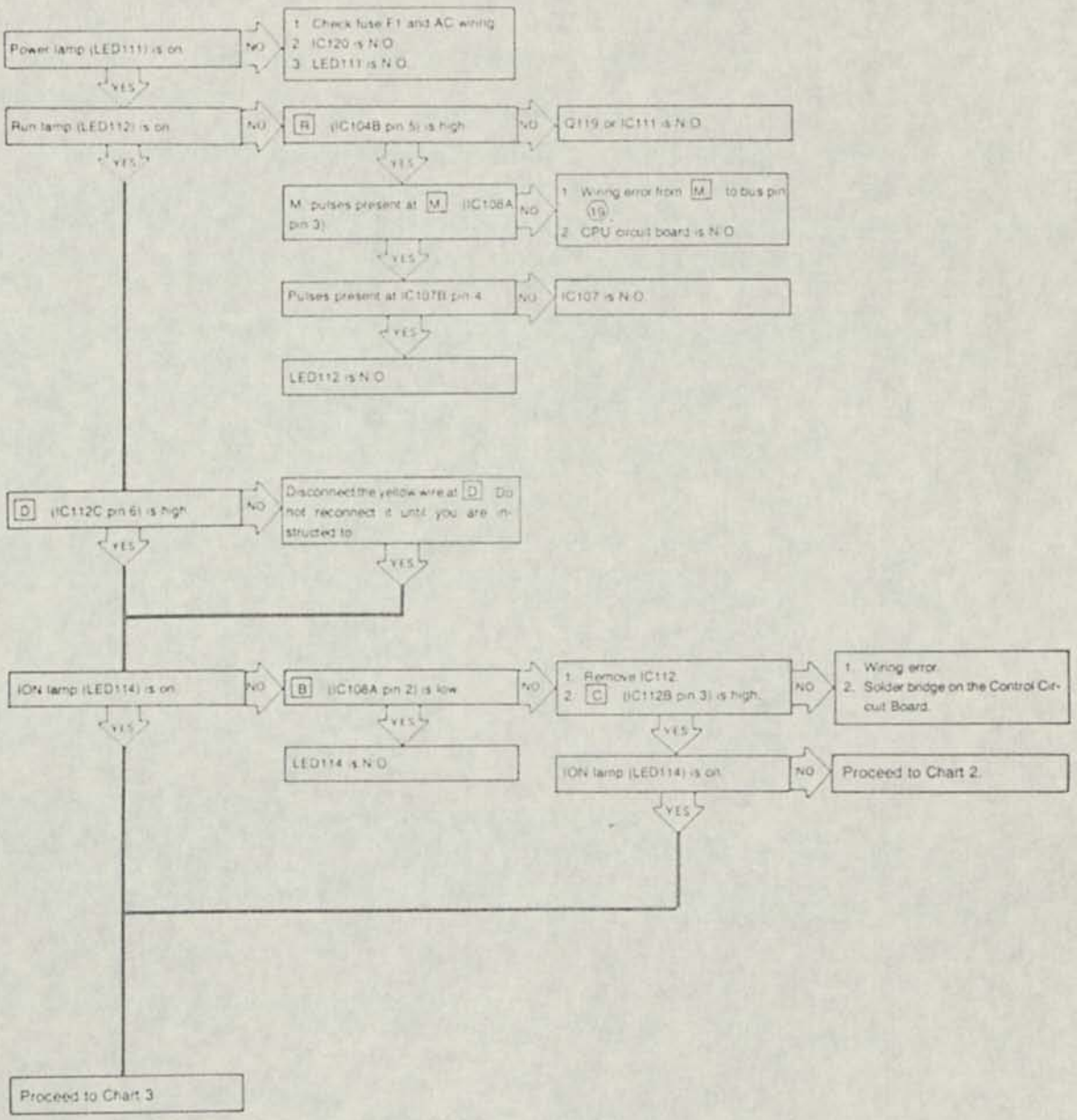
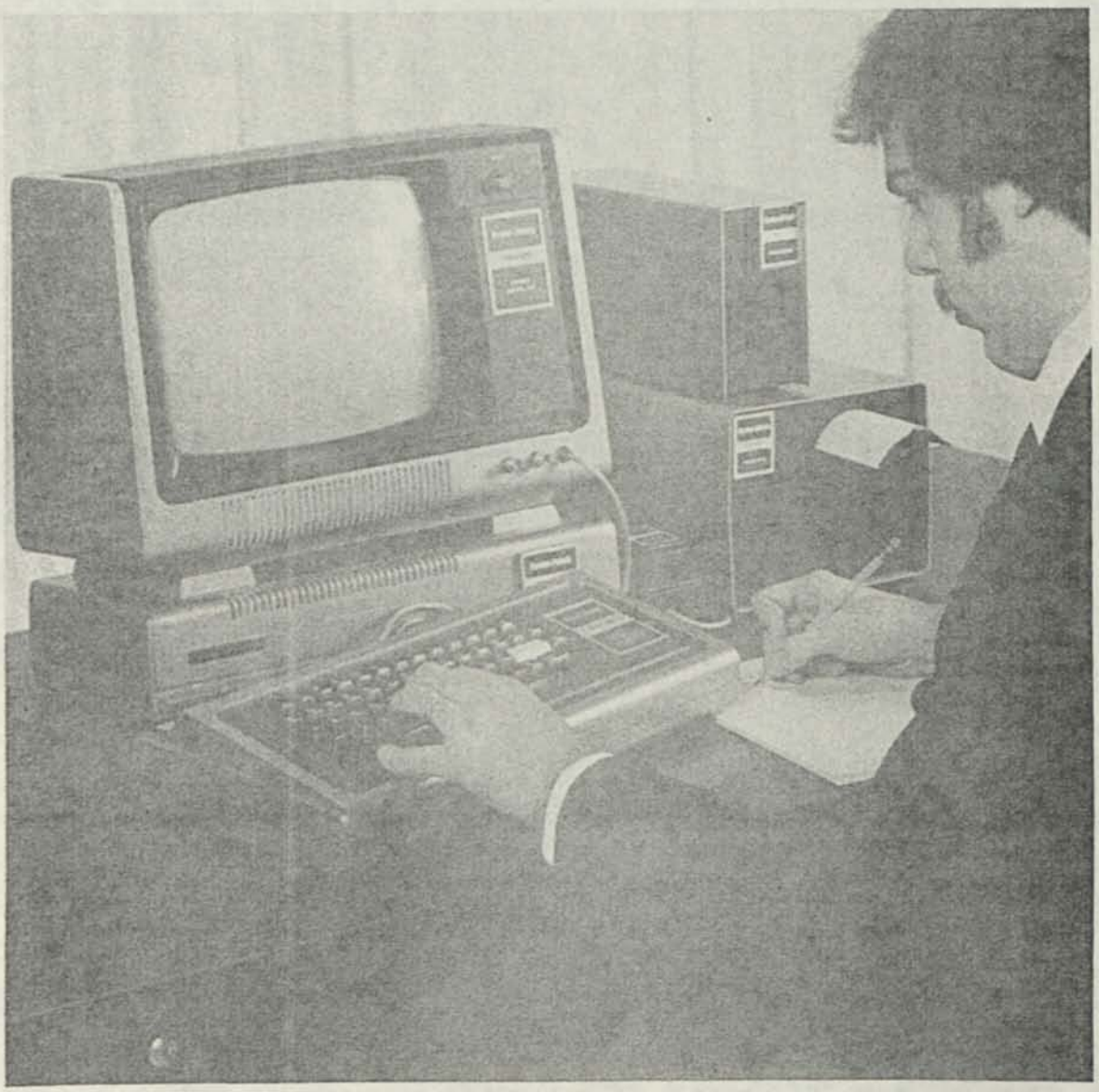


Figure 5-7. Heathkit troubleshooting charts are easy to follow and speed the identification of circuit problems. Courtesy of the Heath Company.

6



THE RADIO SHACK MICROCOMPUTER SYSTEMS

In this chapter we present the Radio Shack TRS-80 microcomputer, which is manufactured by the Tandy Corporation of Fort Worth, Texas. Like many manufacturers Tandy offers the basic microcomputer and a line of compatible peripherals. The situation is somewhat like that for high fidelity audio systems as depicted in Figure 6-1. The purchaser selects a basic system and adds components as his applications require. As with high fidelity audio systems the purchaser can choose over a wide range of microcomputers and peripherals with varying performance and price.

THE BASIC TRS-80 MICROCOMPUTER

The basic TRS-80 system is shown in Figure 6-2. It has four major components. The microprocessor and associated circuits are built into the keyboard. A 12-inch CRT display serves as the means of data output. The power supply is a separate plug-in unit. An audio cassette recorder/player is included for program and data storage. Connecting cables are also supplied.

The TRS-80 employs the powerful Zilog Z-80 microprocessor. The basic TRS-80 offers a 4K Level-I BASIC interpreter permanently stored in ROM. This avoids the delay of loading the BASIC interpreter at each power-up sequence. All alphanumerics and graphics for the 12-inch black-and-white

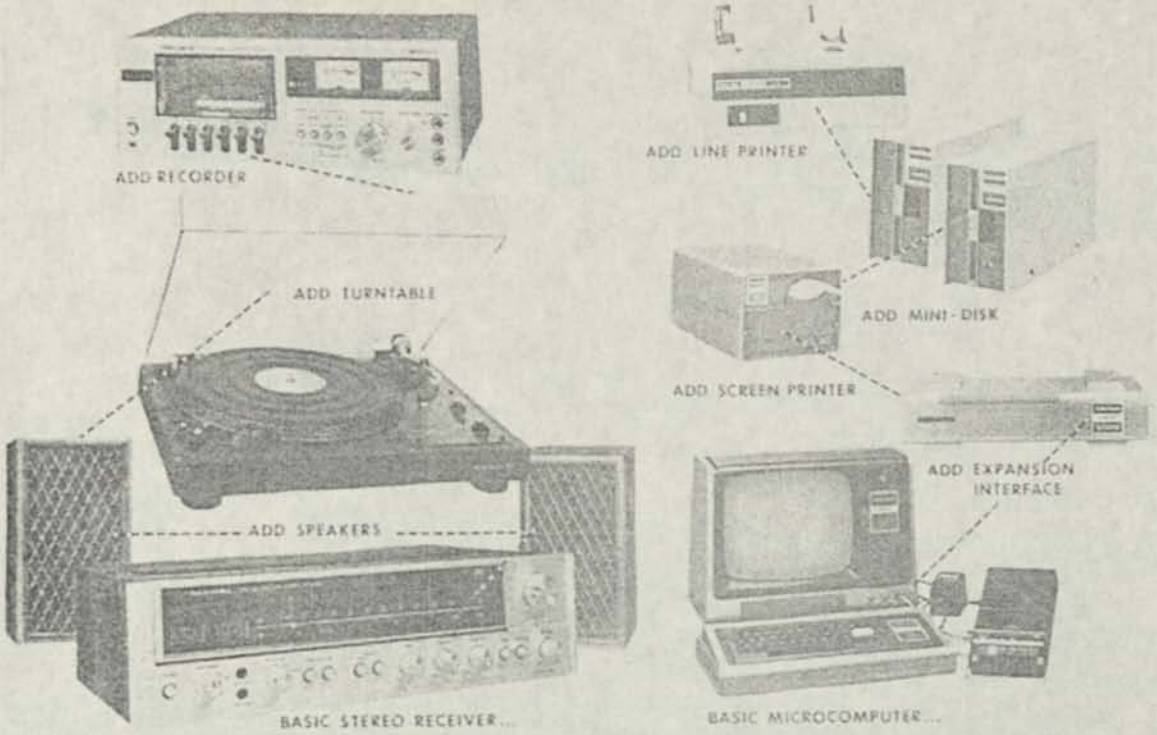


Figure 6-1. Microcomputer systems are like audio high fidelity systems. The user buys the basic unit and adds those peripherals he wants.

video display are controlled by BASIC commands. Cursor control and automatic scrolling is also included. The display offers 16 lines of output of 64 characters each. Graphics are available with 128 horizontal by 48 vertical element resolution. Graphics and text can be interspersed by software in any manner. Memory for the basic TRS-80 is 4K of dynamic RAM. A 53-key ASCII keyboard is built in.

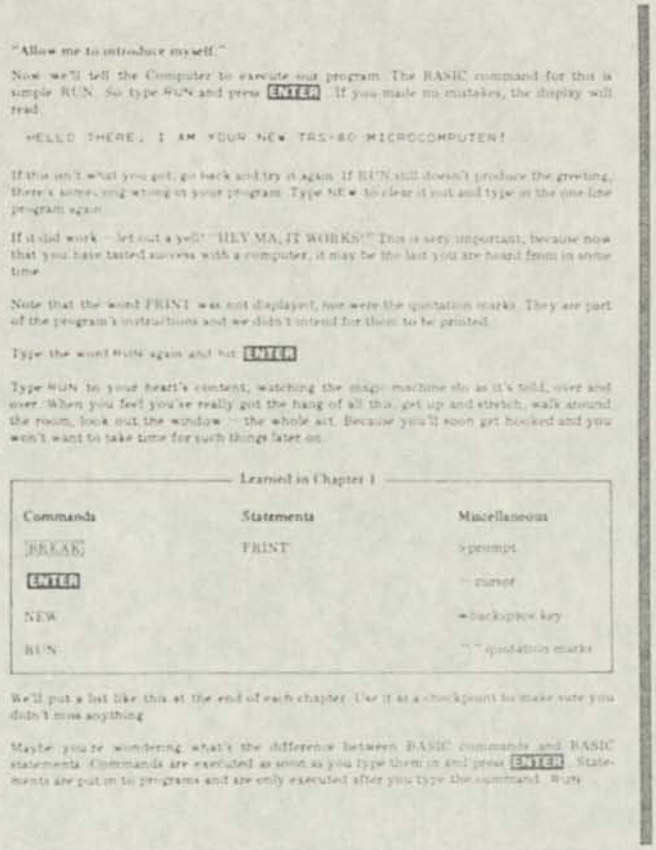
Like all good microcomputers the TRS-80 comes with an easy-to-read and simple-to-follow user's manual. This user's manual not only instructs in the operation of the microcomputer, but it also teaches the user how to program in the BASIC language. A sample page of the TRS-80 user's manual is shown in Figure 6-3. The manual assumes no technical background on the part of the reader, and it uses step-by-step instructions to lead him through the intricacies of microcomputer programming. Fundamental points are emphasized when they are introduced, and they are summarized at the end of each chapter. Within minutes after unpacking your TRS-80 microcomputer,

Figure 6-2. The basic Radio Shack TRS-80 microcomputer system. Photo courtesy of Radio Shack International Headquarters.

you can perform simple arithmetic computations and play games such as blackjack.

Radio Shack offers an 8-lesson introduction on its Level-I BASIC language. This introduction is in the form of a microcomputer program stored on 4 cassette tapes. By interacting with the program, the TRS-80 user quickly learns BASIC in a way that is fun.

Radio Shack also offers a Level-II BASIC interpreter stored in 12K of ROM. Level-II BASIC supports a number of statements and commands not supported by the simpler Level-I BASIC. Level-II BASIC features improved graphics, print formatting, and text editing. Level-II BASIC also provides a 500



"Allow me to introduce myself."

Now we'll tell the Computer to execute our program. The BASIC command for this is simple: RUN. So type RUN and press ENTER. If you made no mistakes, the display will read:

HELLO THERE, I AM YOUR NEW TRS-80 MICROCOMPUTER!

If this isn't what you got, go back and try it again. If RUN still doesn't produce the greeting, there's something wrong in your program. Type NEW to clear it out and type in the one-line program again.

If it did work — let out a yell! "HEY MA, IT WORKS!" This is very important, because now that you have tasted success with a computer, it may be the last you are heard from in some time.

Note that the word PRINT was not displayed, nor were the quotation marks. They are part of the program's instructions and we didn't intend for them to be printed.

Type the word RUN again and hit ENTER.

Type RUN to your heart's content, watching the magic machine do as it's told, over and over. When you feel you've really got the hang of all this, get up and stretch, walk around the room, look out the window — the whole act. Because you'll soon get hooked and you won't want to take time for such things later on.

Learned in Chapter 1

Commands	Statements	Miscellaneous
BREAK	PRINT	>prompt
ENTER		_ cursor
NEW		← backspace key
RUN		" " quotation marks

We'll put a list like this at the end of each chapter. Use it as a checkpoint to make sure you didn't miss anything.

Maybe you're wondering what's the difference between BASIC commands and BASIC statements. Commands are executed as soon as you type them in and press ENTER. Statements are put in to programs and are only executed after you type the command: RUN.

"HEY MA, IT WORKS!"

Whether you're typing in a program, or giving direct commands like RUN, you've got to hit ENTER to tell the Computer to take a look at what you've typed and act accordingly.

Special message for people who can't resist the urge to play around with the computer and skip around in this book. (There always are a few!) It's possible to "lose control" of the Computer, so that it won't give you a READY message when you press ENTER. To regain control, just press BREAK, then ENTER. If that doesn't work, find the Reset button inside the left rear corner of the TRS-80 and push it. There!

Figure 6-3. The TRS-80 user's manual gives easy-to-understand instructions on the use of the TRS-80 microcomputer. Reprint permission courtesy of Radio Shack International Headquarters.

baud data transfer rate from cassette compared with a rate of 250 baud for Level-I BASIC.

Radio Shack makes the TRS-80 microcomputer available with four different options for random access memory and level of the BASIC interpreter. They are:

- 4K RAM and Level-I BASIC in 4K ROM
- 4K RAM and Level-II BASIC in 12K ROM
- 16K RAM and Level-I BASIC in 4K ROM
- 16K RAM and Level-II BASIC in 12K ROM

You may select any option and at any later time upgrade your TRS-80 by purchasing Level-II BASIC and/or 16K RAM. There is no additional charge for installing the purchased options. Level-II BASIC and 16K RAM are required to add a number of the peripherals available for the TRS-80.

SOFTWARE FOR THE TRS-80 MICROCOMPUTER

Radio Shack's software support begins with your initial purchase of the TRS-80 microcomputer. Radio Shack supplies at no extra charge software to play two different games—blackjack and backgammon. This software is available on tape cassette. Radio Shack offers a library of programs for personal computing and small business applications. These include:

Home and school software

- The self-improvement series
- Computer-assisted instruction (CAI)
- Challenging games
- Programs for the kitchen
- Personal finance programs

Business software

- General ledger
- Accounts receivable and payable
- Payroll
- Inventory control

More software is in preparation. Figure 6-4 shows the business systems payroll software. The programs are on tape cassettes, and additional tape cassettes are included for data storage. Complete instructions are included, and both the instructions and tape cassettes come in a binder. Figure 6-5 shows some of the software packages and instruction manuals available for the TRS-80 microcomputer and its peripherals.

PERIPHERALS FOR THE TRS-80 MICROCOMPUTER

As your programming skill and the range of your microcomputer applications increase, you will want to expand the power of your microcomputer system by adding peripherals. Radio Shack offers a full line of peripherals for its TRS-80 microcomputer, and many of these are shown in Figure 6-5.

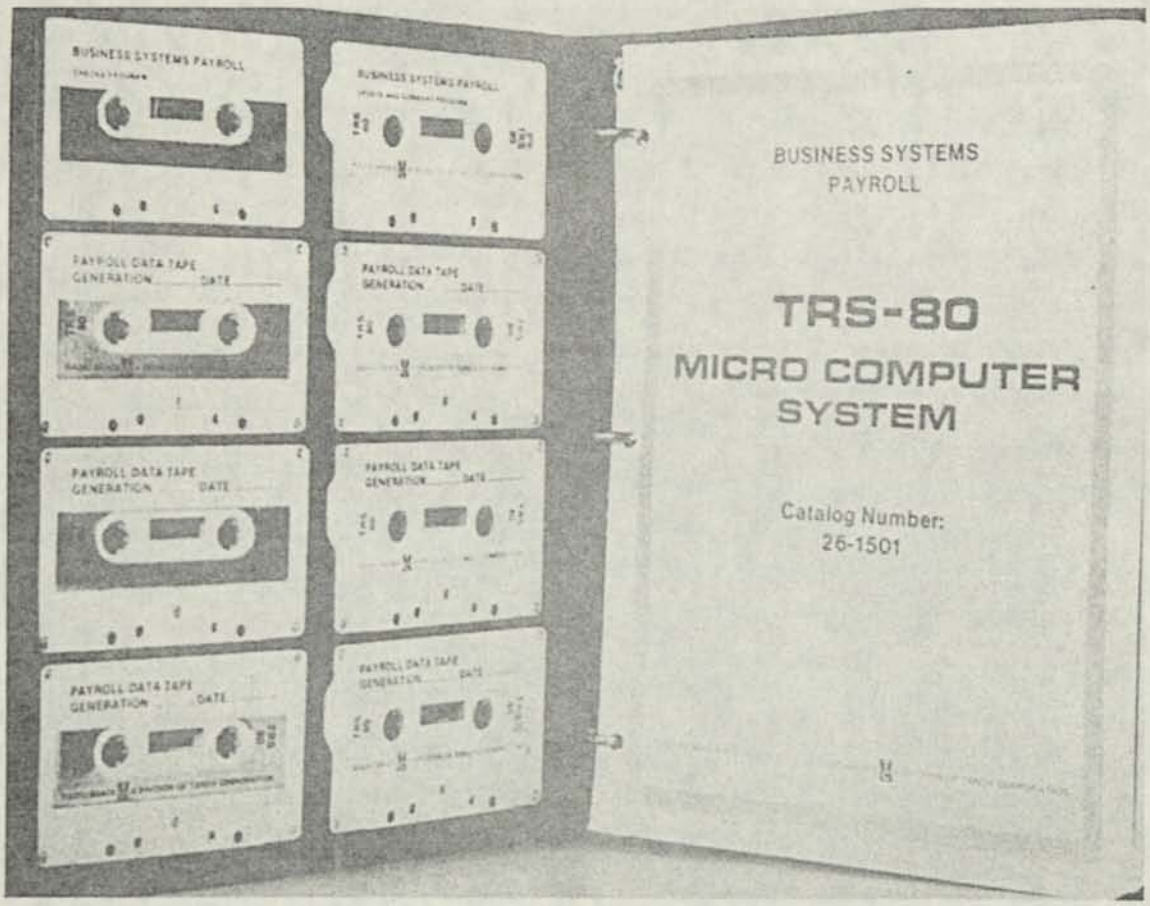


Figure 6-4. Radio Shack offers sizable software support for TRS-80 business applications. Here the payroll software package is shown.

In order to add peripherals to your TRS-80 microcomputer, you will first need the TRS-80 expansion interface. The TRS-80 expansion interface matches the color and style of the display terminal, and it is usually mounted under the display terminal as in Figure 6-6. In this position it raises the display terminal placing it nearer eye level. The expansion interface contains special sockets for an additional 16K or 32K RAM to increase your microcomputer random access memory to as much as 48K. The expansion interface also permits the addition of a disk controller for up to four Mini-Disk drive units, and it permits software-selectable dual cassette recorder/players to be used. This means that a program can read from one cassette recorder/player and write data on the other cassette recorder player. This feature is useful for certain advanced applications, and it is less expensive although slower than the use of dual mini-

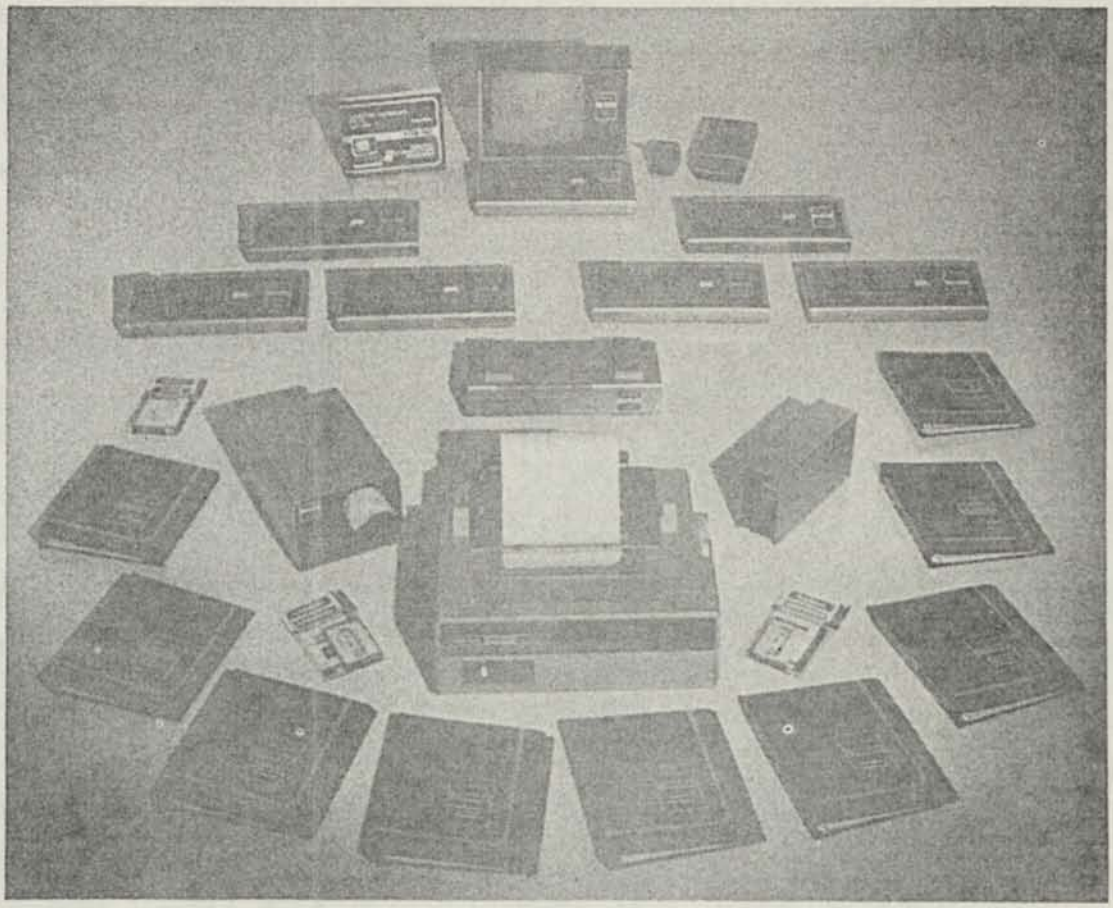


Figure 6-5. The TRS-80 microcomputer, perhipherals, and software. The basic TRS-80 microcomputer is shown in the rear. In front of it are other keyboard/microcomputer units to symbolize the available options. In the center is the TRS-80 line printer, and slightly behind it is the TRS-80 expansion interface. To the right is the TRS-80 Mini-Disk system, and to the left is the TRS-80 screen printer. In the foreground are binders containing TRS-80 software.

floppy disks. The expansion interface also contains a Centronics parallel port for the TRS-80 line printer, a real time clock, and a card socket for addition of a RS-232C serial port.

Program storage on cassette tape has its disadvantages. All data is recorded sequentially. While it is possible to record tape segments by leaving blank areas between the tape segments, it is necessary to load the entire segment into your microcomputer in order to retrieve a program stored in that segment. This procedure is complicated at best. In addition, data transfer from cassette tape is slow.

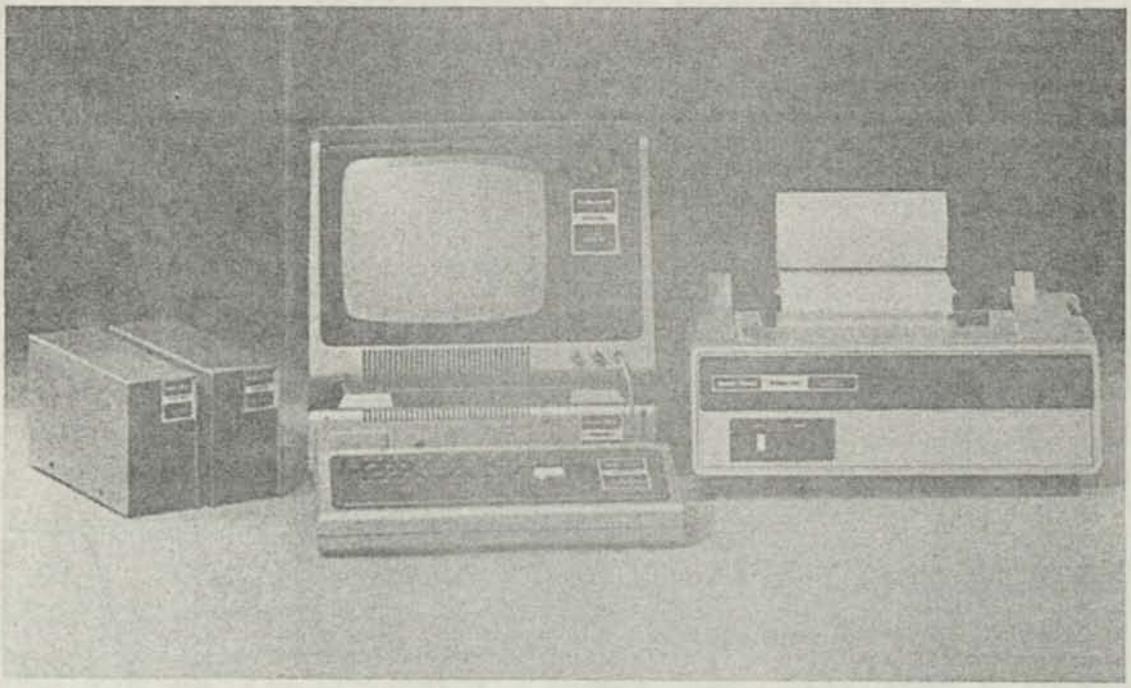


Figure 6-6. The TRS-80 Business System includes the TRS-80 line printer and dual Mini-Disk systems. Photo courtesy of Radio Shack International Headquarters.

Addition of the TRS-80 Mini-Disk system permits the storage of 80 kilobytes of information per disk. Thus four Mini-Disk units permit on-line storage of 320 kilobytes. Data can be retrieved or stored at a rate of 125 kilobytes per second—a fantastic speed compared to cassette loading rates. Because of the nature of disk storage, a program can be accessed and loaded into the TRS-80 microcomputer in an average of 500 milliseconds. A Mini-Disk unit requires Level-II BASIC, 16K RAM, and the expansion interface. It enhances Level-II BASIC by adding 15 extra features. The TRS-80 Mini-Disk is shown in Figure 6-5 and in Figure 6-6.

The capability of producing a printed copy of what you see on your CRT display is a highly desirable feature for any microcomputer system. One of the lowest cost printers available is the TRS-80 screen printer visible in the chapter heading photograph and in Figure 6-5. Any TRS-80 microcomputer can use this printer. No interface is needed as the printer is driven directly from your TRS-80. Everything on the CRT display including graphics is printed on 4-inch wide electrostatic paper at a speed of 2200 characters per second. All you need do is press a button.

Radio Shack also offers the TRS-80 Quick Printer. It uses a 5-by-8 dot matrix format, and like the TRS-80 screen printer, it prints on aluminized 4.75-inch paper. Print density is 20, 10, or 5 characters per inch (software selectable) and print speed is up to 150 lines per minute. It requires the TRS-80 expansion interface and Level-II BASIC. The TRS-80 Quick Printer is priced in the economy printer range. Its low cost combined with its convenient size and high print speed make it an attractive peripheral for many TRS-80 systems.

The Radio Shack TRS-80 line printer is visible in Figure 6-5 and Figure 6-6. It adds a new dimension to any microcomputer system. It prints characters in the 5-by-7 dot matrix format of the CRT display with 10 to 16.5 characters per inch. The printer uses roll paper up to 9.8 inches wide, and the printing speed varies from 60 to 100 characters per second. It can print virtually anything that can be printed by an ordinary typewriter. It can print on roll business forms to produce invoices, inventory printouts, and payroll checks to name but a few possibilities. The TRS-80 line printer requires only 4K RAM and Level-II BASIC plus the TRS-80 expansion interface.

Another useful peripheral offered by Radio Shack is the TRS-80 Telephone Interface II. With this peripheral you can either send or receive data from other computer equipment over the telephone at a data transfer rate of 300 baud. It converts serial data from the TRS-80 RS-232C serial interface board into audio tones that are then transmitted over the phone lines. Audio tones are also received, decoded, and transmitted through the interface to the TRS-80. This device is useful for exchanging data and programs with other microcomputer owners as it saves the time necessary to deliver an audio cassette or floppy disk.

TANDY BUSINESS SYSTEMS

The TRS-80 microcomputer system can be used successfully in a small business. The chapter heading photograph shows the TRS-80 Professional System. It includes the TRS-80 microcomputer with 16K RAM, the 12-inch video display, CTR-41 cassette recorder, TRS-80 expansion interface, TRS-80 screen

printer, and TRS-80 Mini-Disk. This system is useful for applications such as scientific, engineering, and statistical calculations and software development.

For serious business applications at least two floppy disk drives are essential. In rare instances a disk drive may malfunction destroying the data stored on the disk. If your system has dual disk drives, you can make copies of important data files stored on disk. Then, if important data files are accidentally lost or destroyed, it is possible to reproduce them from the backup disks. Also most business applications require a high-quality printer such as the TRS-80 line printer. The TRS-80 Business System shown in Figure 6-6 includes the TRS-80 microcomputer, the TRS-80 video display, CTR-41 recorder, TRS-80 expansion interface, TRS-80 line printer, and dual Mini-Disk drives. The system offers 32K RAM with 16K RAM available as an option. Possible applications include general ledger, payroll, accounts receivable, accounts payable, inventory control, mailing lists, sales and market analysis, and use in medical and

Figure 6-7. The Tandy 10 system supports complete business applications for under $10,000. Photo courtesy of Tandy Computers.

dental offices. Radio Shack offers a large amount of software for these applications.

For complete business applications the Tandy Corporation offers its Tandy 10 system priced under $10,000. The Tandy 10 system is shown in Figure 6-7. It consists of a workstation with diskette drives integrated into a compact metal desk, and a separate dot matrix printer that prints 60 characters per second. Faster printers are available as options. The workstation includes a video display, professional standard keyboard, 10-key calculator pad for numeric entry, and 15 special function keys for data editing. With optional peripherals it can be used as an intelligent terminal to access larger data systems. The Tandy 10 features a dual disk drive. Each diskette can hold up to 256,000 characters providing a total of more than one-half million characters of on-line storage. Standard system RAM is 40,960 characters. A screen formatting language allows the user prompting for data input. The Tandy 10 comes with extended BASIC. Also available as options for the system are FORTRAN IV and Assembly Level programming languages.

MANUFACTURER SUPPORT

Radio Shack offers support for its microcomputers and peripherals that most manufacturers have yet to duplicate. It has established a nationwide chain of service centers that can repair and return to the customer his microcomputer or peripheral within 4 to 7 days depending on his location. In the large metropolitan centers service may be even faster. Since system dependability is very important for small business applications, the quality and speed of service is definitely a consideration in the choice of a microcomputer system. The location of the Radio Shack or Tandy store nearest you is listed in the Yellow Pages of your local telephone directory.

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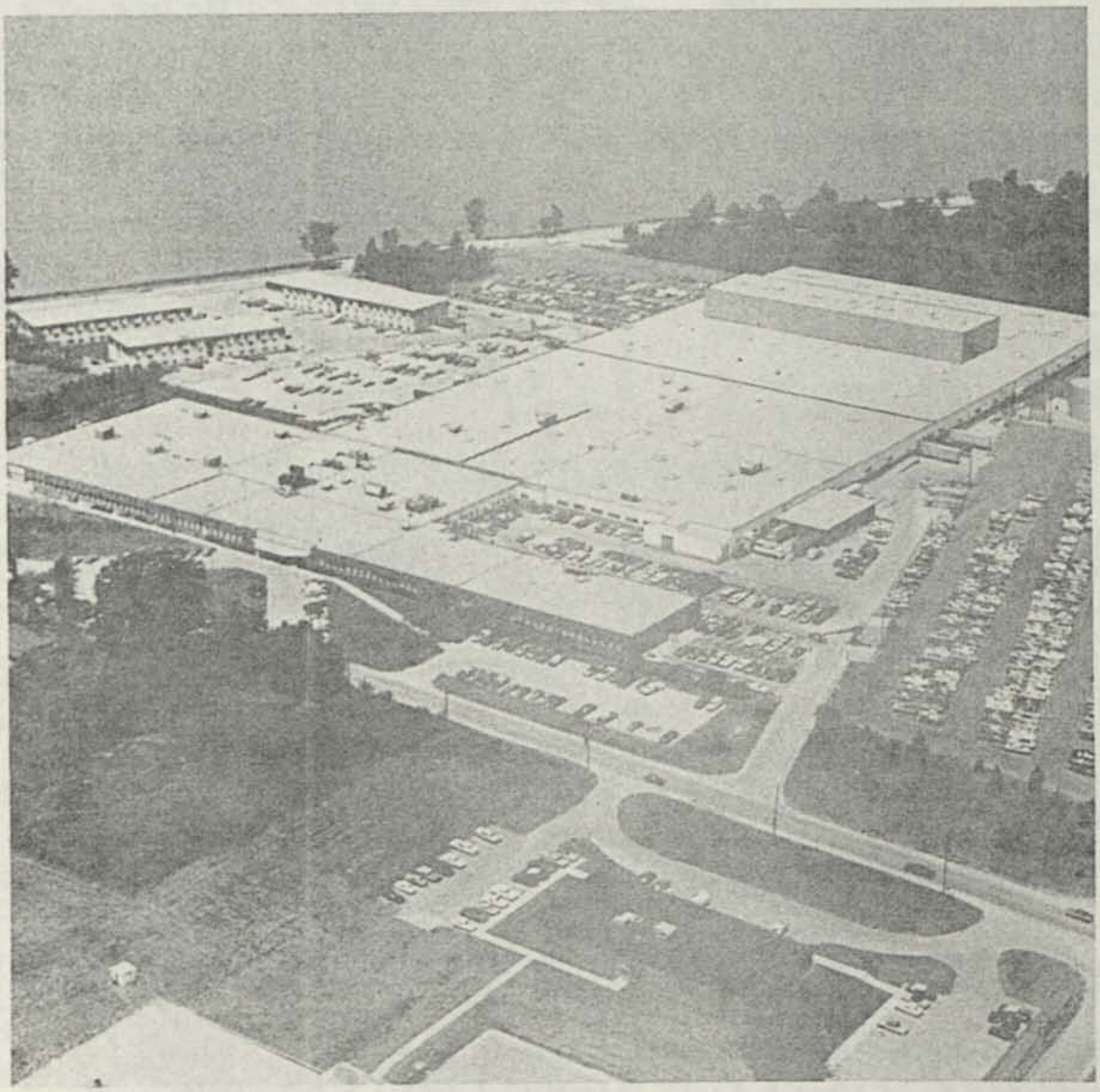

THE HEATHKIT MICROCOMPUTER SYSTEMS

Many hobbyists find construction of microcomputer kits to be extraordinarily rewarding. Not only can kit construction be fun, but the monetary savings are significant. In addition, a microcomputer kit builder usually acquires a working knowledge of his equipment and is capable of making repairs himself should a malfunction occur. It takes some self-assurance to invest hundreds of dollars in a microcomputer kit, but the better kits such as those offered by Heathkit include detailed assembly manuals, and the chance of failure is small.

Many of the microcomputer components offered by Heathkit have been described in previous chapters, and we discussed kit assembly methods in Chapter 5. In this chapter we describe the Heathkit microcomputer systems and their operation.

THE HEATHKIT H8 MICROCOMPUTER

The Heathkit H8 microcomputer shown in Figure 7-1 is an 8-bit machine based on the Intel 8080A microprocessor. It incorporates a 16-key octal keyboard for data entry and a 9-digit LED display for address, data, and I/O port readout. The system bus is a special Heath design incorporating a 50-pin bus connector that permits attachment to the motherboard of up to 10 plug-in circuit boards including the front panel and CPU circuit boards. Four 8K RAM circuit boards plus a H8-2 parallel

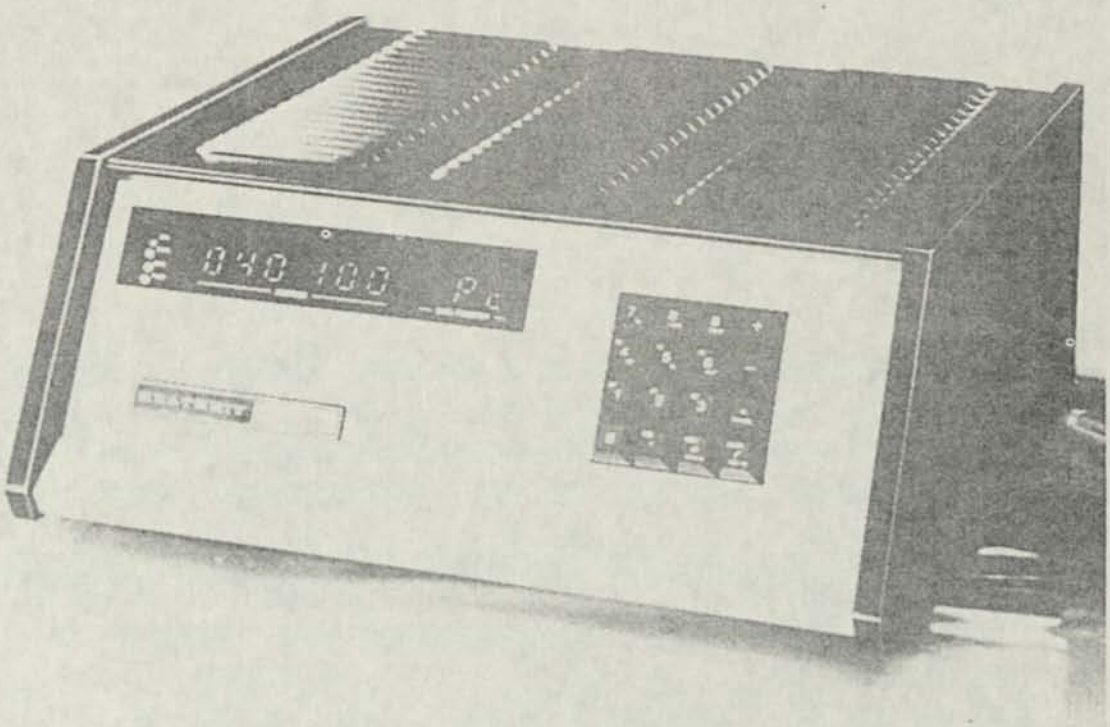

Figure 7-1. The Heath H8 microcomputer with front panel digital display and 16-key octal keyboard. This is a powerful 8-bit machine based on the 8080A CPU. Photo courtesy of the Heath Company.

I/O port circuit board plus a H8-5 serial I/O port circuit board with cassette interface can be attached to the motherboard to increase the computing power of the H8 microcomputer. The serial I/O port features eight data transfer rates from 110 to 9600 baud. The cassette interface operates at 1200 baud, and this data transfer rate matches the format of the Heath software offered on tape cassette. Heath offers its ECP-3801 audio cassette recorder/player for both the H8 and H11 microcomputers. The basic H8 microcomputer includes a heavy-duty power supply, front panel, and CPU. A minimum of 4K RAM is required for microcomputer operation, and this is purchased separately.

The flexibility of the Heathkit H8 microcomputer system is enhanced by the large amount of utility software offered for the H8 by the Heath Company. Utility software is software used by the programmer to create applications software in order to solve specific problems. For instance, the BASIC interpreter is utility software because it allows the programmer to run

programs written in the high-level BASIC language. The Heath software is available on 1200-baud audio tape cassette or alternately on punched paper tape. (The panel monitor is in ROM.) It includes the following:

PANEL MONITOR (PAM-8)

This ROM program controls the front panel and permits you to load, dump, execute, and debug programs written in 8080 machine language. It allows you to examine and alter memory locations and microprocessor registers and to control program execution. It provides self-contained bootstraps for one-button program loading or dumping, and it provides port input and output routines.

BENTON HARBOR BASIC

Two versions of BASIC are available for the Heathkit H8: 4K BASIC and extended Benton Harbor BASIC. BASIC is a conversational programming language that uses simple English statements for instructional commands. It can be used for data manipulation and to solve complex algebraic problems. The 4K BASIC plus program statements require a minimum of 8K RAM and the extended BASIC requires 16K RAM. The extended BASIC is quite flexible and offers features such as character strings, expanded math functions, dynamic storage allocation, access to a real time clock, keyboard interrupt control, and many extra commands.

ASSEMBLY LANGUAGE (HASL-8)

With this two-pass assembler you can create source programs using letters, numbers, and symbols. The source program is assembled into an efficient machine language object program that can be executed by the H8. This software requires a minimum of 8K RAM.

THE TEXT EDITOR (TED-8)

This software converts your Heath H8 and video display terminal into an electronic typewriter. It generates the source code for H8 assembly language, BASIC, and other languages, and it can be used for word processing applications such as preparation and editing of reports, letters, and manuscripts. A minimum of 8K RAM is required.

CONSOLE DEBUGGER (BUG-8)

This is an enhanced and extended version of the PAM-8 front panel monitor. It requires 3K RAM. It permits entry and debugging of machine language programs using an external terminal. It offers single or multiple stepping through programs, breakpointing, and load/dump from tape storage.

THE HEATHKIT H11 MICROCOMPUTER

The Heath Company offers the 16-bit Heath/DEC H11 microcomputer. This is a kit form of the LSI-11 computer offered by the Digital Equipment Corporation (DEC). The Heath/DEC H11 features a bus electrically superior to most other microcomputer buses. It has 38 high-speed lines for data address, control, and synchronization. Data and control lines are bidirectional, asynchronous, open-collector lines that provide a maximum data transfer rate of 833K words per second under direct memory access (DMA) operation. The KD11F circuit board contains the LSI-11 CPU and 4096 words of 16-bit MOS RAM. It comes fully assembled and tested. The LSI-11 CPU executes the PDP-11/40 instruction set that contains over 400 powerful instructions. With additional memory cards the memory capacity contained in the H11 cabinet can be expanded by 20K words to 32K words total. The Heath Company offers the H11-2 parallel interface for interfacing to peripherals requiring parallel input-output such as the H10 paper tape reader/punch. The H11-5 serial interface is offered for peripherals requiring serial input-output such as the H9 video terminal or the LA36 teleprinter. The Heath/DEC H11 is shown in Figure 7-2.

The computing power of the Heath/DEC H11 is very high for its cost. This computing power places the H11 somewhere between minicomputers and microcomputers. The H11 is a 16-bit machine meaning that it handles data 16 bits at a time. While the hardware for a 16-bit machine is significantly more expensive than that for an 8-bit machine, the 16-bit machine is much more efficient for many applications. The Heath/DEC H11 is also available with the H11-6 extended arithmetic chip.

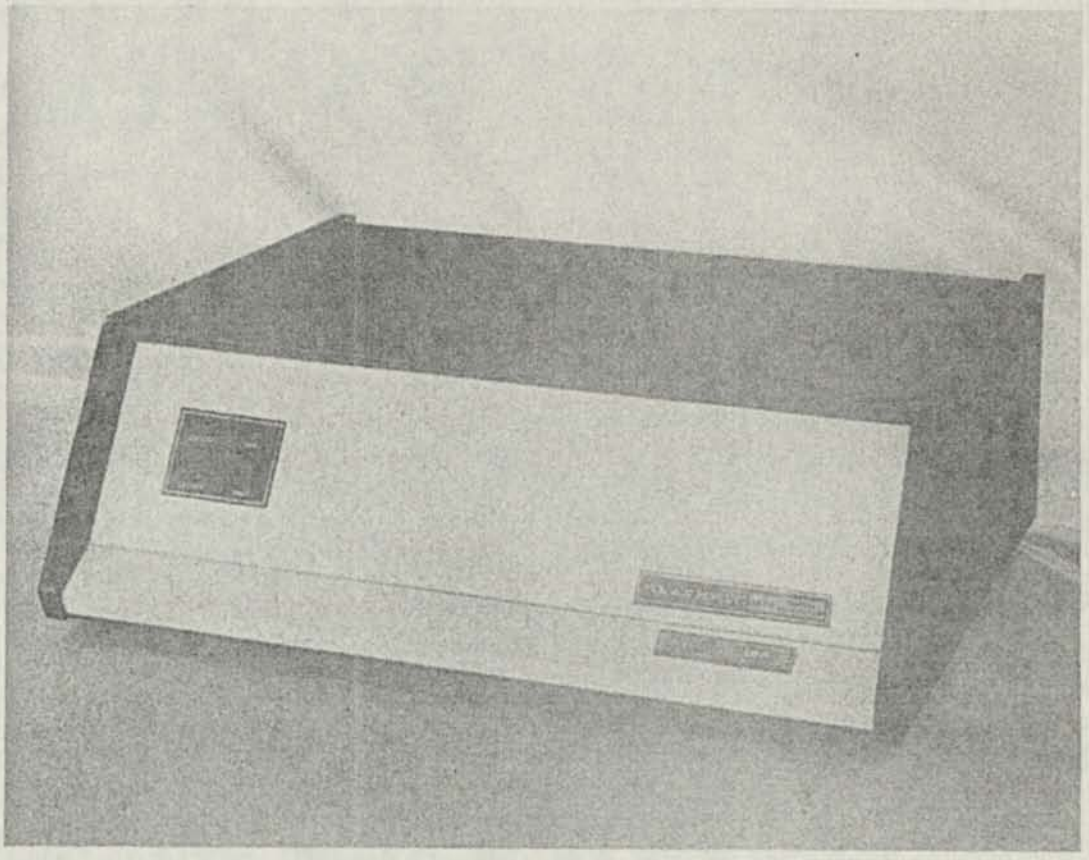

Figure 7-2. The Heath/DEC microcomputer is a powerful 16-bit machine that can use the versatile PDP-11 software. Photo courtesy of the Heath Company.

This adds powerful arithmetic instructions to the LSI-11 that execute the four basic arithmetic operations in fixed point or full floating point. The option is quite valuable for scientific and engineering calculations.

A debate goes on as to whether a 16-bit microcomputer or an 8-bit microcomputer is more cost effective. Several 16-bit microcomputers are available, and no doubt others will be introduced soon. The 16-bit microcomputer is probably better for applications involving extensive manipulation of numbers or for real-time control applications. However, for business and hobby applications an 8-bit machine may be optimum.

Because the Heath/DEC H11 uses the LSI-11 CPU, the H11 can use the software originally developed for the DEC PDP-11. This is a tremendous advantage as a large amount of PDP-11 software is available. The Heath Company offers an

extensive general applications software package with the purchase of the H11. The available software in part determines the power of a microcomputer system. Here is some of the H11 software available for beginning and advanced programmers:

ED-11

This program assists in the development and modification of ASCII source tapes. It can be used to write assembly language programs, and it can be used for general text editing/word processing applications.

PAL-11S

This is a relocatable assembler that converts ASCII source tapes into relocatable binary modules.

LINK-11S

This is a link editor that links modules produced by PAL-11S into load modules ready for execution.

ABSOLUTE LOADER

This program loads absolute binary tapes into H11 memory for execution.

ODT-11X

This program is used to debug programs you have created.

IOX

This is an I/O executive program used with the paper tape reader/punch and line printer.

DUMP-AB and DUMP-R

These programs permit you to dump the absolute binary contents of the memory to the paper tape punch/reader.

BASIC

This is DEC's version of the standard Dartmouth BASIC interpreter.

FOCAL

This is a simple yet powerful interpretive computer language developed by DEC. It is ideal for most scientific, engineering, and math applications. Both 4K and 8K versions are offered.

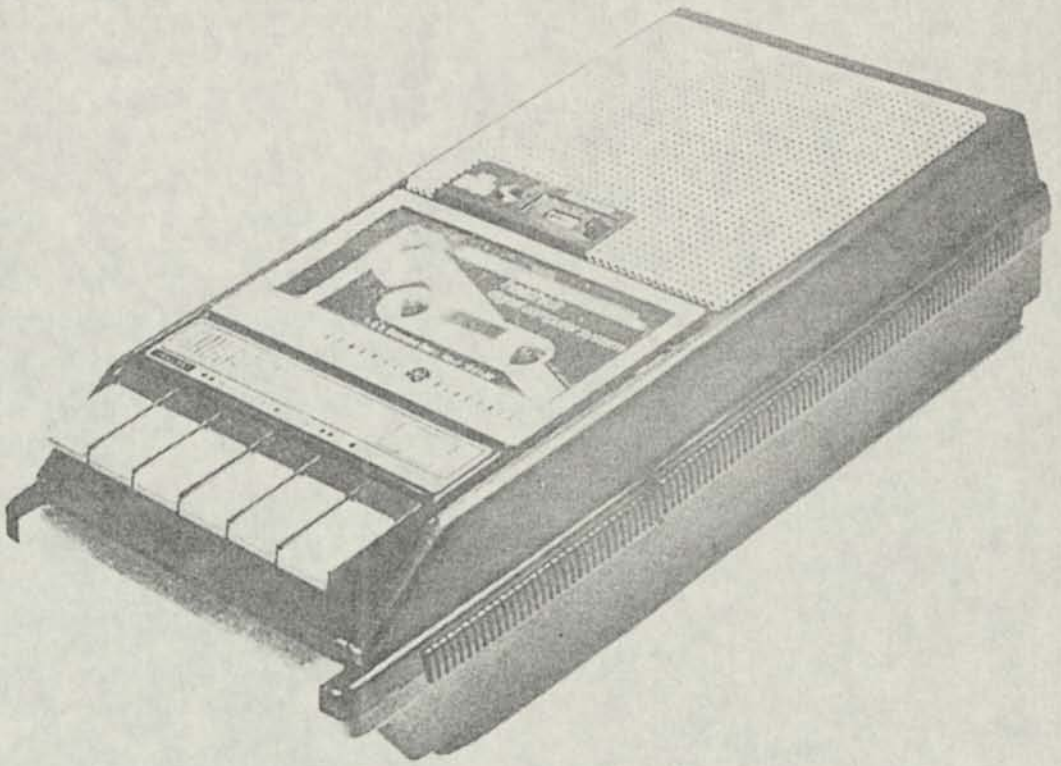

Figure 7-3. The Heath ECP-3801 audio tape cassette recorder/player is offered as a data storage medium for the H8 and H11 microcomputers. Photo courtesy of the Heath Company.

HEATHKIT PERIPHERALS

Most of the Heathkit peripherals for operation with the Heath H8 microcomputer and the Heath/DEC H11 microcomputer have been described in previous chapters. A Heath H8 or H11 system will generally include a H9 video terminal with keyboard as shown in Figure 2-2. For data storage the Heath Company offers its H10 paper tape reader/punch shown in the chapter heading photograph of Chapter 3 and the Heath ECP-3801 tape cassette recorder/player shown in Figure 7-3. Floppy disk systems are available for both the H8 and H11 microcomputers. The Heath WH-17 floppy disk system for the H8 microcomputer is shown in Figure 3-16. For hardcopy output the Heath Company offers its LA36 DEC Writer II printer terminal, which is shown in Figure 7-4. For more details about

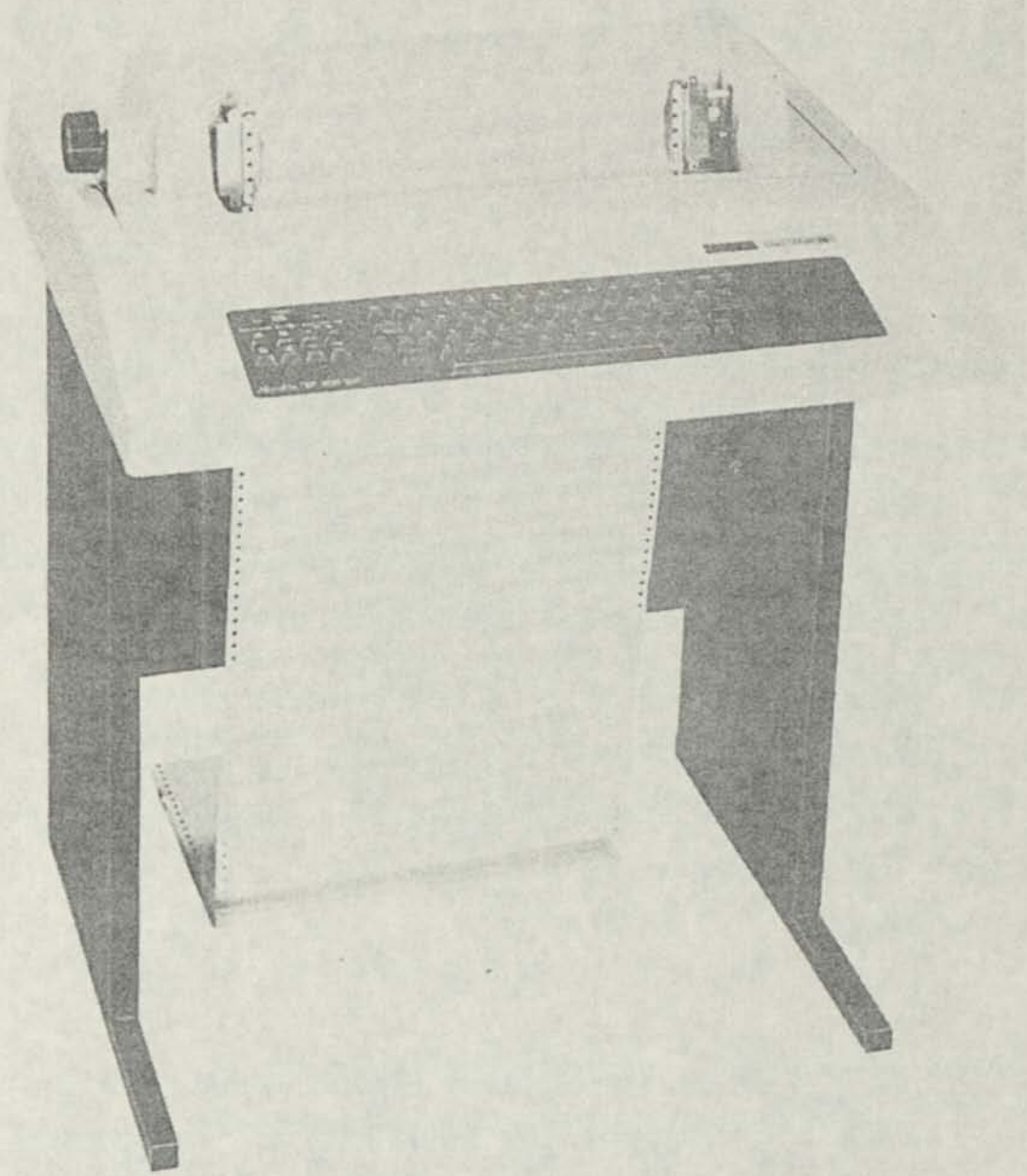

Figure 7-4. The LA36 DEC Writer II printer terminal has a maximum printing speed of 30 characters per second. It features a 7 x 7 dot matrix print format, and comes fully assembled. Photo courtesy of the Heath Company.

the Heathkit microcomputers and peripherals, contact the Heath Company, Benton Harbor, Michigan or visit one of the Heathkit Electronic Centers listed in Appendix II.

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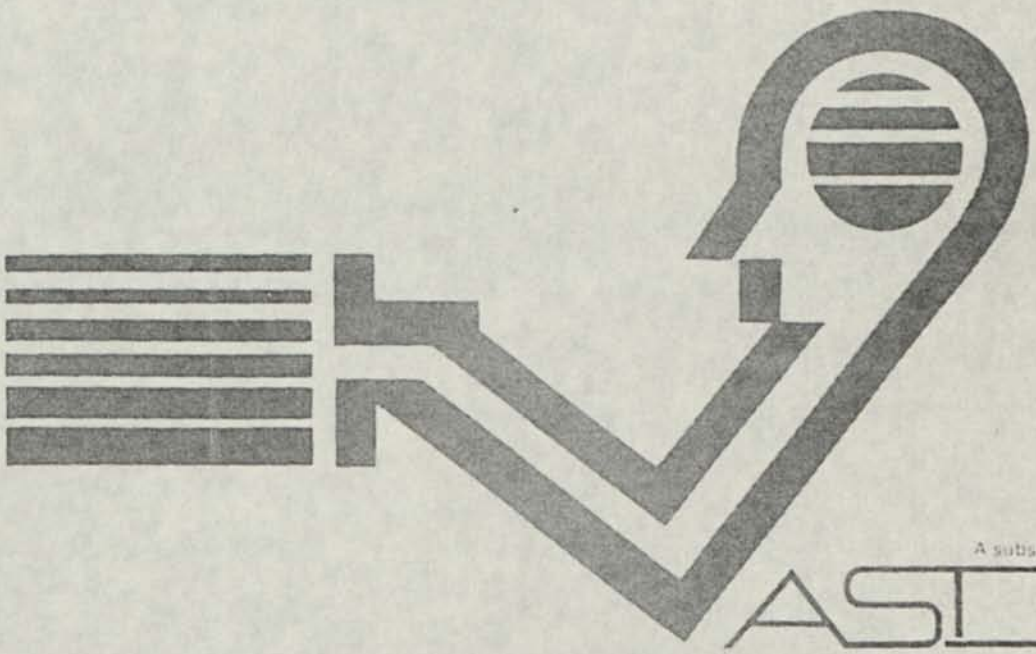

A subsidiary of MITS

ASDC

ALTAIR SOFTWARE DISTRIBUTION COMPANY

THE ALTAIR MICRO-MINICOMPUTER SYSTEMS FROM MITS/PERTEC

Micro Instrumentation Telemetry Systems, or MITS for short, was formed in 1969. In 1974 MITS originated personal computing with the introduction of the Altair 8800 microcomputer. MITS merged with Pertec in 1977 to become one of the largest manufacturers of micro/minicomputer systems in the United States. In just a few short years the Altair microcomputer product line has grown from microcomputer kits to include full minicomputer systems.

Systems is the key word for the small businessman. Few firms employing less than 250 employees can afford any of the large computers sold for accounting and payroll applications. Alternatively, tying into time-sharing computers for these vital business functions is usually much too expensive. Micro and minicomputer systems place computing power within the reach of over 3,600,000 small businesses. While MITS/Pertec offers systems to $15,000.00, the cost factor does not eliminate the hobbyist or experimenter. Altair basic microcomputer kits begin at slightly over $300 and are expandable as your requirements grow.

THE ALTAIR 8800b

The Altair 8800b microcomputer employs the Intel 8080A microprocessor. The MPU, ROM, and RAM circuit board connects to the Altair bus, which is also referred to as the S-100

bus. RAM expansion is accomplished by simply plugging in the RAM circuit boards you need. Numerous interface circuit boards are available to increase the flexibility of the Altair 8800b.

The Altair 8800b is available in two models. Figure 8-1 shows the Turnkey model, which contains only two functional control switches plus a keylock power switch. This Altair 8800b serves as the building block for a number of Altair microcomputer systems. It can be interfaced to minifloppy disk, floppy disk, and hard disk systems. Figure 8-2 shows the Altair dual Minidisk unit and diskettes.

For those who love to flip switches, the standard version of the Altair 8800b shown in Figure 8-3 contains 25 switches you can flip with delight. The switch functions include a "slow" command, which will execute a program at a rate of not more than two machine cycles per second. Normal program execution is at the rate of 500,000 machine cycles per second. A "display accumulator" switch permits the display on the front panel of the contents of the CPU accumulator. The "load accumulator" switch loads into the CPU accumulator the information speci-

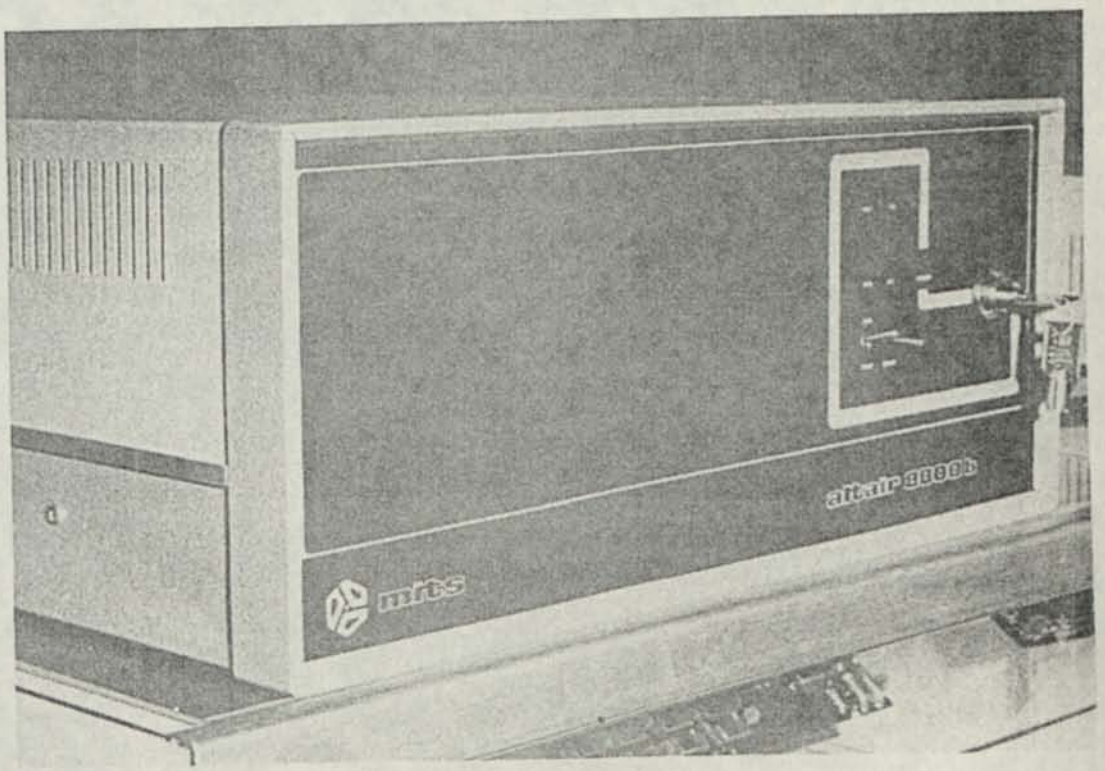

Figure 8-1. The Altair 8800b Turnkey microcomputer.

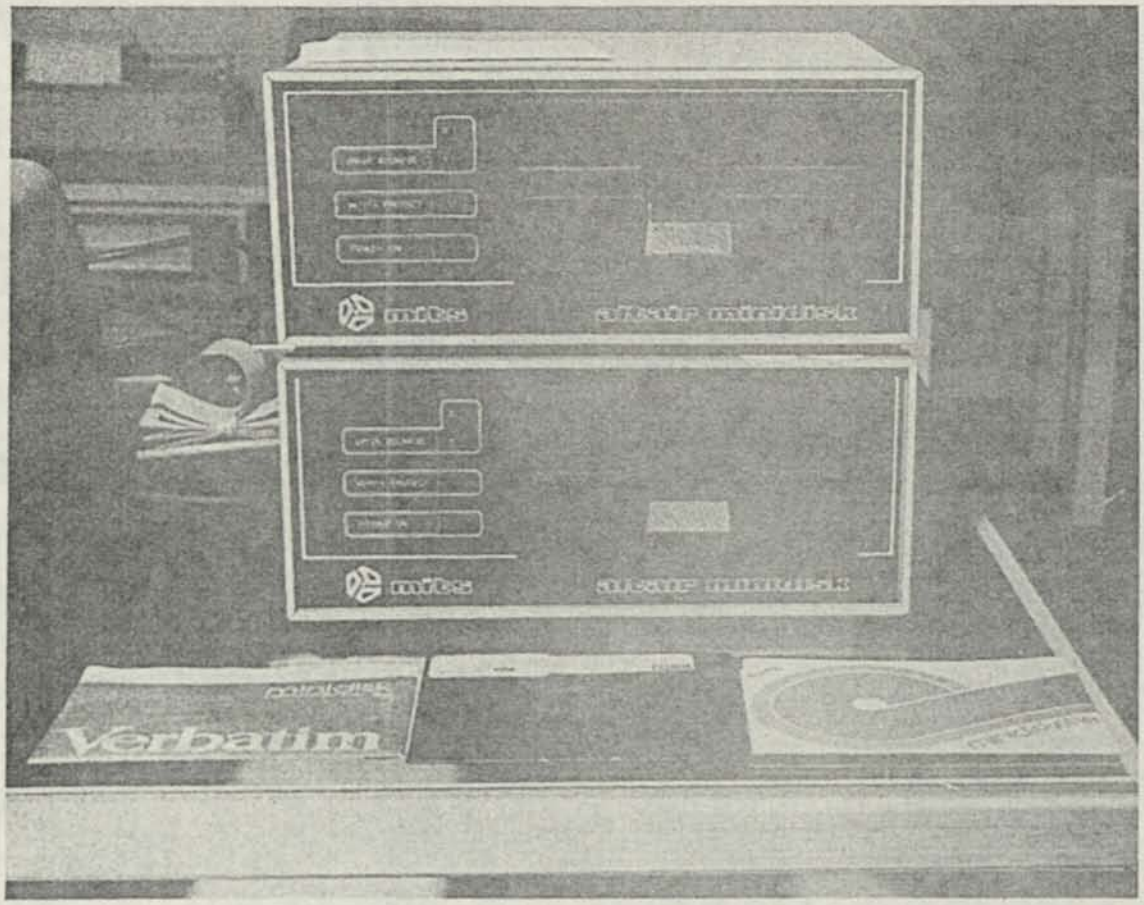

Figure 8-2. Altair Minidisk units and Minidiskettes.

fied by the lower eight address switches. There are eight I/O switches, which are used to manually input data into the microcomputer or send output CPU data to the selected I/O addresses. Figure 8-3 also shows the Altair floppy disk, which is companion to the Altair 8800b. It employs random access and sequential files for data storage and has a capacity of 300 kilobytes of data. The Altair 8800b PROM disk bootstrap loader permits loading Altair extended BASIC from disk in less than 10 seconds. Altair extended BASIC requires a minimum of 20K RAM. The disk drive read/write head life is over 10,000 hours of disk-to-head contact or five years of continuous daily usage.

THE ALTAIR MICROCOMPUTER SYSTEMS

Figure 8-4 shows the Altair small business microcomputer console. On the console desk top is a printer, a 12-inch CRT

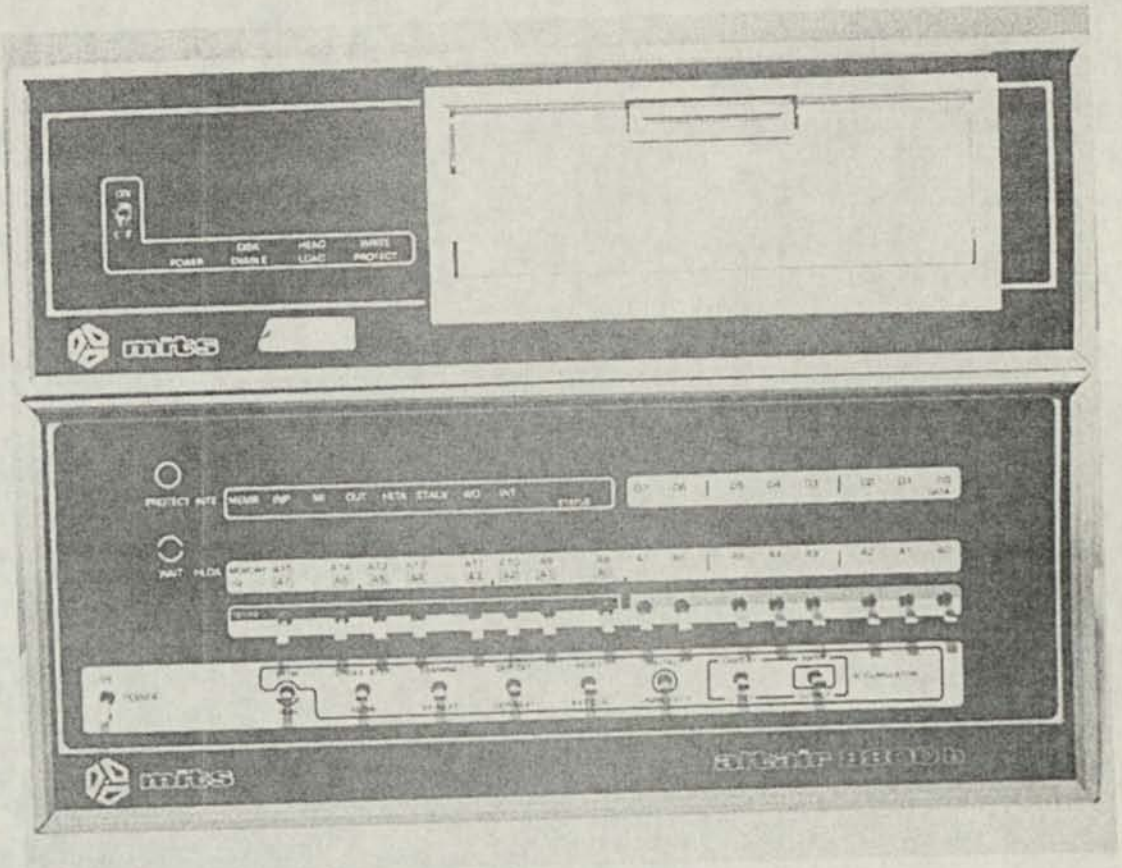

Figure 8-3. The standard Altair 8800b microcomputer with floppy disk drive.

display, keyboard terminal, and desk top storage racks for mini-floppy disks or floppy disks. At the left is the Altair 8800b Turn-key model microcomputer with a single floppy disk drive and a dual floppy disk drive. The combined data storage capability of this system is over 900 kilobytes. Doctors can use this system to maintain patient medical records and office inventories and to process accounts receivable and payroll. Electrical, plumbing, and mechanical contractors can use this system to greatly reduce the cost of preparing bids. Current cost per item can be entered on the floppy disk. Then bid preparation is a matter of recalling stored data and performing the necessary calculations of labor, overhead, and profit. These calculations may take only a few seconds. An advantage of this approach is that it is relatively simple to recompute the bid for a number of different initial assumptions.

This Altair system can be profitably used by small businesses such as:

The Altair Micro-Minicomputer Systems from MITS/Pertec

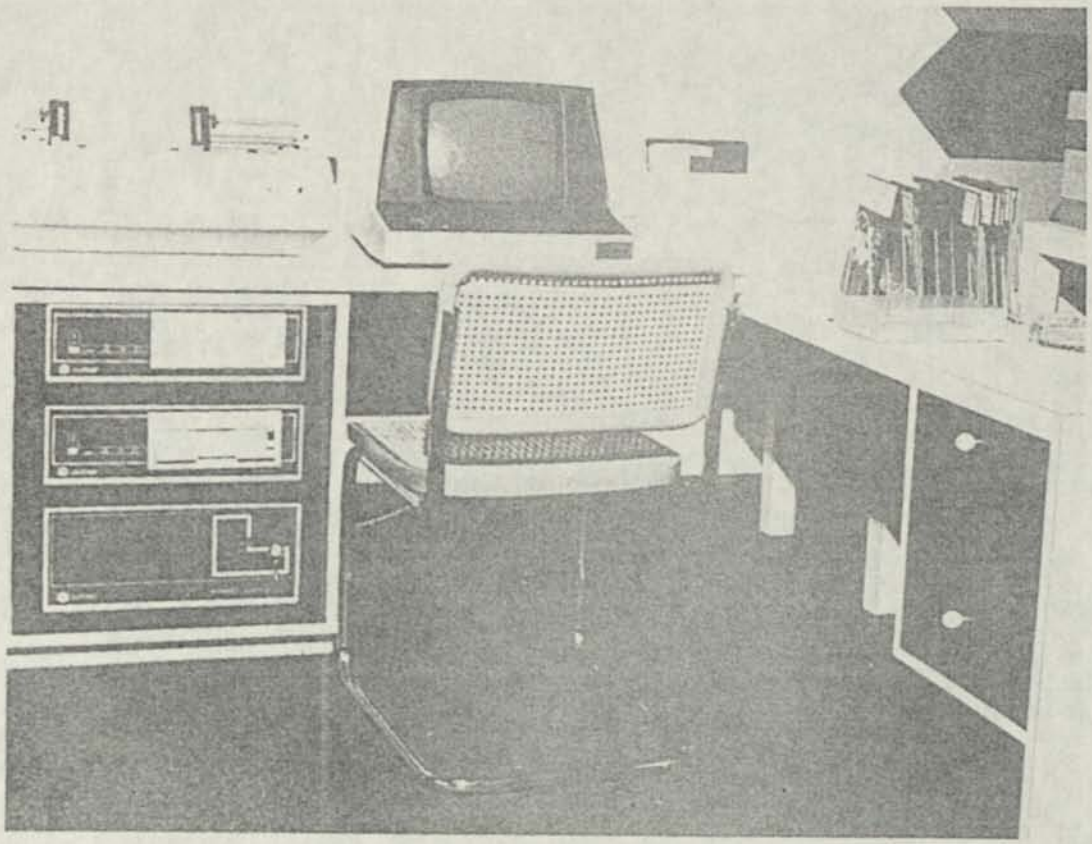

Figure 8-4. The Altair small business microcomputer console.

- Automobile repair shops
- Appliance and home entertainment firms
- Convenience food stores
- Clothing stores
- Shoe stores
- Drug stores
- Book stores
- Discount stores
- Lumber and hardware firms
- Parts distributors
- Electrical and electronic wholesale firms
- Building contractors
- Professional offices
- Engineers
- Educational institutions
- Manufacturing firms

For extremely large data storage capacity MITS/Pertec offers the Altair hard disk drive and controller. These are shown in Figure 8-5 with the Altair 8800b Turnkey model microcomputer. Depending on accompanying hardware, storage capacity of the hard disk system varies from 2 megabytes to 50 megabytes. This microcomputer system with hard disk is capable of full accounting procedures, payroll, and inventory control for businesses with annual sales up to $5,000,000. It also makes possible word processing applications including full editing of contracts and report generation.

Figure 8-5. The Altair hard disk drive and controller with the Altair 8800b Turnkey microcomputer.

The Altair Micro-Minicomputer Systems from MITS/Pertec

MITS/Pertec offers a number of expandable systems based on the Altair 8800b microcomputer. The user adds only those circuit boards required to interface with the peripherals he chooses. Each system requires a video terminal with keyboard, a printer, and one of the four Altair mass data storage systems. A comparison of these data storage systems will permit you to choose the one best suited to your business requirements:

THE MICRODISK SYSTEM

128 bytes per sector X 16 sectors per track X 35 tracks per disk = 71,680 bytes per disk. Data transfer rate = 125,000 bits per second.

THE MINIDISK SYSTEM

128 bytes per sector X 20 sectors per track X 40 tracks per disk = 102,400 bytes per disk. Data transfer rate = 125,000 bits per second.

THE FLOPPY DISK SYSTEM

128 bytes per sector X 32 sectors per track X 75 tracks per disk = 307,200 bytes per disk. Data transfer rate = 250,000 bits per second.

The storage capacity of the hard disk was mentioned above. These data storage capabilities may vary when a specific disk drive is used with different microcomputers. Because system performance is so closely tied to data storage capacity, choice of disk drive is one of the more important decisions made by the purchaser of a microcomputer system. For more guidance see Chapter 12 of this book.

Thousands of Altair 8800 and 680 microcomputers have been assembled from kits, and kit construction continues to be the lowest cost method of acquiring an Altair microcomputer system. For those who prefer a factory assembled microcomputer at modest cost, the MITS/Pertec Computer Corporation offers its iCOM Attache microcomputer. Figure 8-6 shows the iCOM Attache system complete with a 9-inch Sanyo video display and dual minifloppy disks for data storage. The iCOM Attache is available with 4K BASIC or 12K BASIC depending on the level of RAM purchased. Additional peripherals such as

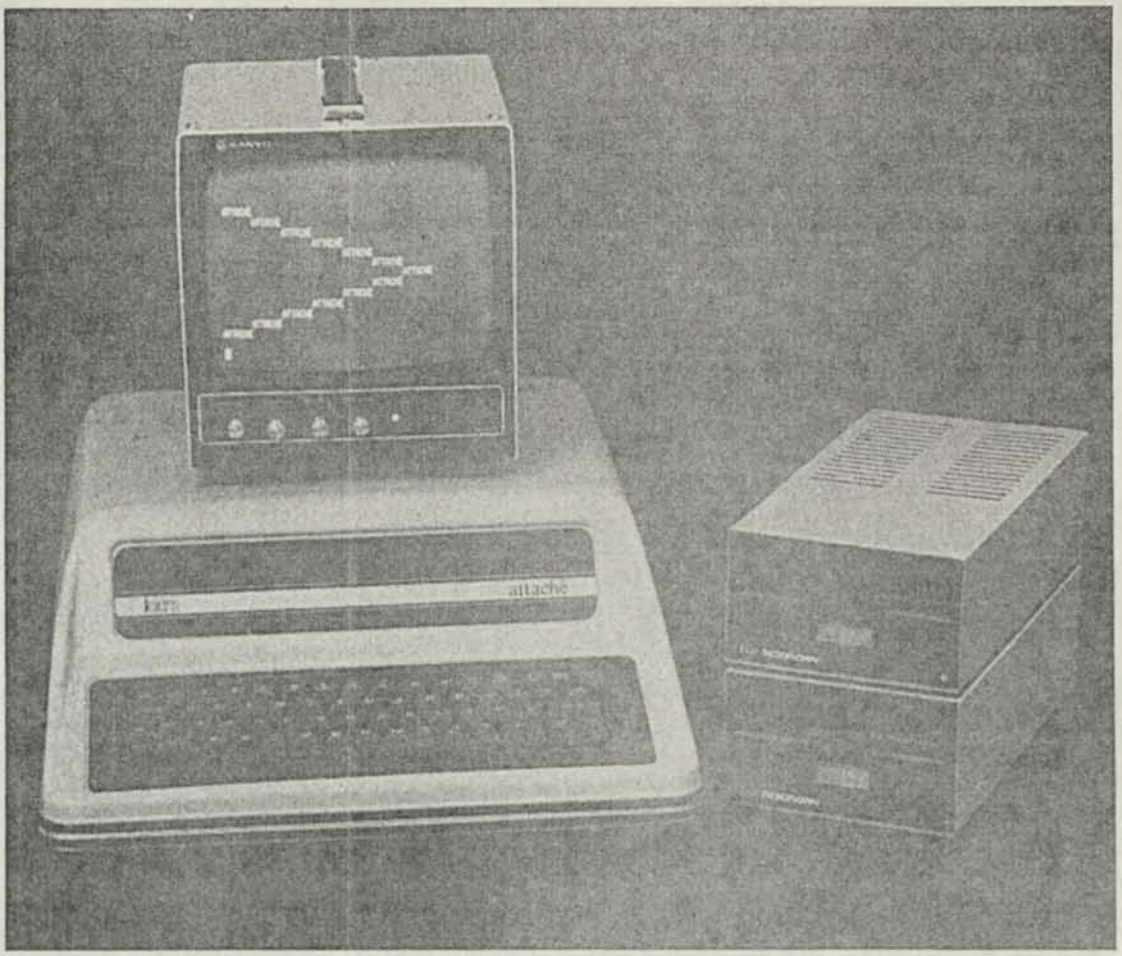

Figure 8-6. The iCOM Attache microcomputer and iCOM Microfloppy disk system.

minifloppy disk drives can be added as the need for data storage capacity increases.

The Altair Software Distribution Company, a subsidiary of MITS, is the software support arm for the Altair microcomputer systems. Comprehensive accounting systems, word processing systems, and inventory systems are but some of the complete software support offered by ASDC for the small businessman. The ASDC catalog lists over 300 programs including microcomputer testing procedures, mathematical functions, and complex games.

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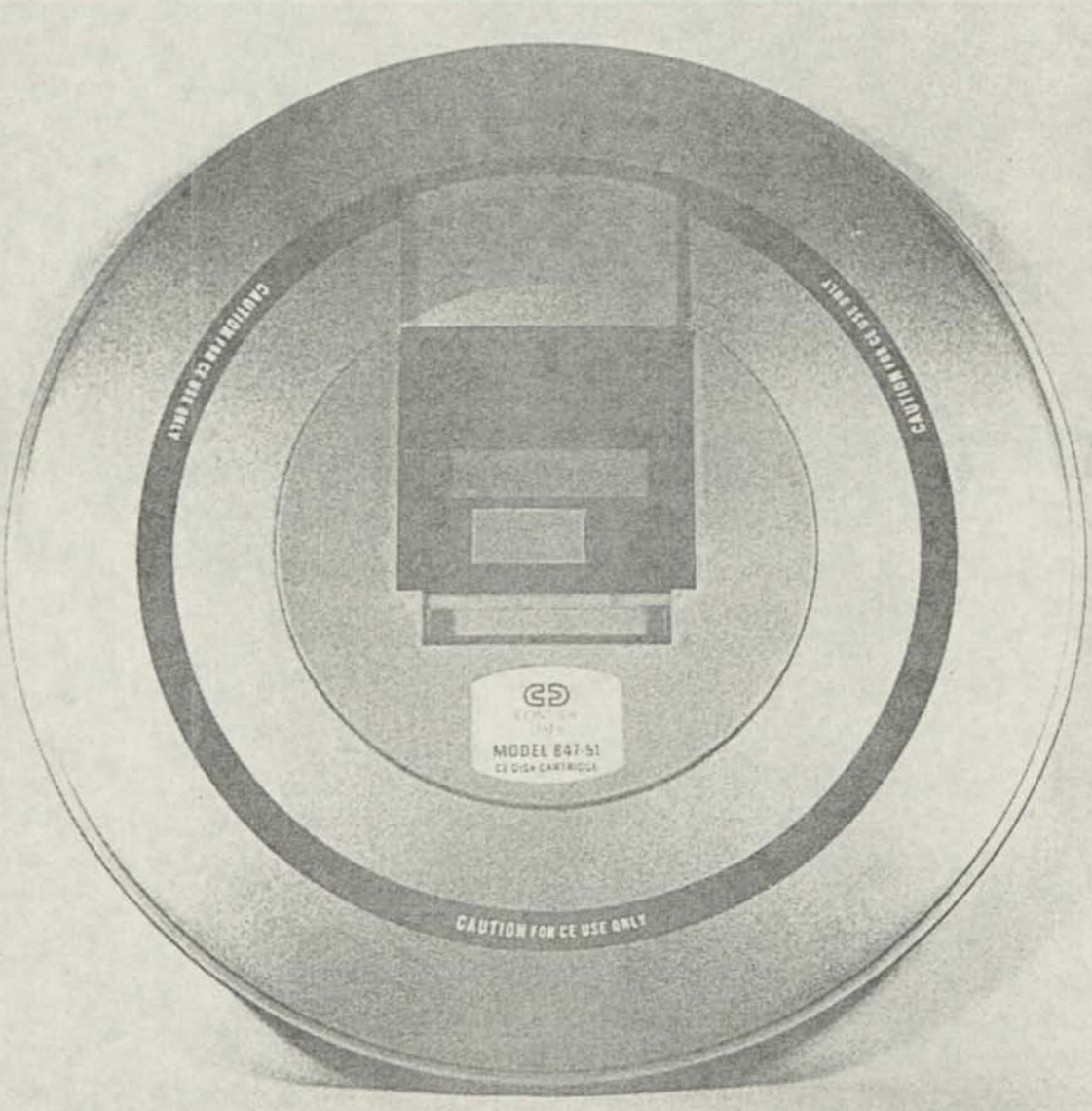


STILL MORE MICROCOMPUTER SYSTEMS

It would be ideal if we could select the best microcomputer components on the market and assemble them into our own personalized microcomputer system. After all, we already do this with high fidelity audio components. Unfortunately, the assembly of a microcomputer system from components is not as simple. Because of the lack of industry standards, many microcomputer components are incompatible. Even software may be incompatible between different microcomputer systems. For instance, each manufacturer offers a version of the BASIC language with certain unique features. Programs written in a particular version of BASIC are often incompatible with the version of BASIC offered by any other manufacturer.

The simplest solution is to purchase one of the complete microcomputer systems available with applications software. While this is the most expensive solution, it may be the best one if you lack the time to assemble a component system.

The addresses and telephone numbers of the manufacturers of products mentioned in this chapter are listed in Appendix II.

APPLE COMPUTER, INC.

Some microcomputer systems are so unusual that they merit special mention. One such microcomputer is the Apple II made by Apple Computer, Inc. of Cupertino, California. Figure

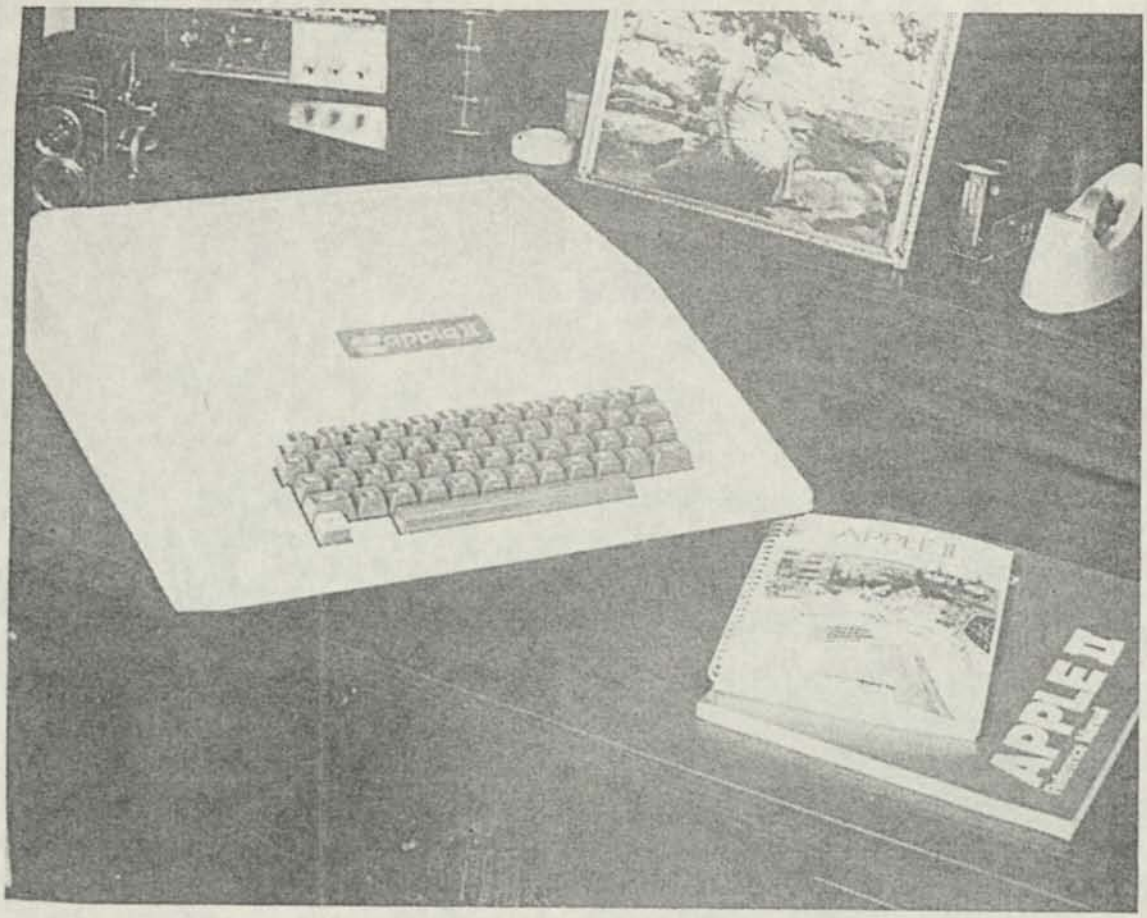


Figure 9-1. The Apple II desk-top microcomputer with color graphics capability.

9-1 shows the complete microcomputer. It is no larger than a portable typewriter case and weighs only 10 pounds. This microcomputer packs an extraordinary number of features into a small case. First, the Apple II offers a monitor, which is a powerful tool for the advanced programmer. Second, the Apple II can use a fast extended integer BASIC in ROM selected by operation of a control key. Audio cassette software is supplied for cassette loading at 1500 baud. This is one of the fastest loading rates available. The ASCII keyboard is included in the lightweight console. The memory of the Apple II is expandable from 4K RAM to as much as 48K RAM. The purchaser can start at any level and add RAM according to his budget and needs.

The Apple II includes a color graphics capability. The resolution is 48 vertical by 40 horizontal elements with a choice of 15 colors. For high resolution graphics the Apple II offers a

resolution of 192 vertical by 280 horizontal elements in 4 colors. You can use the Apple II with your home color or black-and-white television receiver. The video output can be connected directly to the internal circuitry of your TV receiver. Alternately, the Apple II can be used with a TV modulator, which is attached to the antenna terminals of your TV receiver. Figure 9-2 shows a UHF modulator for the Apple II. The television antenna switch on the modulator enables you to switch from television reception to the microcomputer display.

The interior view of the Apple II is shown in Figure 9-3. The 8 expansion slots for future peripherals are visible at the rear of the circuit board near the number 1. The microprocessor is the high-speed MCS6502 identified in Figure 9-3 by the number 2. The ROM containing integer BASIC is at number 3, and 16K RAM is located in the white outlined section, which is numbered 4. Space is available in the case to expand RAM to 48K. The

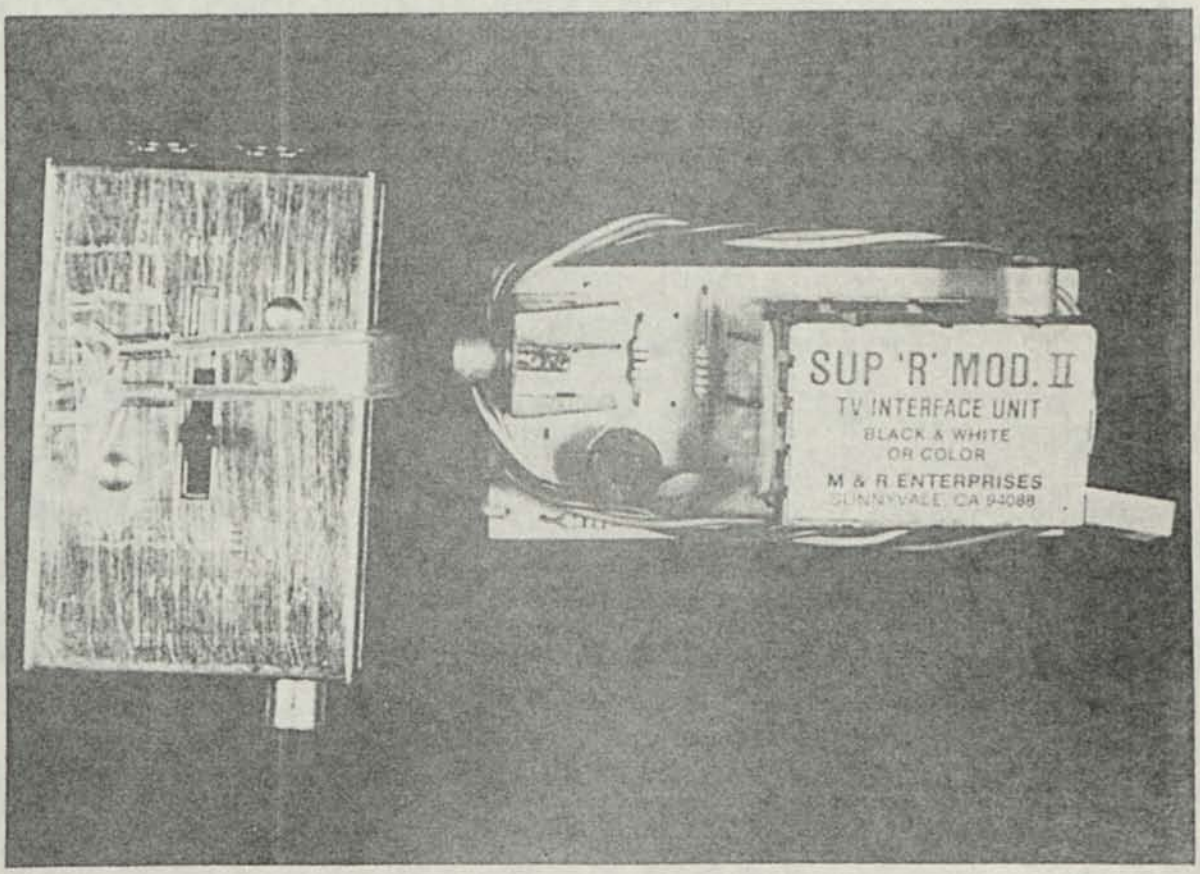


Figure 9-2. A UHF TV interface modulator usable with Apple II microcomputer.

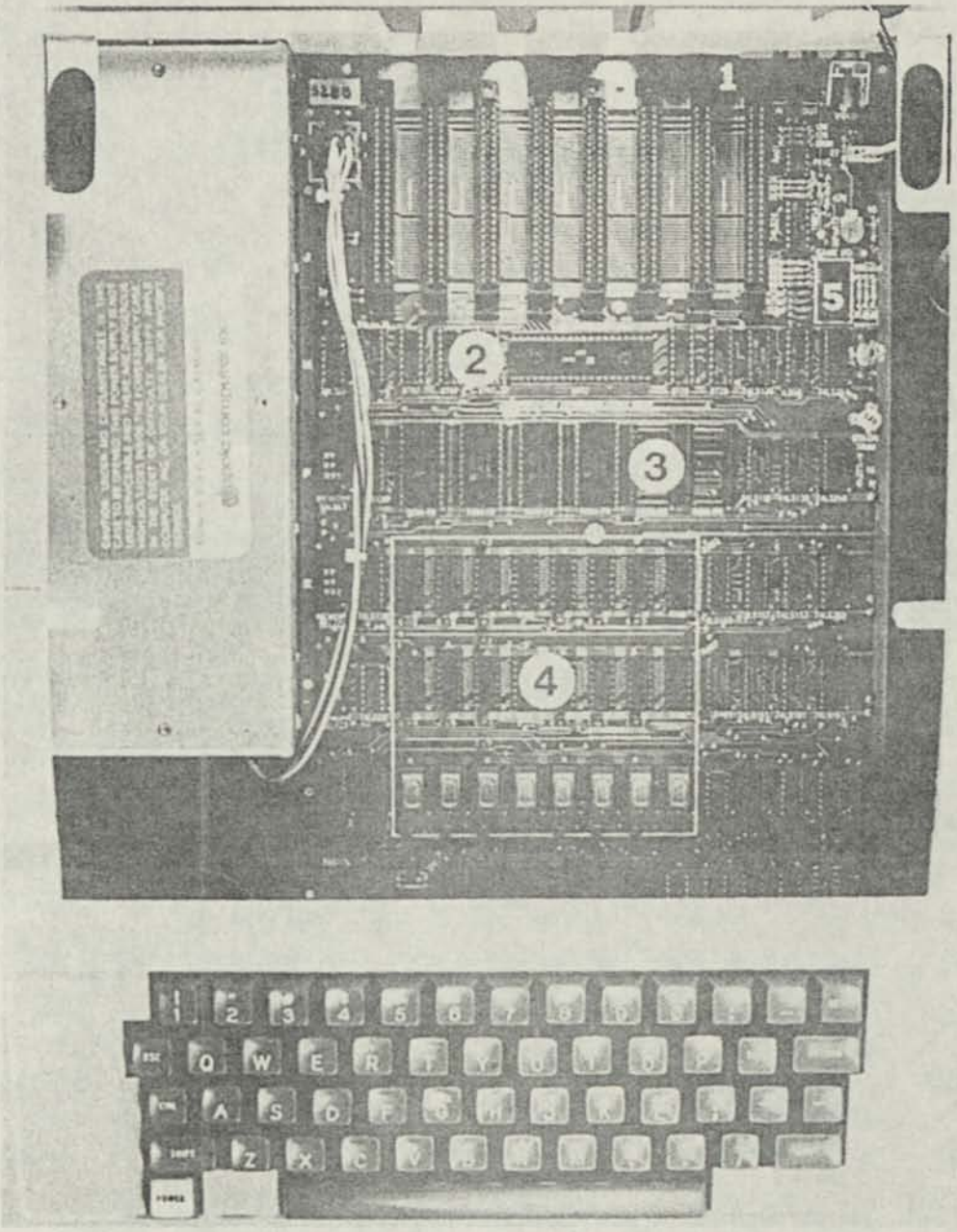


Figure 9-3. A top view of the principal features of the Apple II microcomputer.

Apple II also comes with 2 game paddle units. Programs are available for many games such as Star Trek in which you, as captain of the Starship Enterprise, fight the Klingons. The I/O port for the game controls is located at the right rear at number 5. An important peripheral for the Apple II is the Apple minifloppy disk, which plugs into one of the peripheral edgecard connectors provided for system expansion. While extra RAM is necessary, each disk drive adds 116 kilobytes of on-line storage capacity.

COMPAL

Each microcomputer manufacturer strives for those little extras that make his product unique. At COMPAL (Computer Power & Light, Inc.) this uniqueness is support in software and peripherals. COMPAL, which is based in Southern California, is one of the many microcomputer systems houses that are rapidly appearing. The best of these, like COMPAL, assemble a microcomputer system out of commercially available components or perhaps manufacture some of these components themselves. They then write software (microcomputer programs) for specific applications such as word processing, accounting, mailing list, payroll, billing, or inventory control. Often the application is as specific as inventory control for pharmacies, word processing for legal offices, or real estate analysis and property management. In addition, they offer customer support such as hardware service, software updating, preparation of detailed user manuals, programming classes, and user training classes. While the cost of such a microcomputer system with support services is considerably more than that of many systems on the market, the greater cost is generally justified for businessmen and professionals who want solutions to specific problems and who lack the time or technical expertise to assemble their own system.

COMPAL offers the COMPAL-80 microcomputer, which can be purchased either as components or as a complete system with peripherals to perform a specific application. The COMPAL-80 uses the Intel 8080A microprocessor, and it offers an onboard real time clock. RAM starts at 16K and is expandable to 64K as your system needs expand. I/O ports include a 300 and a 2400 baud audio cassette interface and a serial port. The latter can be configured for the EIA RS-232 format for serial peripherals or in either a 20 mA or 60 mA format for Teletypes and similar devices. The video display offers the full ASCII upper and lower case characters in a format of 16 lines of 64 characters each. For graphics the video display uses a 48 vertical by 128 horizontal element format. The COMPAL-80 is shown in Figure 9-4.

COMPAL offers extensive software support for their systems. The COMPAL Wordpal software package is a powerful video-oriented word processor that edits, prints, stores, and re-

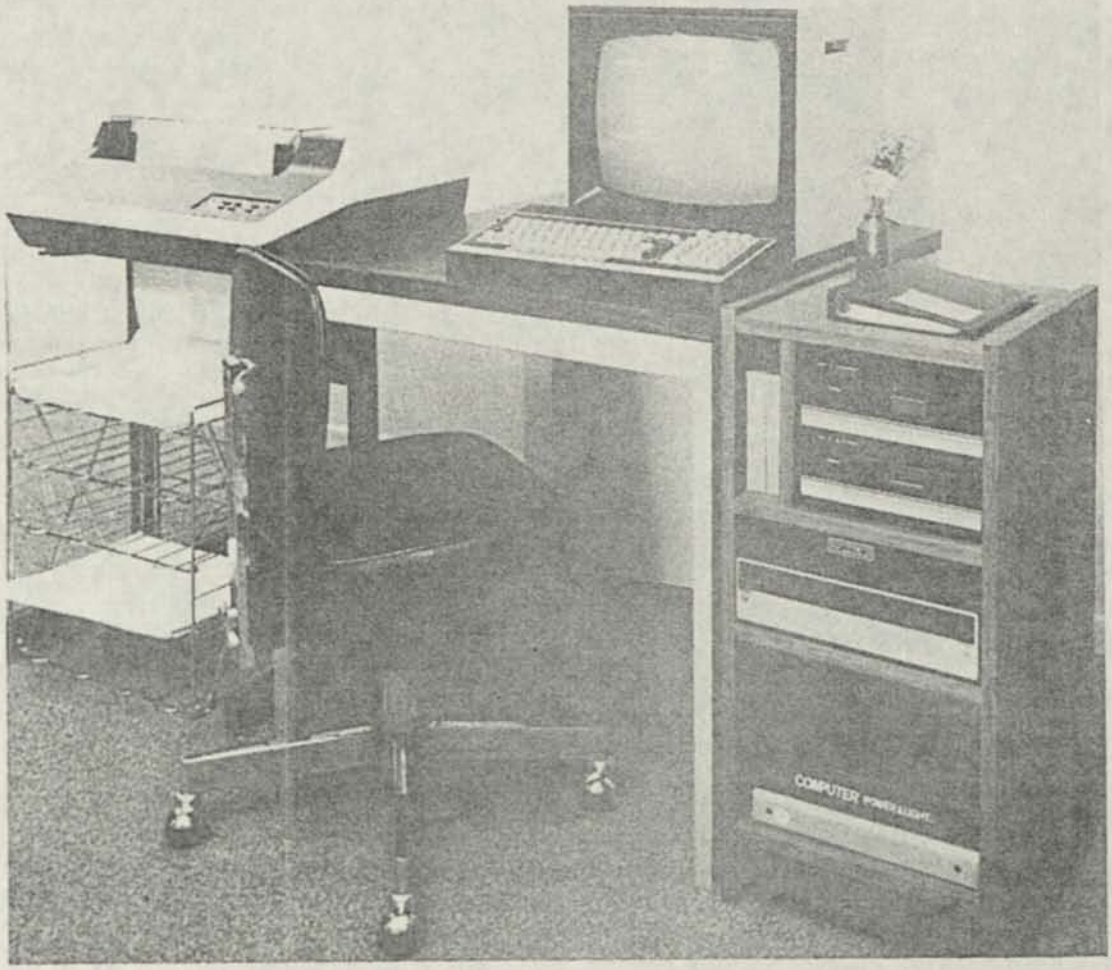


Figure 9-4. The COMPAL-80 customized microcomputer system.

trieves text. It can be used to produce business letters, to assemble long contracts or proposals, or to edit working drafts. The editing function allows the user to insert or delete any character, word, line, or block in up to 350 standard pages of text. For instance, one command can replace any phrase with any other phrase specified by the user wherever it appears in the text. The Wordpal can then print the text at up to 540 words per minute with automatic pagination, right justification, variable line pitch (3 to 15 characters per inch), and variable margins as specified by the user.

COMPAL also offers its CBA software packages for payroll, monthly invoicing, accounting, real estate analysis, and sales follow-up. The payroll software can handle up to 75 employees. The accounting software does automatic double entry

and produces journals, trial balance, general ledger, balance sheet, and income statement. A mailing system is available to handle up to 3000 entries. For schools software is available for grade reporting. It automatically scores tests, keeps student records, and prints reports. Custom software modifications are also available to owners of the COMPAL systems.

CROMEMCO INCORPORATED

Often the expression "most powerful microcomputer on the market" is used to describe a particular make. To what features does this phrase refer? Logically, it might mean memory capacity, CPU speed, or even power supply capability. The Cromemco Z-2 shown in Figure 9-5 excels in all these respects. The Cromemco Z-2 boasts the ability to organize either 4K or 16K RAM cards into 8 banks of 64K each. Any one of the 8 banks can be selected as needed by means of an 8-position switch. The total memory capacity is 512 kilobytes RAM with complete inboard availability. Cromemco utilizes a special Z-80 microprocessor with a 4 megahertz clock. Minimum instruction execution

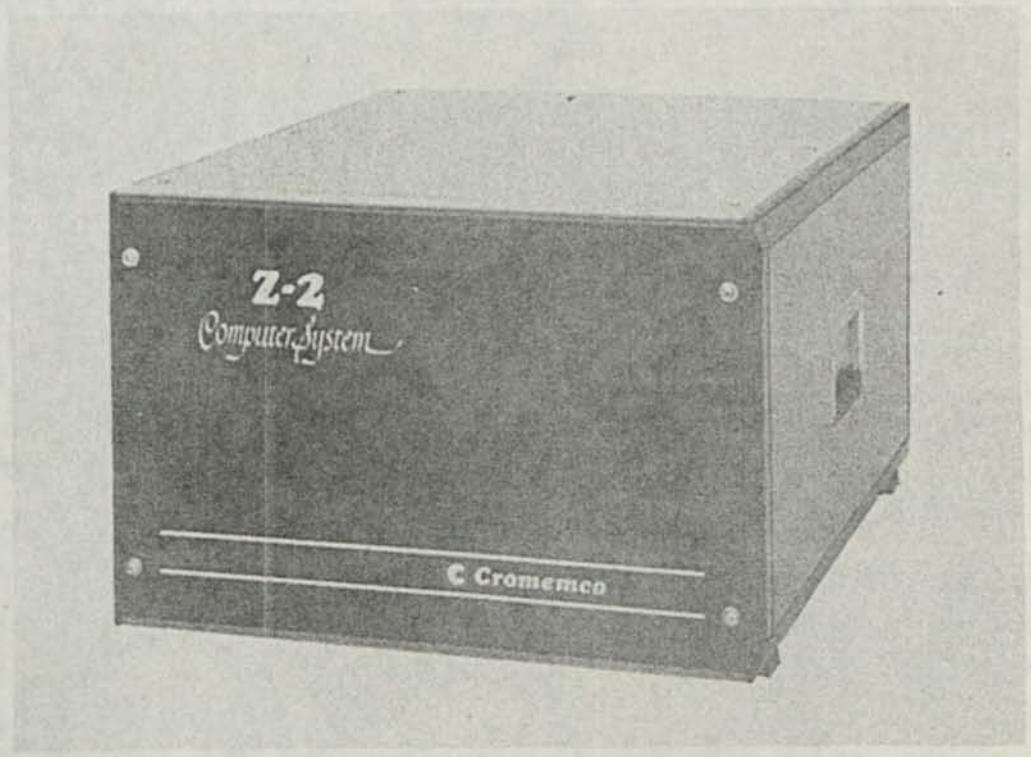


Figure 9-5. The Cromemco Z-2 microcomputer.

time is 1 microsecond. The Z-80 has an instruction set of 158 instructions and can use Cromemco 16K Z-80 BASIC, Cromemco FORTRAN IV, and Cromemco Z-80 Assembler languages and programs. A 30-ampere on-board power supply can furnish full operating power to the 21-card motherboard.

The Cromemco Z-2D microcomputer shown in Figure 9-6 has dual 5-inch disk drives, which together provide up to 184 kilobytes memory. Additional Cromemco interfaces include 8K and 16K PROM cards, the TU-ART digital interface, a disk controller card, and the TV Dazzler. This last item is a color graphics interface that displays microcomputer memory content in full color on your home color television set. The Cromemco TU-ART digital interface is used to interface with CRT terminals, printers, modems, and other such peripherals. The D+7AI/O multi-channel microcomputer analog interface shown in Figure 9-7 is invaluable for process control and other specialized applications. Other peripherals offered by Cromemco include CRT terminals, printers, and additional disk drive units. Oiled walnut cabinets are available for the Z-2, Z-2D, and the dual disk drives to give a professional appearance.

Figure 9-6. The Cromemco Z-2D microcomputer with dual disk drive.

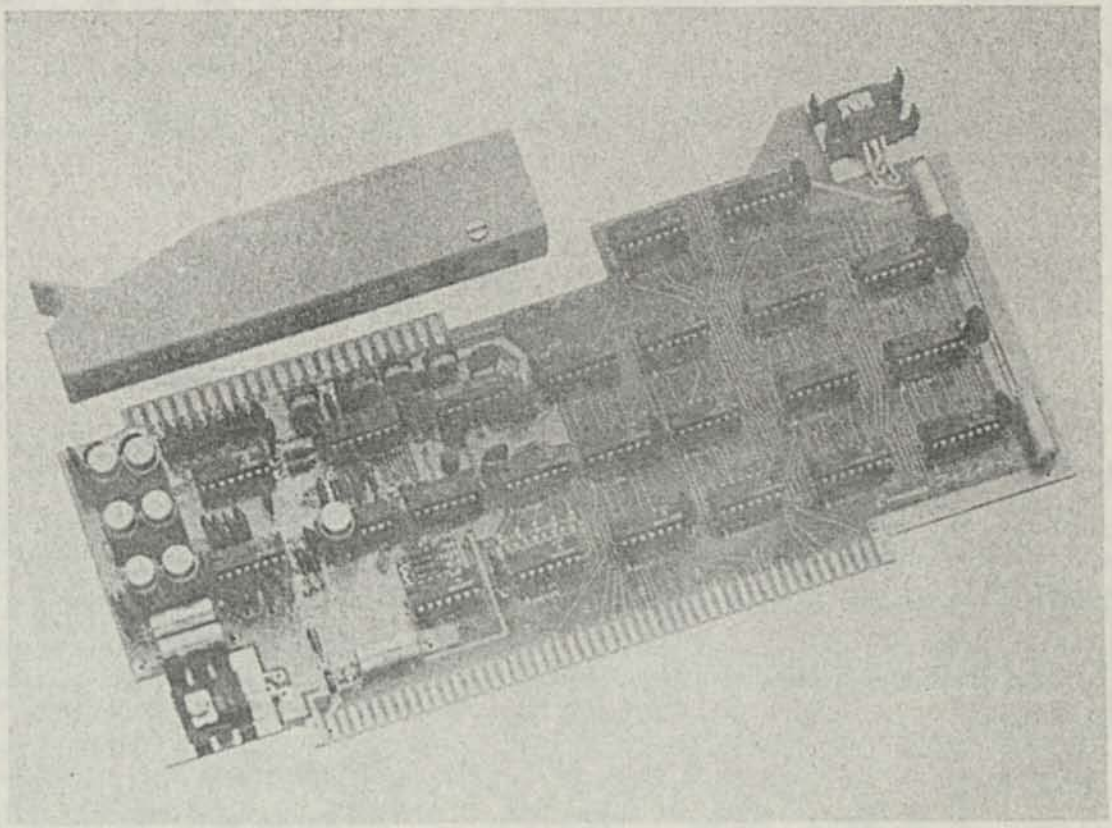


Figure 9-7. The Cromemco D+7AI/O multi-channel analog interface circuit board.

The Cromemco systems excel in flexibility and suitability for engineering, professional, and educational applications.

COMPUTER DATA SYSTEMS

Every microcomputer manufacturer designs his equipment to meet the needs of the hobbyist, experimenter, and small businessman. Computer Data Systems goes an extra step further and includes applications for doctors, lawyers, teachers, engineers, and government agencies. The Computer Data Systems Versatile 3 microcomputer system is shown in Figure 9-8. Its size makes it ideal for desk top operation. The Versatile 3 comes complete with the 8085 microprocessor, 24K static RAM, a serial I/O port with EIA RS-232 serial connector, a 9-inch CRT display screen with a page display of 24 lines of 80 characters each, and a 143K dual minifloppy disk drive. The Versatile 4 expands memory capacity to 32K static RAM and 315K disk storage. Computer Data Systems offers extended BASIC by Micropolis.

Figure 9-8. Computer Data System's Versatile 3 microcomputer system.

This is the full 20K BASIC and not a reduced version. A software package is offered on three diskettes:

Disk 1 Disk operating system (DOS) and 20K extended BASIC.

Disk 2 Games including Lunar, Horse Race, and Blackjack. The disk contains extra space for user-developed games.

Disk 3 Small business accounting package that includes financial analysis, mailing list, inventory, and more.

Computer Data Systems' software library is open to all purchasers of the Versatile systems. Any program may be obtained on diskette for a copying charge only. Library listings are available on request from owners of Versatile system. Both the Versatile 3 and 4 microcomputers are compatible with most S-100 interface circuit boards, RAM cards, and process control circuit boards.

OHIO SCIENTIFIC

Only Ohio Scientific offers a microcomputer with three microprocessors—the Challenger III with 6502A, 6800, and

Z-80 microprocessors. The microprocessor is selected by a switch on the back panel allowing the Challenger III to run programs written for any of these three MPU's.

Figure 9-9 shows Ohio Scientific's Challenger II. It features 4K RAM, 8K ROM, the Kansas City Standard cassette interface, and a video display with 32 lines of 64 characters each. The cassette recorder/player and video display terminal are priced separately and are not part of the basic Challenger II.

For the hobbyist Ohio Scientific's Model 500 circuit board is an excellent way go get started in microcomputers. Fully assembled and tested, the Model 500 circuit board includes the 6502 MPU, 8K BASIC in ROM, 4K RAM, and a serial I/O port. The Model 500 circuit board needs only a serial terminal and power supply for operation. As you advance in microcomputer skill, the Model 500 can be expanded with an 8-slot backplane, additional memory, and more I/O ports. Ohio Scientific offers the hobbyist and experimenter the choice of 6 starter systems ranging from under $300 to slightly over $2000.

For the small businessman Ohio Scientific offers the Challenger II with 32K RAM and dual floppy disk drives. This system is capable of handling most bookkeeping, accounting, and payroll functions for a small business with annual sales of $100,000 to $2,000,000. The basic Challenger II system starts at

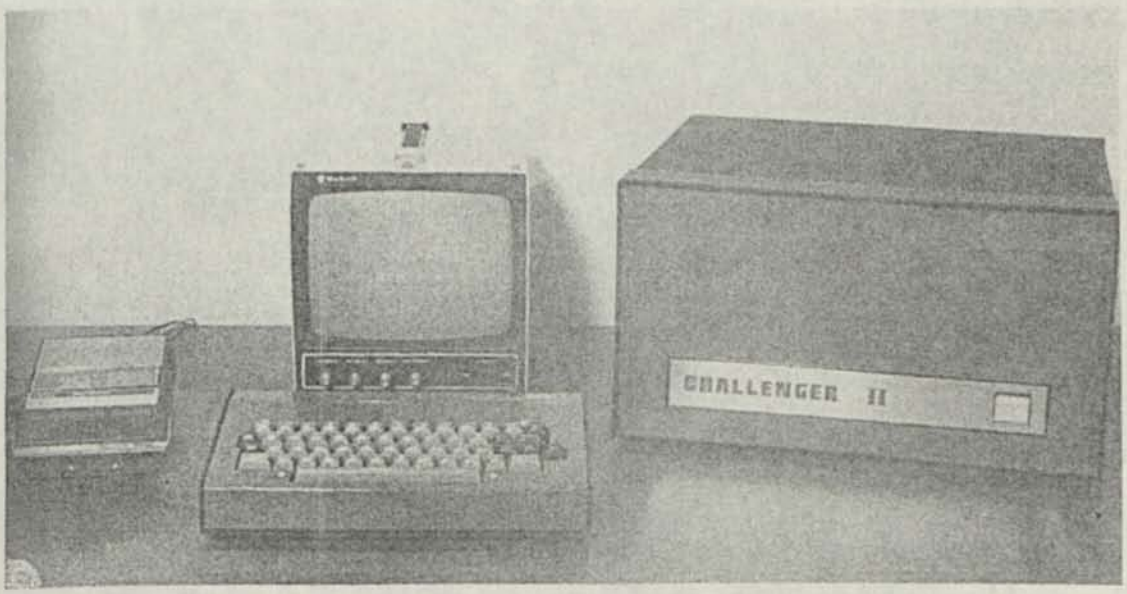


Figure 9-9. Ohio Scientific's Challenger II basic system.

a little over $3000. It can be expanded with peripherals and RAM to handle almost any small business function.

For educational administration the Ohio Scientific Challenger III with 32K RAM and dual disk drives offers greater flexibility than any other similarly priced system. Ohio Scientific's Education System incorporating the Challenger III starts under $3500 and is expandable with peripherals and memory to meet the demands of any size student body. Student scheduling, report card preparation, grade averaging, fees and activity costs can be performed with the Challenger III system, which is shown in Figure 9-10.

For industrial applications the Challenger III system with hard disk drive can perform many control and operating functions now performed manually. It is ideal for engineering design, machine control, device control, and for estimating and cost control applications. Specific uses include environmental control, chemical process control, and monitoring of waste disposal to guarantee environmental safety. Industrial applications of the microcomputer are almost unlimited.

SOUTHWEST TECHNICAL PRODUCTS CORPORATION

Southwest Technical Products Corporation (SWTPC) was one of the pioneers in the microcomputer field. SWTPC

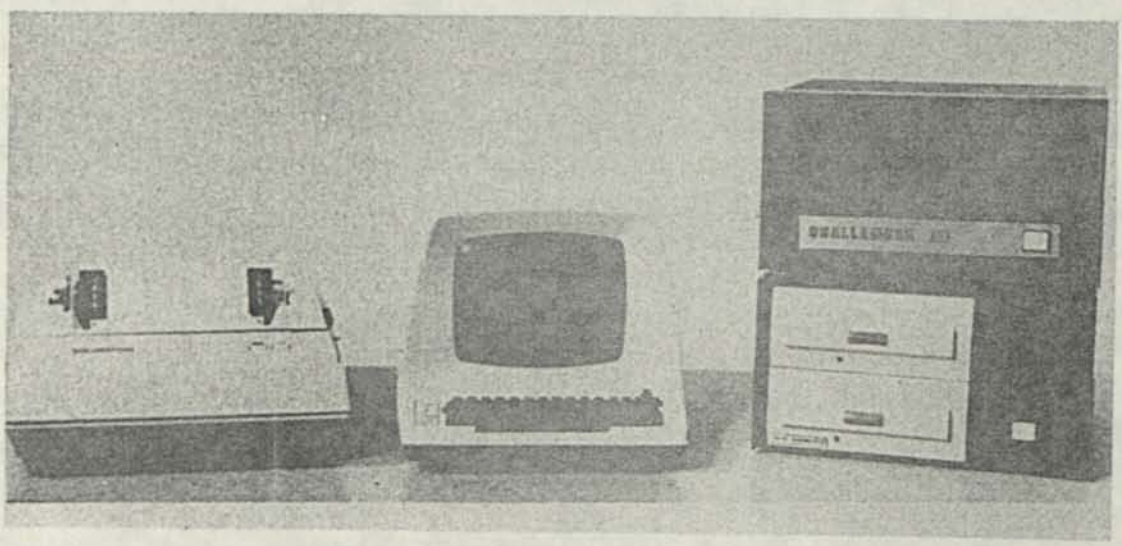


Figure 9-10. Ohio Scientific's Challenger III dual disk drive system.

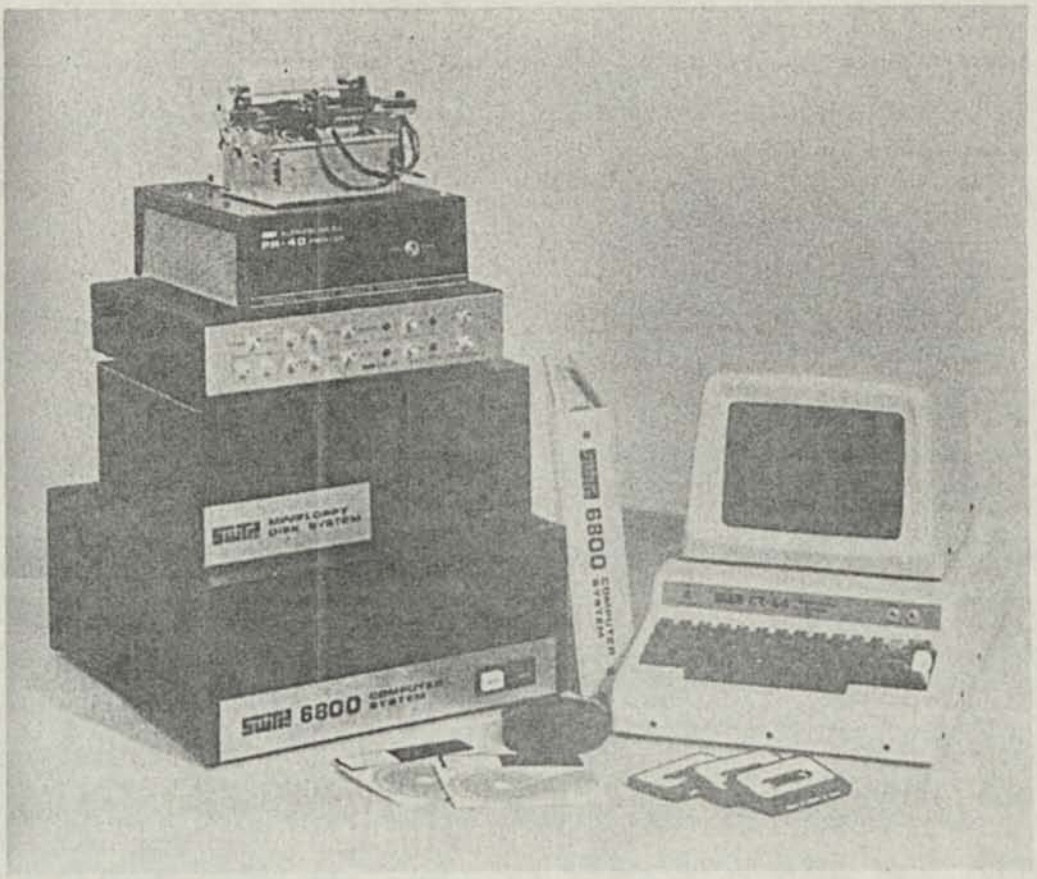


Figure 9-11. A complete microcomputer system from Southwest Technical Products Corporation.

developed a line of microcomputer and peripheral kits, based on the Motorola 6800 CPU, that today ranks among the leaders in personal low-cost microcomputing. Figure 9-11 shows the entire SWTPC 6800 microcomputer system. At the left top is the SWTPC PR-40 alphanumeric printer, which prints in a 5 X 7 dot matrix format the entire 64 ASCII characters at 75 lines per minute with 40 characters per line. The PR-40 is available in kit form or factory assembled and requires a SWTPC 6800 parallel interface for use with the SWTPC 6800 microcomputer system. Below the PR-40 printer is the SWTPC AC-30 audio cassette interface, which stores and inputs data to systems with EIA RS-232 serial I/O interfaces. It is based on the Kansas City Standard of 300 baud, but it offers greatly expanded flexibility of operation. Below the audio cassette interface is the SWTPC MF-68 minifloppy disk system, which utilizes the WD1771 disk controller IC. The MF-68 is available factory assembled or in kit form, and it can be easily expanded to a maximum of four disk drives. Each diskette has a maximum storage capacity of 85K.

On the bottom of the stack is the SWTPC 6800 microcomputer. This microcomputer is available in kit form or factory assembled, and it can address over 64K of memory. The SWTPC 6800 includes a serial interface with a wide selection of data transfer rates.

Technical documentation is essential to anyone planning to build their own microcomputer, and the quality of such documentation is one criterion for the choice of a microcomputer system. Like most reputable companies SWTPC provides full documentation for their products. The SWTPC 6800 technical manual is visible in Figure 9-11 with tape cassettes and diskettes. Also visible is the SWTPC CT-64 terminal with keyboard and CT-VM CRT monitor. The CT-64 contains the keyboard, power supply, serial interface, and beeper. The CT-VM video monitor operates using the CT-64 power supply. Both the CT-64 and CT-VM are available either in kit form or factory assembled. SWTPC backs each microcomputer system with a library of high-quality software or audio cassette tape or paper tape. A full library of MF-68 disk programs is available to minidisk owners. SWTPC products are available by mail from SWTPC and from numerous computer stores.

INTERTEC DATA SYSTEMS

Intertec Data Systems offers the Intertec System 10, which combines a microcomputer with a dual floppy disk drive. This system comes with 32K RAM standard and employs the Zilog Z-80 microprocessor. Also standard are two RS-232 serial I/O ports to drive the Intertec Intertube video terminal and the Intertec SuperDEC Optimizer printer. The compact Intertec System 10 microcomputer/dual disk drive is shown in Figure 9-12. This system is compatible with the IBM flexible disk and offers both BASIC and FORTRAN IV computer languages.

Figure 9-13 illustrates the Intertec Intertube video terminal with keyboard. The Intertube is a "smart" terminal with a Z-80 microprocessor built in to provide a number of special features such as line and character editing. It displays 24 lines of 80 characters each in both ASCII upper and lower case characters. It offers keyboard selection of dark characters on a light

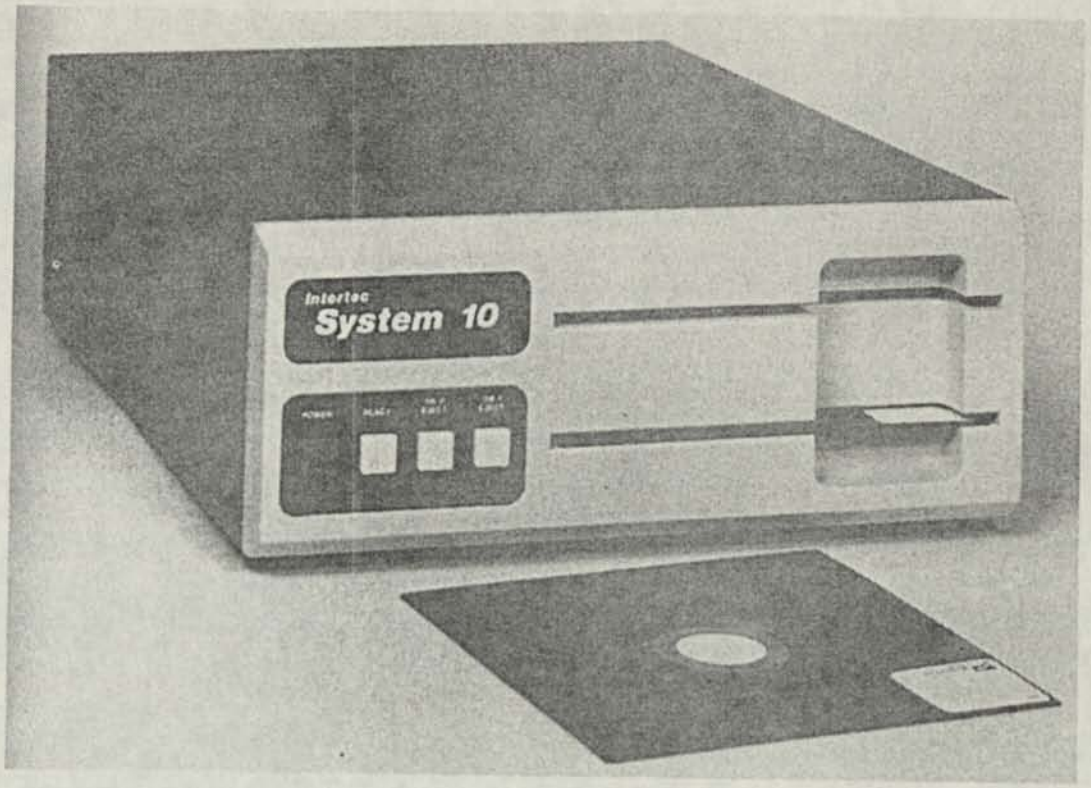


Figure 9-12. The Intertec Data Systems Corporation System 10 microcomputer/dual disk drive for small business applications.

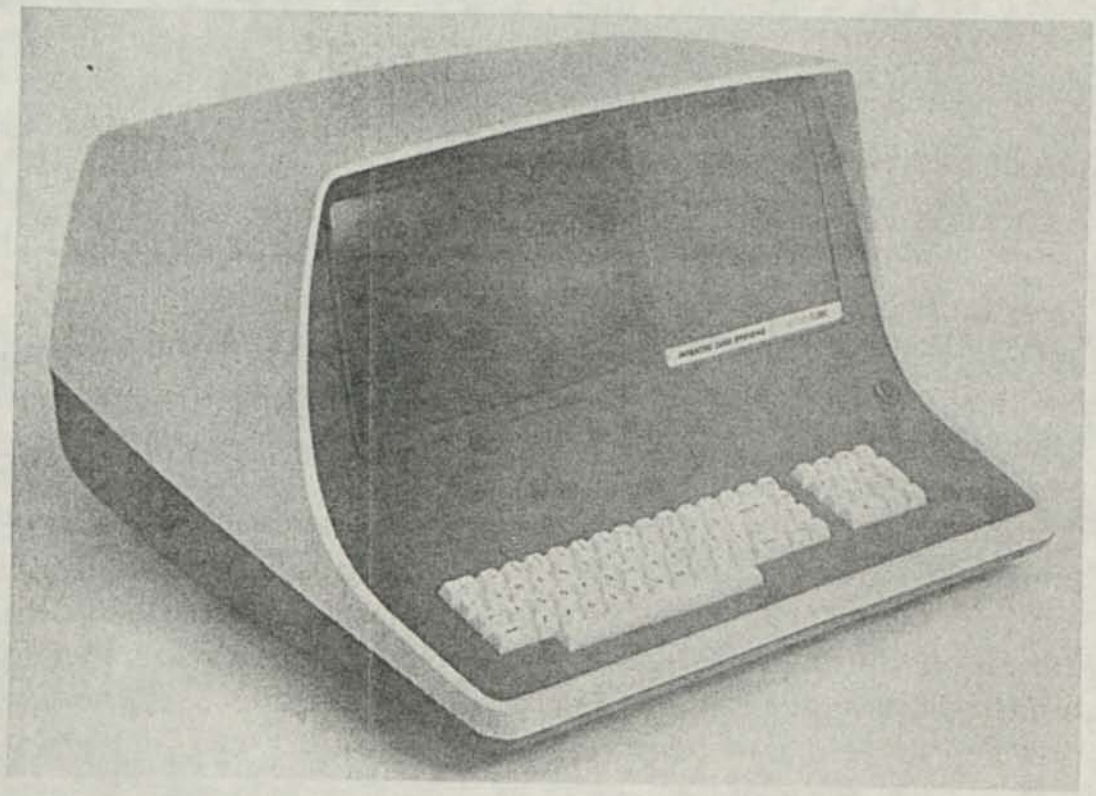


Figure 9-13. The Intertec Data Systems Corporation Intertube video terminal with keyboard.

background—a most useful video terminal feature. The CRT is a standard 12-inch dark-face design. This size provides clearer displays than the smaller 9-inch CRT size. The keyboard offers a selection of two transmission modes: either half-duplex or full-duplex. Up, down, forward, backward, and home cursor controls are offered. In addition to the ASCII keyboard the Intertube offers a 14-key numeric key pad for fast data entry.

Intertec Data System's SuperTerm data terminal is shown in Figure 9-14. It has a number of features not normally found in a printer. Some of these are:

- Bidirectional printing
- Horizontal and vertical tabs
- 165 characters per second impact printing
- Adjustable right and left hand margins
- RS-232 interface
- Data transfer rates selectable to 1200 baud
- Double-width characters selectable
- Intel 8080A microprocessor control
- SuperDEC software contained in ROM
- Magnetic tape I/O
- 7-by-7 dot matrix characters
- Maximum print line of 132 characters

HOW TO COMPARE DIFFERENT MICROCOMPUTERS AND PERIPHERALS

The newcomer to the microcomputer field is immediately confronted with a large number of microcomputers and peripherals from which he may choose. Even if he limits himself to the products of one of the major manufacturers, he still has a large number of decisions to make. Does he want a video terminal? What about floppy disk drives? Does he want a printer? Most microcomputer systems to be used for serious applications will include a video terminal and a printer. Yet the cost of a printer can vary from a few hundreds to thousands of dollars. The size of the printer can range from a small box that

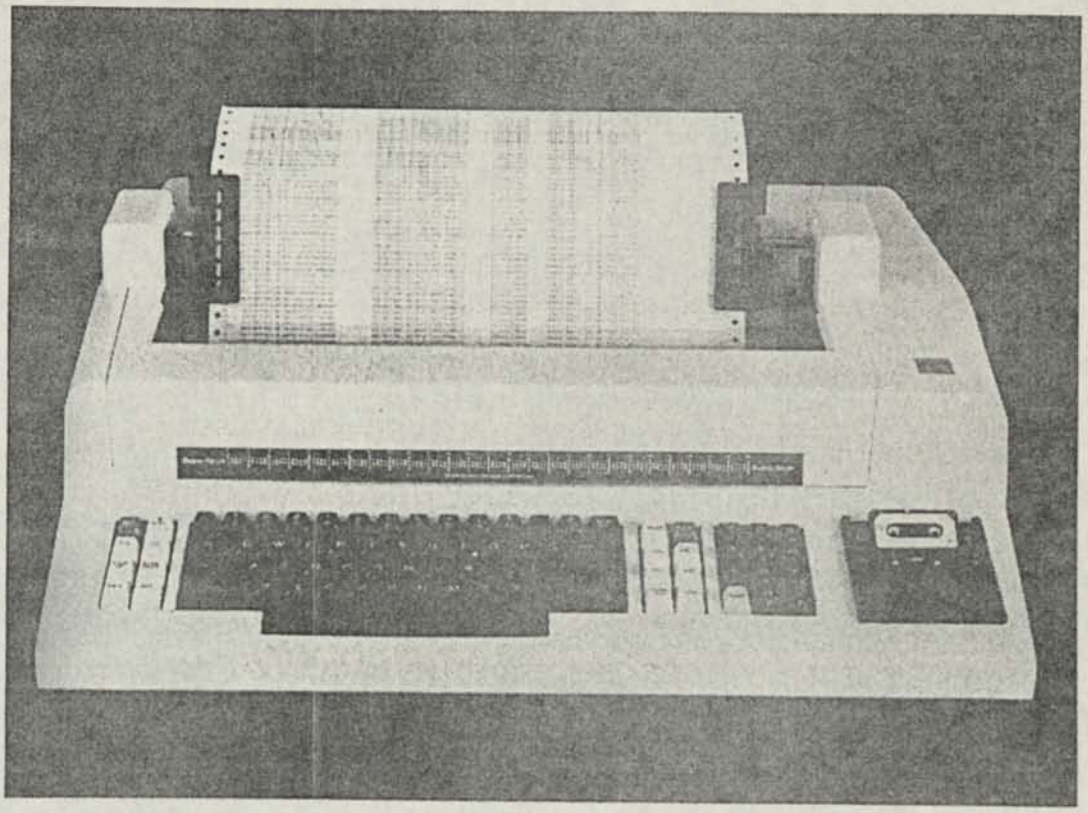


Figure 9-14. The Intertec Data Systems Corporation SuperTerm line printer with keyboard.

can be placed on the corner of a table to a large console that must stand alone on the floor. Why choose one printer and not another? The reason is performance measured against your applications for your microcomputer system. If you are a hobbyist, one of the small, inexpensive printers may suffice. However, if you are a businessman who will use his microcomputer system for full business applications including accounting, payroll, inventory, and word processing, your needs will be somewhat different. You will want a reliable high-speed printer that prints on full-width paper. If the printer is to be used for word processing applications, the print quality should be high. In Chapter 12 we discuss the features needed by a microcomputer system to perform the functions required by a business of a specified size. Below we discuss some of the criteria you might use to choose a microcomputer or peripheral within a given category.

Every microcomputer manufacturer emphasizes the microprocessor his systems use. There are significant differences between the microprocessors currently on the market in terms of

power and speed. Even more powerful microprocessors have been released and no doubt will soon be available in commercial systems. Yet, unless you plan to program in assembly language, perform extremely complex scientific or engineering calculations, or use your microcomputer for sophisticated control applications, the specific microprocessor used in a system under consideration should be only one of many criteria.

Unless you plan to write all your own programs, the availability of software is much more important. Programs or software are lists of instructions that tell your microcomputer what you want it to do and how to do it. Unfortunately, software written for a microcomputer system from one manufacturer in most cases cannot be directly used by a microcomputer from another manufacturer. Usually applications software must be written especially for your microcomputer. Alternately, applications software written for another microcomputer can be converted for use on your machine. Either procedure can be lengthy and expensive. However, if a microcomputer system with the software and hardware you need for your application is not available commercially, software preparation or conversion may be the preferable route.

Much software is available for most of the popular microcomputers. It ranges from the BASIC interpreter offered for almost every machine to applications programs written in BASIC for full accounting, inventory, payroll, and word processing functions. (See Appendix I for a description of programming languages.) Available applications software varies significantly in quality. Even the power and speed of the BASIC interpreters sold by different manufacturers vary widely. Generally it is possible to determine before purchase the suitability of particular software for your applications. Find out the reputation of the company offering the software, and if possible talk to someone who has used it. Also obtain any available software manuals and study them. If you cannot understand the manuals, you probably will find it difficult to successfully use the software.

Next consider manufacturer support. A large service network is certainly a plus for any microcomputer system. If you intend to use your system for business applications, the availa-

bility of service can be very important. If you are a hobbyist or if you have the skills to perform your own service, the speed and availability of service might be a secondary consideration.

Manufacturers also differ widely in the number and performance of the peripherals they offer for their microcomputers. Because the capability of a microcomputer system is determined in a large part by its peripherals, their availability should be an important factor in the decision to purchase a particular microcomputer system. Many microcomputers can use only the peripherals supplied by the manufacturer. Others, such as S-100 machines, are compatible with the peripherals sold by many manufacturers when special interface circuit boards are used. This is an important advantage because it gives you a wider choice. If you want your microcomputer to perform special applications such as process control or analog-to-digital conversion, be sure that the necessary circuit boards are available.

Commercially available microcomputers differ widely in their physical size. The main printed circuit board of the TRS-80 microcomputer is located inside a small enclosure with the keyboard on top. (See Figures 1-7 and 1-9.) Others such as the Heath H8 (see Figure 1-2) enclose their circuit boards in a large box. Expansion of the Heath H8's memory or interface capabilities simply is a matter of plugging in the appropriate circuit boards. For the TRS-80 expansion is accomplished by purchasing the TRS-80 expansion interface. Under many circumstances the size of a microcomputer system will not be important. However, if you are an apartment-dwelling hobbyist, you may want to choose one of the small tabletop systems. At the other extreme a business microcomputer with peripherals may occupy as much space as a full-sized desk.

Microcomputers are offered with a large variety of enclosures. These range from a simple plastic or metal box to a complex unit that includes a keyboard, CRT screen, and floppy disk drive. Some of the more expensive microcomputer business systems are built into a desk, and some even offer extras such as oiled walnut. While a hobbyist may prefer a simpler and less expensive enclosure, a more elegant one might be chosen for a medical or legal office.

The first step in choosing a microcomputer system is to determine for what it will be used and what level of performance these applications will require. The performance will be determined mainly by the random access memory capacity and by the number and capabilities of peripherals such as printers and floppy disk drives. Next look at the availability of software designed to perform your applications. Then look at the overall microcomputer system keeping in mind price, quality of construction, speed of delivery, and availability of service. The recommendations of knowledgeable friends and acquaintances are an important source for this information. Also much can be learned from the many magazines devoted to microcomputers and their applications. The names and addresses of some of these magazines are listed in Appendix II. Choice of a microcomputer system for business applications is discussed in more detail in Chapters 11 and 12.

SUMMARY

Table 9-1 lists some of the criteria you might use to evaluate a microcomputer system. Of course, depending upon your application some criteria may be much more important than others. For example, power consumption is not significant for most applications. Yet, for mobile applications it can be quite important. Some systems such as the TRS-80 use a separate keyboard and a video monitor. For such systems only some of the criteria for evaluation of a video terminal will be relevant.

Table 9-1. Checklist for Evaluation of Microcomputer Components.

Any Component	☐ Cost
	☐ Quality of manuals
	☐ Quality of construction
	☐ Reliability
	☐ Warranty
	☐ Availability of service
	☐ Required maintenance
	☐ Appearance
	☐ Size and weight
	☐ Power requirements

Still More Microcomputer Systems

Microcomputer

- ☐ Availability of software
- ☐ Memory capacity—RAM and ROM
- ☐ Availability of compatible peripherals
- ☐ Microprocessor
  - Instruction set
  - Machine cycle time
- ☐ Expansion capabilities
- ☐ Availability of special-purpose circuit boards

Printer

- ☐ Print speed
- ☐ Print quality
- ☐ Characters per line
- ☐ Size and type of paper
- ☐ Type of print mechanism
- ☐ Typeface
- ☐ Quietness of operation
- ☐ Upper and lower case letters?

Video Terminal

- ☐ Quality of display
  - Size of screen
  - Character quality
  - Number of characters on screen
  - Color capability?
- ☐ Keyboard
  - Feel
  - Numeric keypad?
  - Lower case letters?
- ☐ Data transfer rate
- ☐ Data manipulation capabilities?

Floppy Disk System

- ☐ Data storage capacity
- ☐ Data retrieval time
- ☐ Data reliability
- ☐ Data transfer rate

10

SOME MICROCOMPUTER CONTROL APPLICATIONS

It is appropriate that the Great Galaxy in the constellation of Andromeda appears on the chapter heading photograph as this chapter includes some really "far out" applications for microcomputers. A microcomputer is useful for much more than games, accounting, and educational applications. One marvelous accessory, shown in Figure 10-1, is the Computalker CT-1 Speech Synthesizer, which can give your microcomputer the power to talk to you or to serve as a voice for your homemade robot. Should you construct a robot, you will also need an interface such as the MITS process control circuit board shown in Figure 10-2. This interface transmits control signals from your microcomputer to the controlled device and relays back status signals indicating the effects of the control signals. A process control interface is very useful because it enables the microcomputer to control many different types of electrical devices in home and industry. For instance, this interface can be used in conjunction with your microcomputer to provide fully automatic climate control of your home. The versatility of a microcomputer allows many exciting applications.

HOW TO USE A MICROCOMPUTER TO INCREASE SECURITY IN YOUR HOME OR BUSINESS

Statistics say there is a crime committed every 8 seconds in the United States. The microcomputer is ideal for home or business security applications. At home it can do many things,

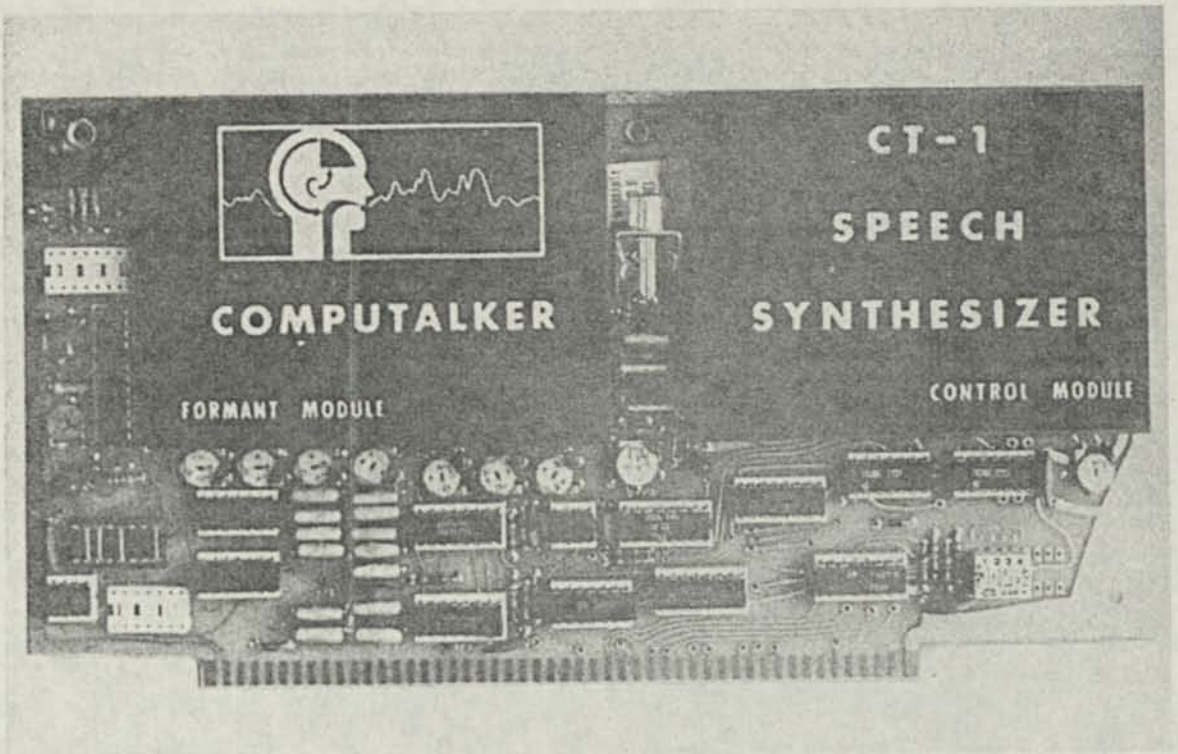


Figure 10-1. The Computalker CT-1 speech synthesizer and interface.

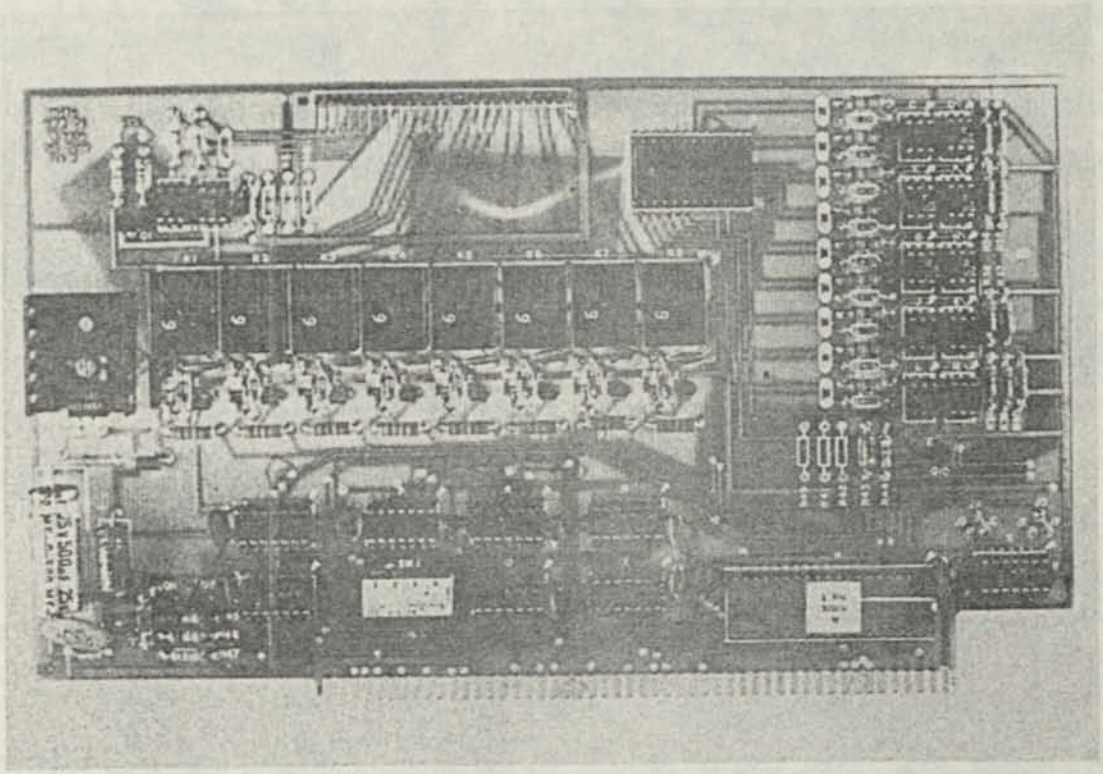


Figure 10-2. The MITS/Altair process control interface circuit board. Eight square control relays are visible in the center of the board.

such as sequencing house lights to simulate occupancy when you are away. The beauty of a microcomputerized home security system lies in the fact that you can make it as simple or complex as you wish. Figure 10-3 depicts the floor plan of a typical home and identifies the security control points. Each door and window can be protected by magnetic reed switches like the one shown in Figure 10-4. Most commercially available home security systems are wired in series and will sound an alarm if any door or window is opened. However, with a microcomputer home security system, you can wire each door or window separately. Then your microcomputer can query all entrances and notify you of any unsecured point of entry anywhere in the house.

The wiring for most home security systems is restricted to 6 or 12 volts and uses small-diameter low-cost wire. The wiring can be run through the attic space or under the house through the crawl space. It connects each magnetic reed switch to the input of the process control interface. The power source may be either a battery or a stepdown transformer operating from house line voltage. Stand-by battery power for both the alarm and the microcomputer system is recommended in order to prevent system failure during power blackouts. The alarms, shown as

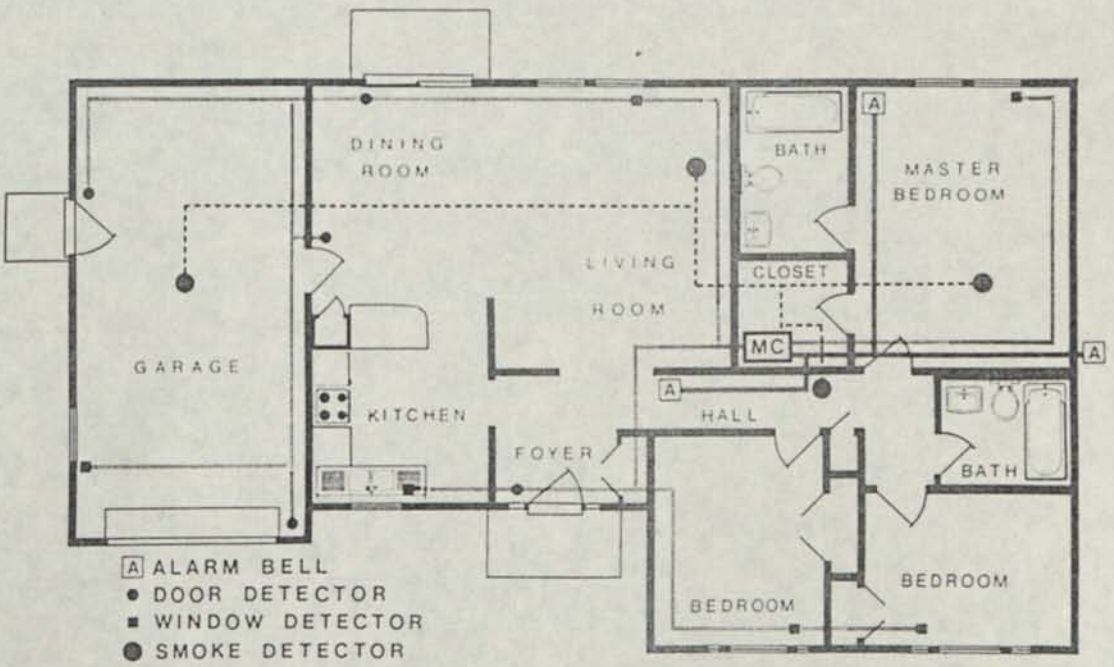


Figure 10-3. A home security system with door and window detectors, smoke detectors, and alarm bells.

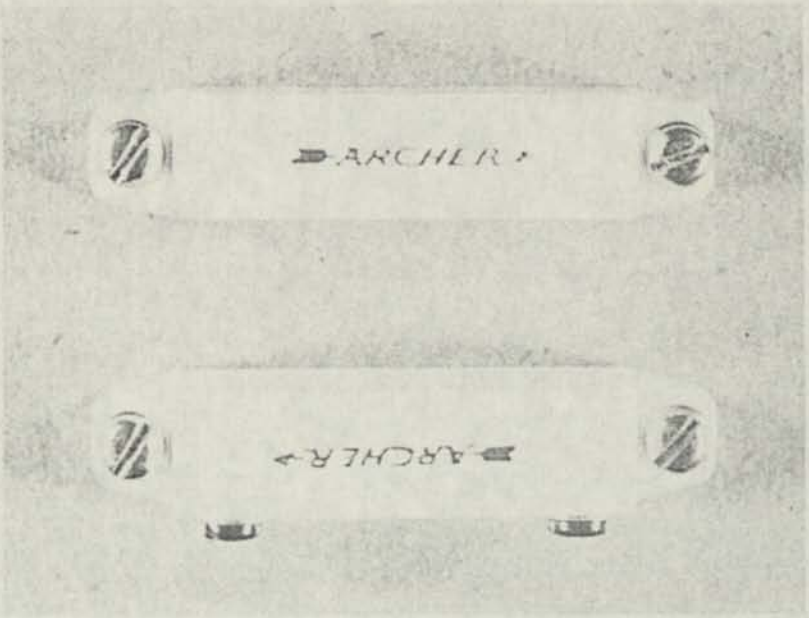


Figure 10-4. Magnetic contact switch. Part with two electrical contacts on its side contains a magnetic reed switch. Other part contains magnet. For burglar alarm system the magnet is mounted on door or window and the magnetic reed switch is mounted on door or window frame close to magnet. If door or window opens, the two parts separate and electrical contacts in reed switch open signaling burglar alarm system.

squares with the letter A inside in Figure 10-3, can be heavy-duty bells. Figure 10-5 illustrates a typical outside battery-powered alarm bell that can be used to alert your neighbors should security of your home be breached in your absence.

The home security system can be expanded to include smoke and fire detection. Detectors should be positioned near areas of high fire hazard or near places where smoke may accumulate. For instance, a smoke detector should be placed in the garage because the automobile and flammable liquids stored there represent a high fire risk. Detectors should be located in the hallway leading to the bedrooms as smoke often gathers there. These detectors can be routinely tested by the microcomputer during the nightly security check.

If your microcomputer has a real time clock, you can program a lighting sequence into the microcomputer so that in your absence the microcomputer can operate the household lights to

simulate your nightly pattern. The microcomputer can also vary the sequence from night to night. Such a microcomputerized system gives a much more realistic light sequence than one controlled by a simple timing device.

This home security system could be further expanded with code locks mounted on all doors. A code lock is a group of push buttons mounted together on the outside of an entrance. For the lock to function, the buttons must be pushed in a fixed sequence. For a code lock with 5 buttons, there are 3125 possible 5-button sequences. With a microcomputer security system, the sequence (code) can be changed as often as you wish. In addition, ultrasonic or microwave motion detectors could be added to the system. Whenever they detected motion in your home,

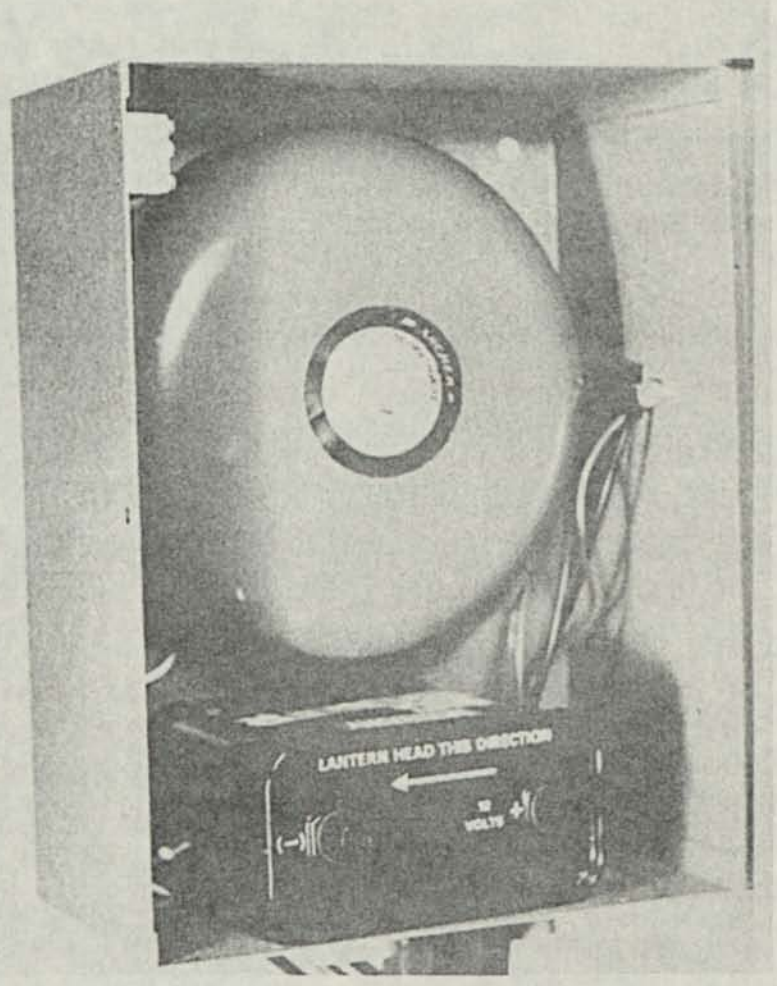


Figure 10-5. A typical alarm bell with battery power source.

they would inform the microcomputer. The microcomputer could be programmed with the daily schedule of the occupants of your home. For instance, there might be times of the day when everyone is at work or in school. Then, if motion were detected or a door switch were tripped, the microcomputer would sound the alarm. If a member of your family came home during these hours, he would have a minute or two before the alarm sounded to press a concealed button informing the microcomputer that everything was alright.

If you are often away from home for extended periods of time, then it is a good idea to include an automatic telephone dialing system. A message to the effect that the security of your home has been breached is placed on the automatic telephone dialing system. Then if the security of your home is violated, the microcomputer can direct the automatic telephone dialing device to notify the police. Alternately, you can have the microcomputer call you at another number.

The major components of a home security system are:

- A microcomputer system with process control interface and an applications program designed for security operation.
- A real time clock for your microcomputer.
- A home instrusion alarm system with sensors including door and window switches and smoke detectors.
- An automatic telephone dialing system (optional).

These are only some of the possible home security applications of the microcomputer. The advantage of a microcomputer security system is that it has the flexibility to be adapted to a wide range of different security requirements. Most of the features of the home security system described above could be included in a security system to guard your business. For instance, if your business security system detected an unauthorized entry at night, it could instruct the automatic telephone dialing system to call you at home.

SOLAR ENERGY CLIMATE CONTROL FOR YOUR HOME

Some day our homes may be heated and cooled by means of solar energy. Solar heating systems are in use today, but the

task of manipulating valves to match the changing heating requirements is performed manually. What an opportunity for the microcomputer! Let's examine some of the year-round climate control functions that a microcomputer can perform. Figure 10-6 illustrates a climate control system. The valve system, controlled by the microcomputer, can direct the flow of heated water from solar panels through the heat exchanger to raise the interior temperature of the house. Alternately, it can divert the heated water to an insulated storage tank.

Each room in the house has its own heat sensor. The microcomputer opens or closes hot air ducts to each room in order to maintain the desired temperature. When the outdoor temperature begins to fall and the change is noted by the external heat sensor, the microcomputer system anticipates heating demand and automatically increases room hot air flow proportionately.

All system electrical requirements, including power for the electrically operated valves, are satisfied by a 12-volt storage battery that is under constant trickle charge from roof-mounted solar cells and a wind-driven 12-volt alternator. The fireplace and chimney have embedded water pipes to collect additional

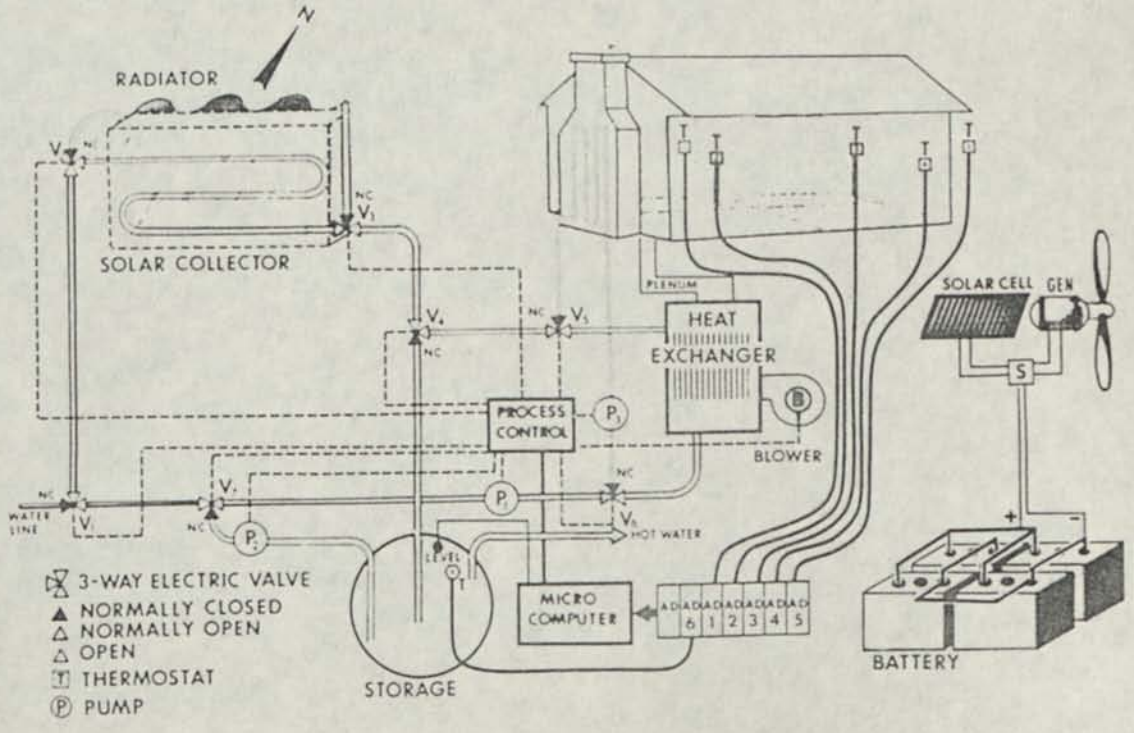


Figure 10-6. Diagram of a solar energy climate control system.

heat to boost the temperature of the stored water or to provide hot water at night without drawing on the stored hot water. After sundown, when no solar heat is being generated, the microcomputer automatically drains the solar collector panels to prevent the pipes from freezing.

During the summer period the solar collector panels are used primarily for generating hot water for household use. The heat exchanger can also remove heat from the air and use it to heat the water. The heated water then circulates up to the north-oriented radiators where the excess heat is radiated to the cool northern sky. The cooled air is ducted into the house.

MICROCOMPUTER PROCESS CONTROL FOR COMMERCIAL APPLICATIONS

Many large corporations increase efficiency and improve the quality of their products by computer control of industrial chemical processes. Let's look at two process control applications within the capabilities of a microcomputer. The first is a system currently used in the textile industry to add dyes and bleaches into high-temperature high-pressure dyeing machines. Such a system can be used for many chemical processing operations. Computer-controlled valves add a significant safety factor when chemicals must be handled under dangerous conditions.

Figure 10-7 illustrates a typical chemical add-and-flush system as modified for microcomputer control. The system is relatively simple. The add-valves open only upon command from the microcomputer. When the addition is complete, the add-float switch opens. This signals the microcomputer to close the add-valves. When the chemicals are exhausted, the microcomputer opens the drain and flush valves to clean out any residuals left in the tank. The system in Figure 10-7 is designed for two additives or for one additive plus a backup booster chemical.

A process control relay is capable of handling only very low power. For applications requiring the control of high power, each control relay can be used only to control a power relay. This in turn actuates whatever device is required—for instance, an electric solenoid valve. Whenever compressed air is

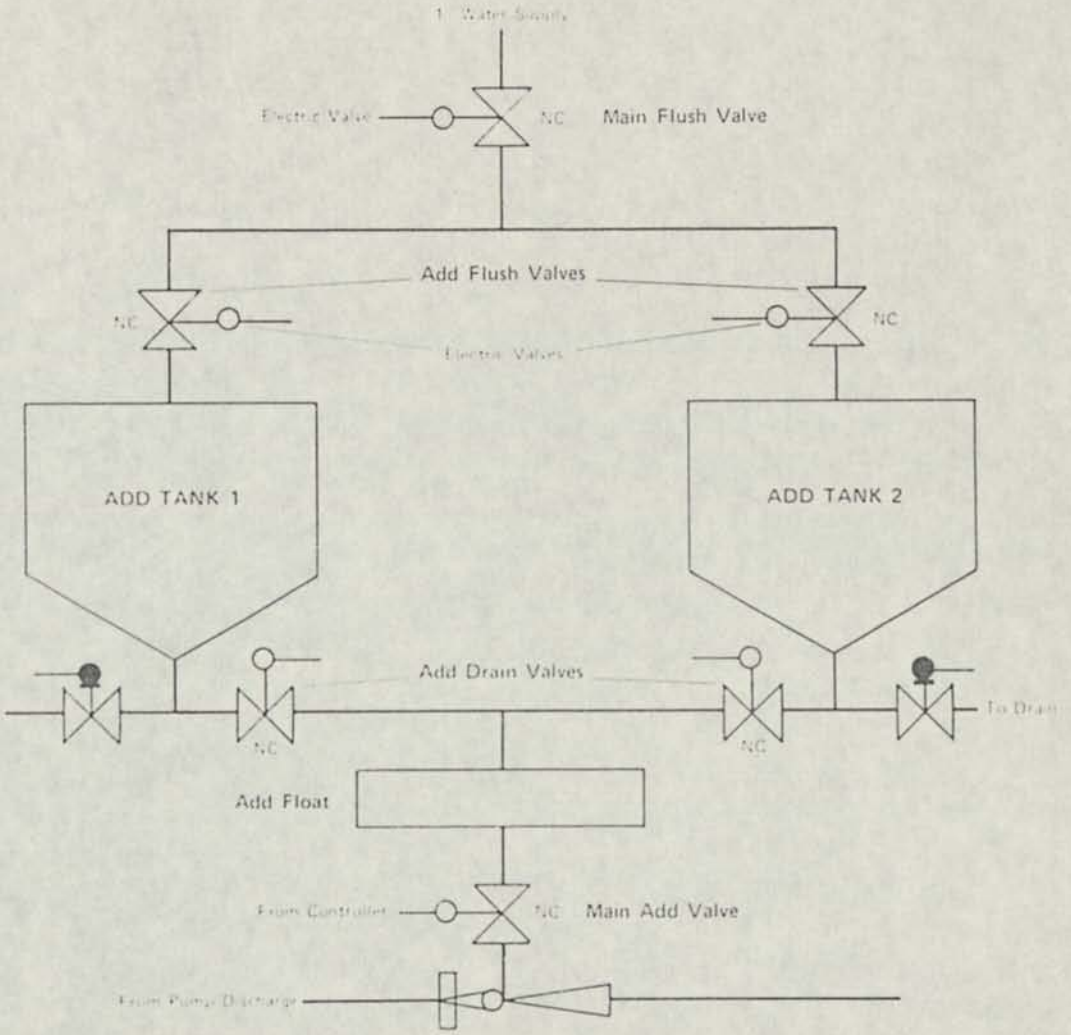


Figure 10-7. Diagram of a process control system used by the textile industry.

available, relays can be used to actuate air valves, and these in turn can actuate fluid valves.

The second example of industrial process control is a color chemistry replenishment system of the type used in commercial photographic processing labs. This system, which is illustrated in Figure 10-8, includes the control of chemical pH (the degree of acidity or alkalinity) and temperature—both essential for quality color processing. The chemical pH has two set limits: that when freshly mixed and that when exhausted (the low-limit pH). Below the low-limit pH, product quality will be diminished unless the chemical is replenished. Designed into the system is a fluid level sensor. It prevents opening of the replenishment valve if the addition of replenisher would cause overflow. If the tank is full and replenishment is needed, the microcomputer opens the drain valve leading to the neutralization hold tank. Once the

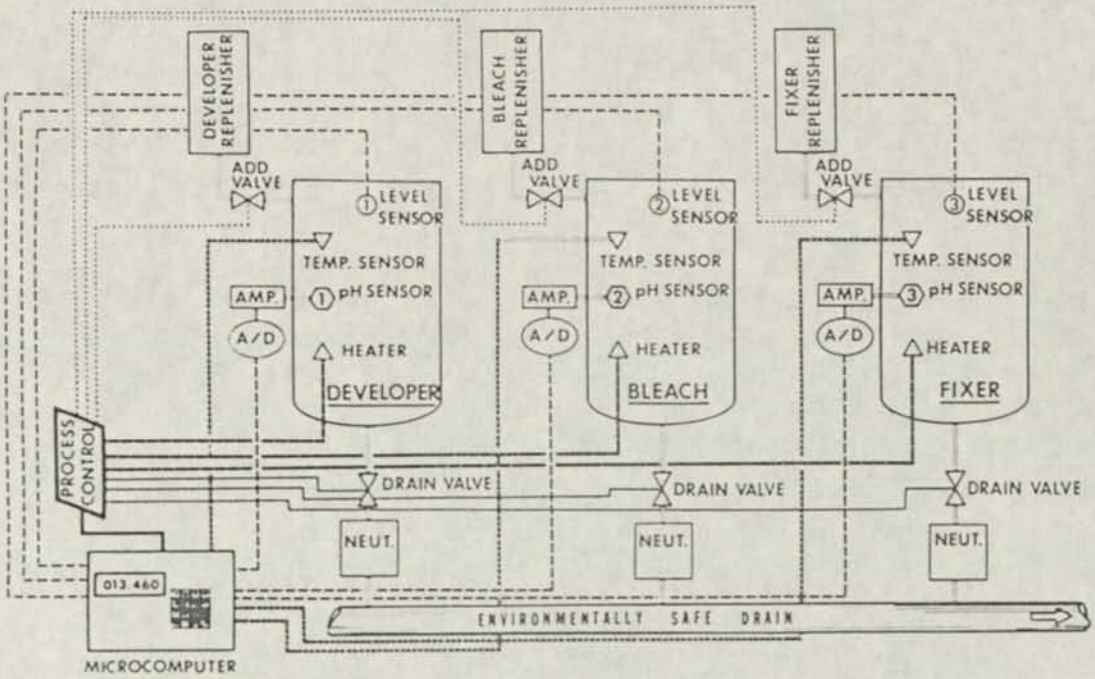


Figure 10-8. Diagram for microcomputer control of a color photoprocessing process.

level in the tank reaches a point where the needed replenisher can be safely added, the microcomputer shuts the drain valve and opens the replenisher valve. The pH sensor monitors the chemical pH and signals the microcomputer to close the replenisher valve as soon as the pH returns to within the operating range.

Likewise, temperature must be controlled within ± ¼ degree Fahrenheit. This is accomplished with the aid of temperature sensors mounted in each tank. If tank temperature falls below a threshold value, electrical heaters are turned on until the temperature returns to the proper operating range. This system could be modified to include pH monitoring of the neutralization hold tanks. Once the solution in the hold tank was neutralized, it would be automatically discharged into the drain. Environmental considerations require neutralization before disposal.

OTHER MICROCOMPUTER CONTROL APPLICATIONS

Microcomputer control applications are limited only by the imagination of the microcomputer process control designer.

Almost any manually operated device can be put under the control of a microcomputer with greater accuracy and repeatability than is possible with manual control.

Computers are used in complex data acquisition and processing tasks. In Figure 10-9 are two NASA photographs of the surface of Mars. The NASA Viking Lander 1 digitized television camera images of the surface of Mars and transmitted the data to Earth. NASA computers then enhanced the quality of the images by eliminating the effects of noise introduced in the transmission process. The quality of the final product is that of a good photograph. Notice that the usual TV raster lines are not detectable.

Some applications are closer to home. Figure 10-10 shows a special interface that can create and produce original music with the aid of your microcomputer and an audio amplifier system. Music is basically a form of mathematics in which tempo

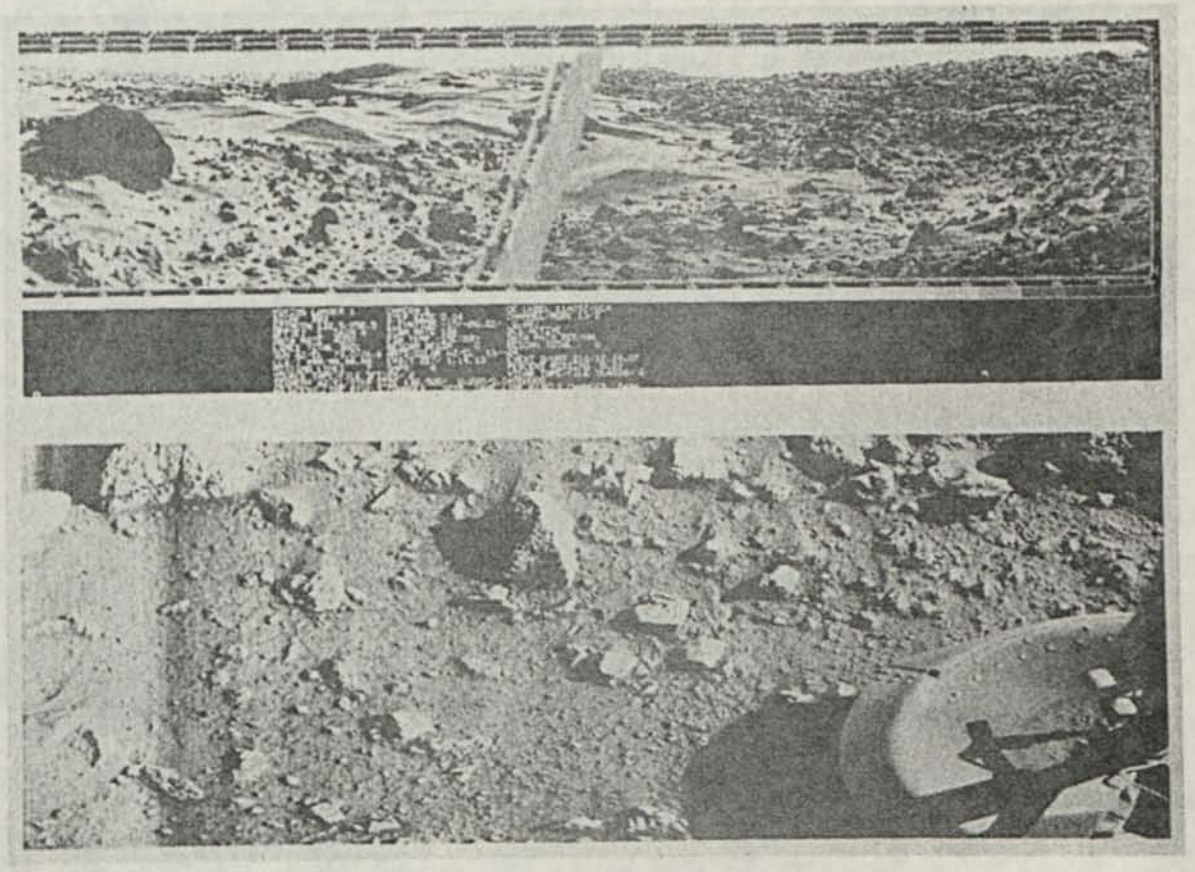


Figure 10-9. Photographs of the surface of Mars taken by NASA Viking Lander 1. Spacecraft footpad is visible in lower photograph. Courtesy of NASA Goddard Flight Center.

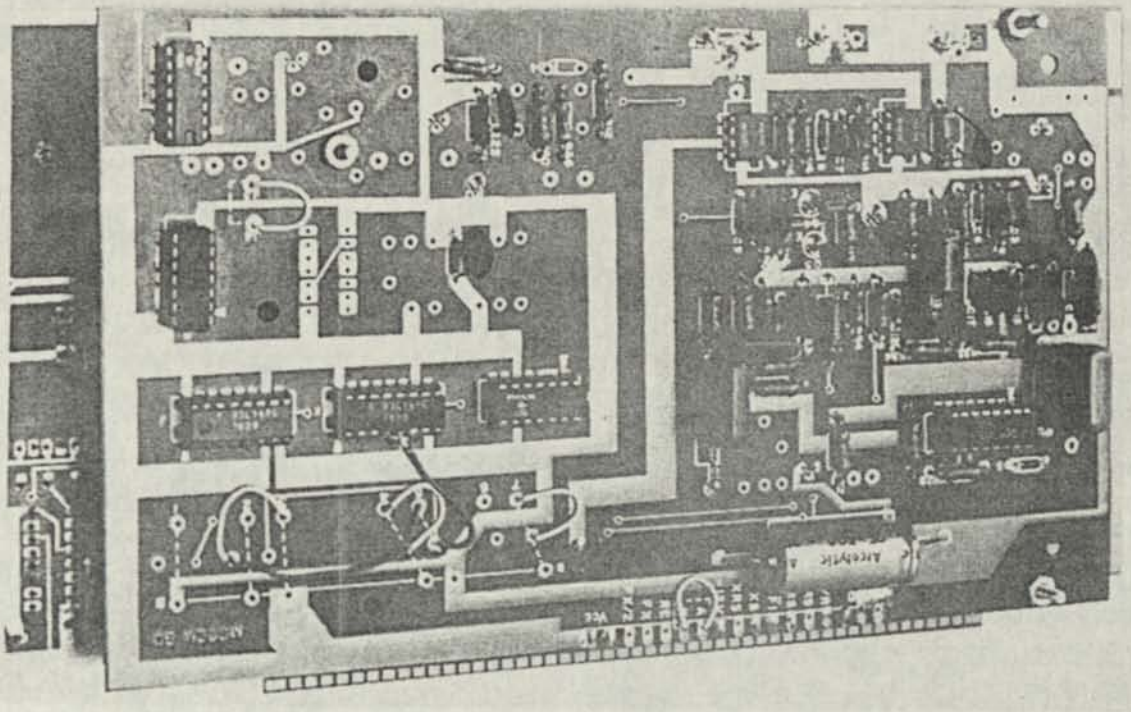


Figure 10-10. Music synthesizer interface.

expresses time relationships and the musical notes express frequency relationships. These elements are combined by the microcomputer to generate musical sounds.

The experimenter who is mechanically inclined might consider construction of a robot. The speech synthesizer in Figure 10-1 could be combined with the process control interface in Figure 10-2 to provide speech as well as movement for your robot. The United States Robotics Society, whose address is in Appendix II, is a source of information of what is currently being done with robots and microcomputers. The mechanical and control devices you need may already be available.

In many control applications the microcomputer must know the actual time of day. This requires additional circuitry called a REAL TIME CLOCK. The circuitry resembles that in a digital watch. One such real time clock is the Lincoln uCT-1 real time clock, which is available in kit form. It has seconds, minutes, and hours available as decimal-digit output or as BCD output. It has a seven-segment display output so that with the addition of a LED display, you can have a digital time readout at your microcomputer. The high-quality printed circuit board

needs only a few jumper wires plus components to complete assembly.

THE TERRAPIN TURTLE

One simple microcomputer-controlled robot is already available commercially. This is the Turtle, which is shown in Figure 10-11. The Turtle is five inches high and can "walk" on its

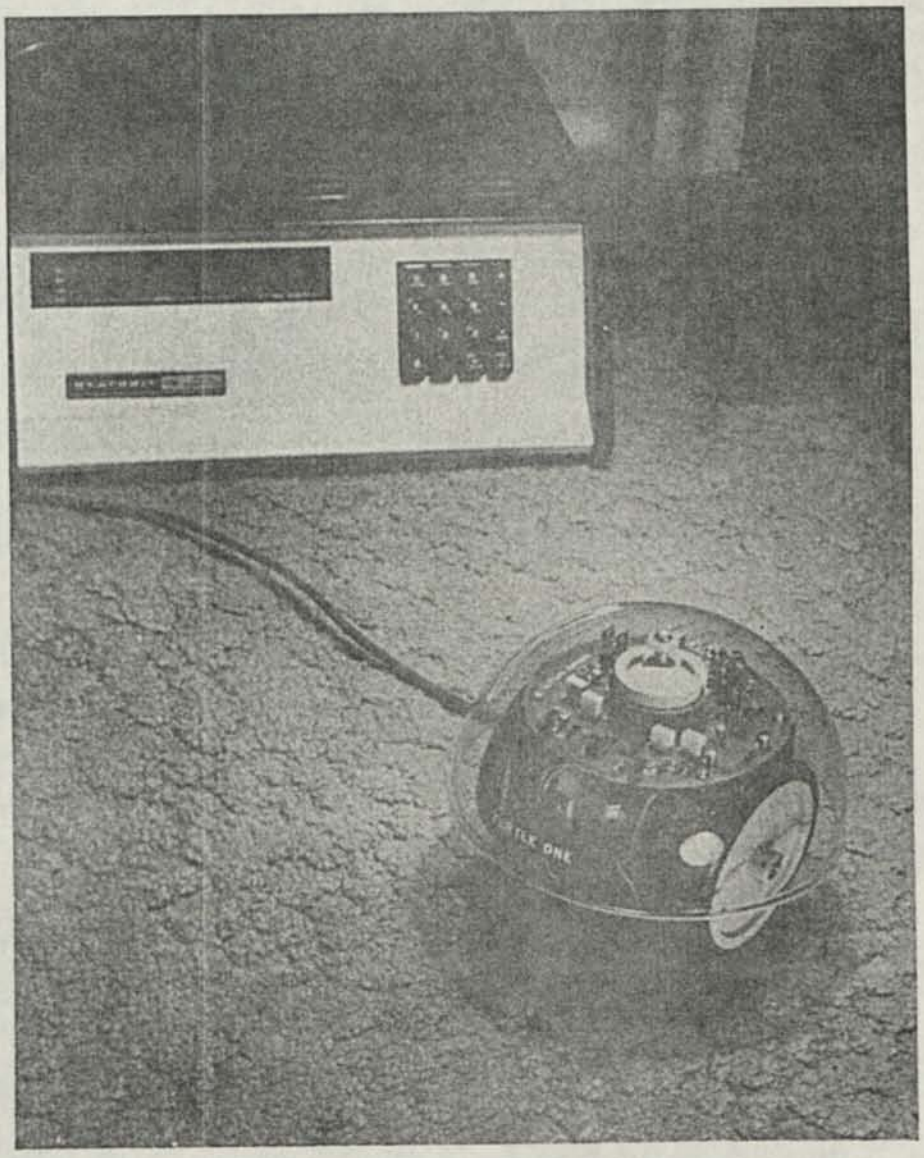
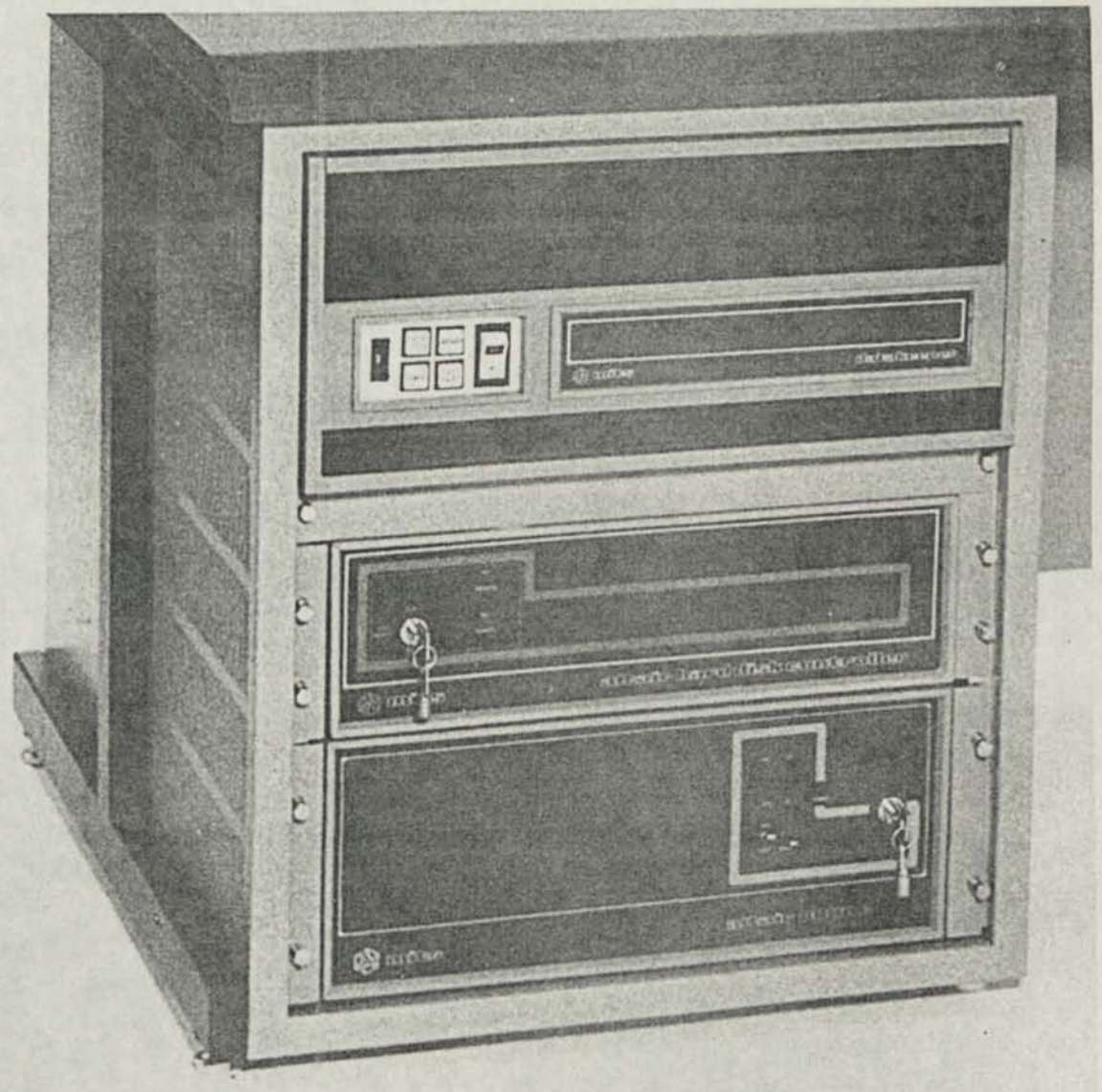


Figure 10-11. The Terrapin Turtle is a microcomputer-controlled home robot. Control signals and power reach the Turtle by means of a flexible cable. Sensory signals from the Turtle return to to the microcomputer along the same cable.

motor-powered wheels at six inches per second. It can "talk" with its two-tone speaker, and it can "feel" using its plastic shell as a touch sensor. The Turtle can be programmed to run mazes. When the Turtle bumps into a side of the maze, the touch sensor tells the Turtle, and it concludes that it has struck a wall. It "remembers" this experience, and eventually it forms an image of the features of the maze. Unlike simple mechanical devices, it learns from experience, and its performance on subsequent maze-running attempts improves. Using the same approach the Turtle can enter a strange room, move about in it, and form a two-dimensional view of the room. Then, with the aid of a solenoid-controlled pen attached to the Turtle, it can draw a repesentation of the floor plan on any scale. Many other applications are possible and are limited only by the ingenuity of the programmer. The turtle is available from Terrapin, Inc. (see Appendix II for the address).

11



SMALL BUSINESS APPLICATIONS FOR MICROCOMPUTERS

Virtually every microcomputer manufacturer emphasizes the small business features and accounting software support of its machines. None tries to define just what a small business is. According to the Small Business Administration, a small business is:

> "Any business activity employing up to 250 people and with an annual gross income up to five million dollars."

By this definition the majority of businesses in the United States are small businesses. Most of these would profit if they placed one or more of their business functions on a microcomputer.

SHOULD YOU COMPUTERIZE YOUR BUSINESS?

Some businesses are prime candidates for computerization. For instance, if your business is growing rapidly, computerization may be the only way you can retain control. Alternately, your business may generate a lot of paperwork involving printing, sorting, or matching. All these are suitable for computerization. Functions such as preparation of payroll are highly repetitious, and many companies computerize only payroll. Computers are also useful in high-volume manufacturing operations. Here they can be used advantageously when a large number of people are involved, when there is much incoming paper work, or when there are many production decisions to be made.

Computers can be used to keep track of a large number of model options or for costing with rapidly changing materials cost. Perhaps, your large customers may want you to computerize in order to be compatible with their own computerized accounting systems.

While the uses of a microcomputer in a small business are limited only by the imagination of the businessman, business software packages usually include certain standard functions, which are described below. A businessman may want to computerize only certain business functions. Not all businesses will require inventory control. Yet, this feature is included in many standard business software packages. Not all stores engage in credit sales, and these may not want the accounts receivable software, which is often included in the small business software package. The small businessman should choose only those programs pertinent to his specific business activity.

The features offered by the MITS/Pertec 300 Business System are typical of the software coverage available to the small business with a microcomputer. These features are listed in Table 11-1, and a sample general ledger microcomputer printout is shown in Figure 11-1. This system was designed especially for the small business. It includes not only the usual accounting and bookkeeping functions, but also more advanced functions such as inventory management and word processing. When loaded into the Altair Business System with hard disk data

Table 11-1. Business functions performed by the MITS 300 Business System.

General Ledger
- List Chart of Accounts
- General Ledger Detail Report (Trial Balance)
- Department Income Statement
- Balance Sheet
- Income Statement (Profit and Loss)

Accounts Payable
- Vendor File List
- Open Voucher Report
- Accounts Payable Aging Report
- Cash Flow Requirements
- Check Register
- Check Preparation

Accounts Receivable
- Periodic Activity Report
- Aged Accounts Receivable
- Customer Account Status
- Current Customer Accounts Listing
- Invoice
- Statement

Payroll
- Employee File List
- Payroll Register
- Pay Check
- 941-A Report
- Unemployment Tax Report
- W-2 Form

Inventory Management
- Inventory Status Report
- Exceptions Report
- On Order Report
- End-of-Period Report
- Analysis by Cost of Inventory
- Year-to-Date Sales

Word Processing
- Raw Document File
- Finished Document Preparation

storage, shown in the chapter heading photograph of Chapter 12, this software will provide major accounting procedures for any business with gross sales of $5,000,000 or less and a payroll of 250 employees or less. Even with this system, it will be necessary for your bookkeeper to perform special procedures manually. Examples are last-minute preparation of vendor checks and calculation of termination pay.

GENERAL LEDGER

The chart of accounts is like an index of the accounts used in posting to the general ledger. These accounts include cash, marketable securities, accounts receivable, inventory, fixed assets, accumulated depreciation, accounts payable, notes payable, payroll related liabilities, other accrued liabilities, and

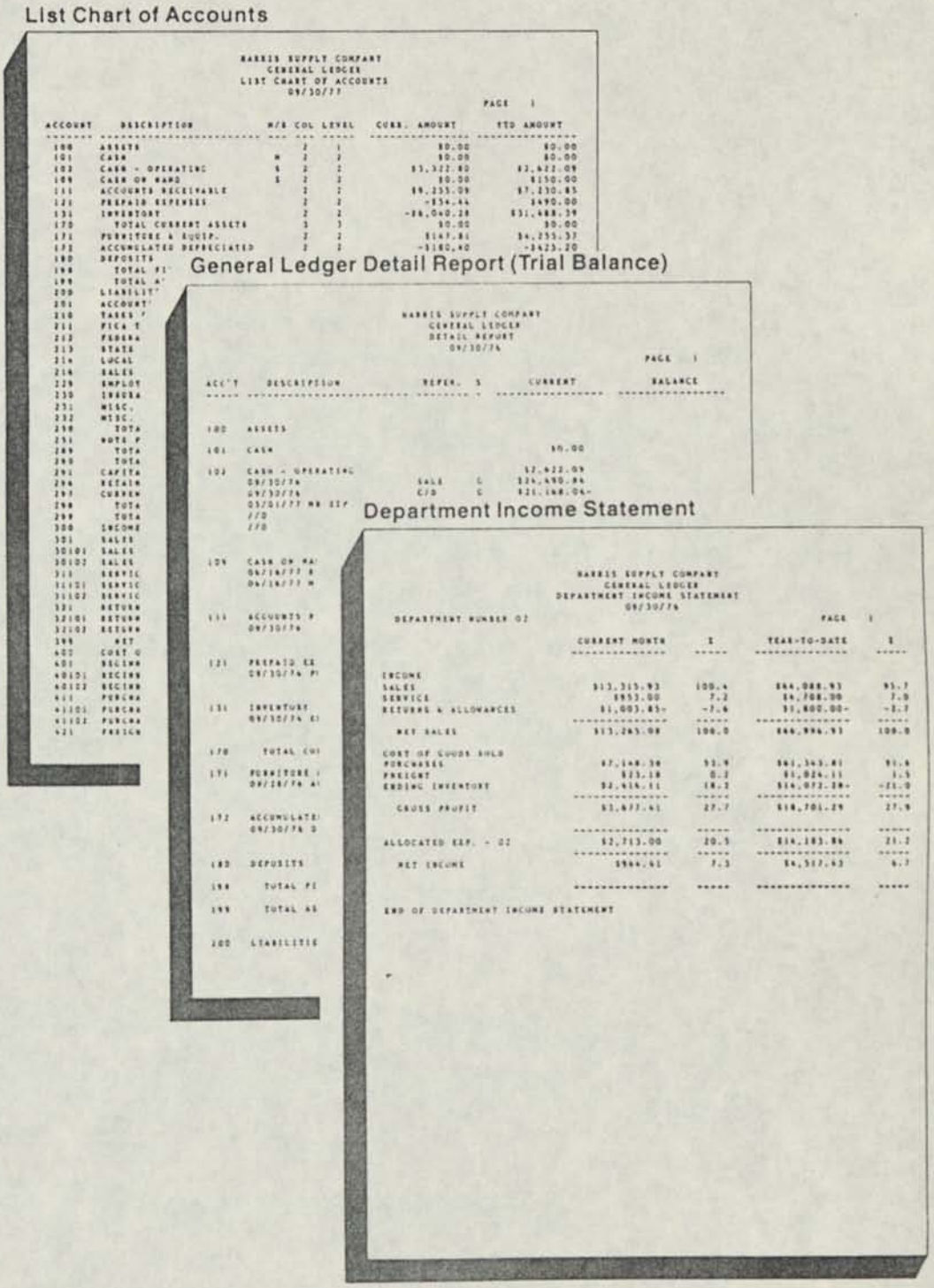


Figure 11-1. A general ledger printout. Courtesy of the MITS/Pertec Computer Corporation.

revenue and expense accounts. Journal entries are made daily, weekly, monthly, or quarterly according to the activity level and the nature of the entry. A general ledger detailed report (trial balance) will print out the net result of the entries by account

number for the time period. Provisions include departmental profit-and-loss statements, if so desired, and a balance sheet that totals assets, liabilities, and equity for the year to date. Finally, an income statement is produced. This income statement is actually a profit-and-loss statement for the operating period.

ACCOUNTS PAYABLE

This accounting function includes a vendor file list, which contains the year-to-date purchases and payments to each vendor and the current balance owed to that vendor. An open voucher report lists all open orders by cost and discount including the last date the discount is deductible. The check register report lists each vendor, the date, the amount of the billing, the amount of discount, and the net amount due. The check writing function prepares the vendor check for signature and includes a printout stub that lists vendor, address, invoice number, amount, and discount. An accounts payable aging report helps the user decide which vouchers to pay in order to benefit from discounts and to maximize cash flow.

ACCOUNTS RECEIVABLE

The accounts receivable package includes a listing of current customer accounts with the customer's name, address, and current balance. The aged accounts receivable report lists unpaid invoices by customer, account, date of charges, the total amount due, and the outstanding balance classified by aging category (current, 30 to 60 days, 60 to 90 days, and over 90 days). A special query report lists in detail the status of each customer account including recent transactions and open invoices. Invoices and monthly account statements are produced. The accounts receivable package also generates a periodic activity report, which lists customer transactions conducted for each period. It includes the type of transaction, its date, the account to which it is debited or credited, the amount of sale or purchase credit, freight, taxes, and the total of each transaction.

PAYROLL

The employee file list is a complete employee payroll record including name, address, exemptions, marital status, social security number, date hired, earnings, deductions, and totals by current pay period, month, quarter, and year to date. The employee's pay is automatically computed from time card or salary base, and the payroll check is printed to the net amount. The check stub lists hours worked, rate per hour, overtime, and the total gross amount. Deductions for federal, state, or local taxes plus FICA are tabulated for the pay period and the year to date. The payroll package includes payroll-related forms such as the 941-A report required at the end of each quarter, unemployment tax report, and the W-2 form for the year's wages and tax statement.

INVENTORY MANAGEMENT

Not every business requires an inventory management program. But for those that do, Altair offers an inventory management software package.The inventory status report lists each item in inventory by item number and lists the previous balance, number used or sold, returns, and receipts. It also shows total number on order, total currently in stock, and the total value. The on-order report lists all items ordered during the period by order date, lead time, due date, quantity, cost per unit, and total cost of order. The end-of period report lists each item of inventory, current balance, description, year-to-date sales, cost, and gross profit (loss). Finally, a year-to-date sales report lists all sales by item, cost, sales price, number sold, and gross profit.

WORD PROCESSING

A word processing capability in your office can be a very valuable asset for the preparation of business correspondence and reports. Word processing enables you to write, edit, and store each line of a business letter and then print out the letter in perfect format at a speed no human typist can match. If the

same letter is to go to a number of addresses, word processing can print out the total number of copies and change the address for each copy. For company reports, quotations, or bids, word processing makes possible automatic insertion of standard data such as prices, labor rate, overhead, and standard text describing company capabilities and facilities.

A word processing capability is obtained by acquiring software designed for your microcomputer. The text is entered on the keyboard of the microcomputer along with format commands. These control the printing of the document by specifying such things as positioning and size of the text on the page, justification, indentation, capitalization, and paragraphing. Most word processors also have an edit feature that allows the user to modify the text. When the user is satisfied with the text, he types a print command that causes the finished text to be printed out. With a good system printer, a business letter or report prepared with the aid of word processing is indistinguishable from one prepared by slower conventional techniques.

Altair offers a word processing software package, and COMPAL offers a complete microcomputer system with word processing software. The COMPAL system is described in more detail in Chapter 9.

APPLICATIONS IN THE LEGAL OFFICE

A microcomputer can be used in a legal office for instant access to client records and legal precedent libraries in addition to automatic time keeping and billing. Word processing is invaluable to the legal profession for preparing briefs, standard forms, contracts, and correspondence from dictation. It is particularly useful for preparing documents containing large amounts of standardized text. Many of the usual business applications of microcomputers are feasible in a legal office. A microcomputer can efficiently perform cost accounting, client invoicing, and accounts receivable. The applications are limited only by the available software and the wants of the user. One law firm specializing in product liability suits uses its in-house microcomputer to perform engineering calculations for case evidence.

APPLICATIONS IN THE MEDICAL OFFICE

Many medical office accounting procedures can be performed with the aid of a microcomputer. These include itemized patient billing and insurance form preparation. A microcomputer can be used for scheduling of patient visits, hospital admittances, and operating room use. Inventory control of medications, drugs, and narcotics can be performed as well as recordkeeping of patient medications to prevent prescription of reaction-producing drug combinations. Microcomputers can be used to take medical histories and write standard referral letters to other medical professionals. Notices recalling patients for standard medical procedures can also be prepared inexpensively.

Today there are a number of small firms offering microcomputer hardware and software packages tailored for the medical office. While the better ones are priced over $10,000.00, the cost should be measured in terms of reduced clerical expense and increased operating efficiency. The size of the medical practice is the criterion for the size of the microcomputer system. A medical office with one to three medical professionals can justify a basic microcomputer system if it performs 100 to 200 medical procedures per day and prepares 200 to 1000 statements per month. Such a system will have two to four large floppy disks, a single printer, and a single video terminal. A larger system for a three to ten-man office would incorporate a hard disc, several printers, and perhaps several video terminals.

THE IMPORTANCE OF SOFTWARE

Computerization of a small business often encounters one important difficulty. The emphasis always seems to be placed on the microcomputer system and not on the programs that run the microcomputer system. True, you must have both, but it is possible to purchase a very good microcomputer system lacking the business software necessary to perform the functions required for your business. If the necessary software package simply is not available, there are two possible solutions to the problem. You can create your own software programs, or you can modify existing software to meet your needs. The modifica-

tions can be performed by yourself, if you are qualified, or by a software house engaged especially for the purpose.

WHAT ARE YOUR ALTERNATIVES TO THE MICROCOMPUTER?

There are several alternatives to the acquisition of a microcomputer system:

- Continue to do your accounting manually
- Buy or continue to use an accounting machine
- Employ a part-time bookkeeper to do your accounting work
- Share a microcomputer system with other businesses

Each of these alternatives can be inefficient and may only add to your cost. Likewise, there are two more alternatives that are even more costly:

- Invest in a microcomputer system with expensive features you do not need
- Invest in a microcomputer system with fewer features than you need

The logical answer is to review your accounting procedures and determine the functions in your business that can be efficiently placed on a microcomputer system. Then select the software and the microcomputer system or components that will meet these needs. It is worth repeating. First select the software necessary for your accounting procedures. Then select the microcomputer system that operates with this software. Your accountant can advise you on the suitability of any software you are considering.

CAN YOU WRITE YOUR OWN MICROCOMPUTER ACCOUNTING SOFTWARE?

If you are considering the purchase of a microcomputer system for accounting purposes, you may find that your business requires accounting procedures not currently available as software. Can you develop your own special accounting programs?

As a general rule, no. You would need to have taken a number of special college or technical school courses specifically oriented to system development. While a number of small businessmen with this sort of background have successfully developed accounting programs, it would be better to engage an in-house programmer or seek the services of a firm specializing in system development to design your special microcomputer system. In either case the cost will be many times the standard software cost, and extra expense may be encountered in order to eliminate errors caused by the differences between your microcomputer and the microcomputer on which the programs were developed and tested.

WHO WILL OPERATE YOUR MICROCOMPUTER SYSTEM?

One question in the minds of most businessmen contemplating purchase of a microcomputer system is who is going to operate it. The owner will operate the microcomputer system in approximately 50% of the businesses, a secretary or bookkeeper will run it in 49%, and someone with previous microcomputer or large computer experience will be employed in about 1%. Operation of a microcomputer system should present no problem once the simple BASIC language commands and instructions have been mastered. Anyone who can type, follow clear-cut step-by-step instructions, and apply these basic operating instructions in actual practice, should quickly become proficient in microcomputer operation.

Most accounting software packages are designed so that relatively little technical or accounting knowledge is required for their use. Modern programming techniques, such as the use of "menu selection" and user prompting, make the learning period relatively short. A program written with these techniques presents the user with the choices he may make at each step or directs him to enter specific information. The user responds with a standardized keyword to specify the next procedure to be performed by the microcomputer or he enters the requested alphanumeric information.

Your bookkeeper should be able to operate a well designed microcomputer accounting system after one week of instruction. However, some application programs require

considerable knowledge on the part of the microcomputer operator. Several months of experience may be required to reach proficiency.

HOW TO PLACE YOUR SMALL BUSINESS ON A MICROCOMPUTER

You may have heard of the difficulties encountered by small businessmen during the computerization of their businesses. Most of these difficulties are avoidable with planning and foresight. The businessman should be prepared for some difficulty during the first year. Each business is in some way unique, and often computerized procedures must be modified to take this fact into account. If your business has over 50 employees, you may have to hire one or two additional employees during this transitional period, but the eventual savings will more than make up for the extra cost.

You can place your business on a microcomputer in a number of different ways. The method you select depends on the size and nature of your business. First, be sure to consult everyone involved in the computerization process: your accountant, branch managers, and so on. You may choose:

The Parallel Method

This is a conservative approach. You use both your established manual accounting system and your new microcomputer accounting system. The output of the two systems is compared over a period of time such as six months or one year. Then, if errors exist in your microcomputer software, they probably will be detected. Also, if for some reason the microcomputer system fails, you can fall back on the manual system. This method can be used with the entire accounting system or with individual accounting functions.

The Phase-In Method

In this method the individual functions of your accounting system are computerized one-by-one. Payroll might

be the first function to be computerized. After any problems with this function have been resolved, then the next function would be computerized. An advantage of this method is that it prevents problems from becoming too large. A disadvantage is that it may be difficult to coordinate the different parts of the accounting system.

The Pilot Method

In the pilot method only one plant, office, or installation is placed on the microcomputer system at a time. The advantage of this approach is that the system can be refined at one location prior to introduction at other locations. For instance, the programming bugs can be eliminated from the software, and, if necessary, the software can be modified to give any special reports. A disadvantage is that it may be difficult to compare accounting reports produced by the microcomputerized accounting system with those produced by the manual system.

The Burn-Your-Bridges Method

This is a high-risk approach; the entire accounting system is placed on the microcomputer at one time. This method requires careful planning and a full understanding of the capabilities of your software. If you fail to take these precautions, you may experience serious difficulties.

HOW TO GET THE MOST OUT OF YOUR MICROCOMPUTER BUSINESS SYSTEM

Microcomputer business systems can process business data rapidly and inexpensively. However, like any other business tool, certain precautions must be taken in their use. A microcomputerized accounting system must meet certain standards. Otherwise, your CPA will not certify your financial statements, and you may not be able to obtain a bank loan. A poorly designed microcomputerized business system can create opportunities for employee dishonesty and under certain circum-

stances can cause you to lose control of your business. No doubt you would experience serious difficulties if your billing files were lost. If elementary precautions are taken, problems like this should not occur.

Paperwork Helps You Control Your Business

A microcomputerized accounting system should generate what is known as an AUDIT TRAIL. This term designates the documentation used to trace a transaction forward to a summarized total or to resolve the summarized total into its constituent transactions. The audit trail is used by the auditor in his examination of your books, and you will use it in the normal operation of your business. For instance, if a customer asks for a copy of an invoice to support your billing, you will consult this documentation. The reports generated by a microcomputerized accounting system are part of the audit trail, and periodic listings of major files are another part. However, it is still necessary to maintain paper copies of certain documents. You should keep:

- Copies of invoices filed alphabetically by customer and also filed numerically by invoice number.
- Copies of receipts and deposit slips supporting customer payments.
- Copies of purchase orders (accounting and receiving department copies), invoices, and check copies matched and filed in paid vendor files.
- Employee time cards.
- Authorizations of changes in employee pay rates, deductions, and so on.

These documents may be requested by your certified public accountant, by IRS agents, and by workman's compensation auditors to substantiate the reports generated by your microcomputer system. Laws and regulations (state and Federal) require that some of these records be retained for specified periods of time. If possible, they should be retained indefinitely. If you accumulate a large number of such documents, you may want to transfer them to microfiche to save space.

How To Get Accurate Business Data Into Your Microcomputer System

The accuracy of the data that comes out of your microcomputer depends on the accuracy of the data that goes in. There are a number of special techniques that help you get accurate data into your microcomputer business system. One such technique is BATCH PROCESSING. It greatly facilitates data entry and reduces errors. Documents of all transactions affecting a particular master file are accumulated for a period of time such as a day or week. For instance, sales could be so grouped. Then these transactions are arranged in sequence, and a BATCH CONTROL TICKET is created. This batch control ticket accompanies the documents at all times. It contains a record of batch origin and destination, batch number, the number of documents in the batch, beginning and ending document serial numbers, date of creation, and control totals (see below). The entire batch is entered into the microcomputer system at one time, and a record of the time of entry and responsible personnel is created.

A complete log of microcomputer operations should be kept. For each batch of data a log entry should be made of its complete history, the time of entry, the steps performed, and the results. In addition, a special log should be kept of system error messages and the corrective actions taken. These logs are an important part of the audit trail.

Good accounting software should generate reports that contain all necessary accounting data in an easily understood form. Furthermore, an accounting software package written for a business with more than 25 employees should provide certain controls to check the accuracy of input data. Most errors are caused by KEYPUNCHING mistakes. (Keypunching is the process of typing data into a keyboard.) One technique to detect input errors is the EDIT LIST. As transactions are entered into the microcomputer system, they are placed into a holding file. After each batch of transactions has been entered, it is printed out or LISTED. The operator then checks this LISTING or EDIT LIST in order to detect and eliminate any errors. Only then are the transactions in the holding file entered into the master accounting files. This procedure is strongly recommended by most accounting firms.

The accounting software itself can perform a number of tests to determine the validity of input data. A CHECK DIGIT can be used to verify an identification number. A check digit is an extra digit added to a number. For instance, to calculate a check digit for the number 123456, the following procedure could be used:

1. Multiply alternate digits by 2: 2 6 10
2. Sum resulting digits and digits not multiplied:
   $2 + 2 + 6 + 4 + 10 + 6 = 30$
3. Sum the digits of the resulting number to obtain the check digit: $3 + 0 = 3$
4. Append check digit to the original number: 1234563

This is one of many possible procedures that can be used to generate a check digit. The identification number with appended check digit is entered into the microcomputer system, and the microcomputer calculates the check digit and compares it with the last digit of the identification number. If digits have been omitted or transposed in the identification number, there is a good chance that the microcomputer will detect it.

CONTROL TOTALS can be used to detect errors in data. A control total is calculated manually for each batch of data prior to entry into the microcomputer. After the batch of data is entered into the microcomputer system, the corresponding total is calculated by the microcomputer. If the two numbers do not agree, an error has occurred and the operator is informed. A variety of different types of control totals are in common use. For instance, the number of transactions or the total number of documents in a batch is a commonly used control total. For payroll, the total number of employees would serve as a control total. FINANCIAL TOTALS can be used to check the accuracy of data entry. Financial totals are monetary totals of sales, payroll, and such. These totals are included in the reports of most accounting software packages. Again, the manually calculated total is compared with the total calculated by the microcomputer in order to detect errors.

HASH TOTALS are used to check the validity of identification numbers such as customer numbers, invoice numbers, or

purchase order numbers. For each batch of data the identification numbers are added prior to entry into the microcomputer. Then the total is compared with that calculated by the microcomputer.

The microcomputer can perform a number of other tests to check on the validity of input data. These include:

1. Check of an identification number against the master file. For instance, only certain customer numbers are valid. If a customer number is not found in the master file, a mistake has been made.
2. Check for valid characters. If the microcomputer expects a number in a particular data field, but instead encounters a letter or symbol, an error has been made. The microcomputer should inform the operator exactly where the error was detected.
3. Check on data format. If the microcomputer expects a 6-digit number, but instead encounters something else, it should issue an error message.
4. Limit tests. If the amount of a transaction is negative or outside accepted limits, the microcomputer should be programmed to call this to the operator's attention.
5. Sequence tests. If the documents in a batch of data have been arranged in sequence, the microcomputer should check the input data to see if this sequence is found. For instance, transactions might be numbered in an ascending sequence with no numbers omitted. If transaction numbers were found to be omitted or out of sequence, an error message would be issued.
6. Internal consistency of data. Certain numbers should be less than other numbers. For instance, any individual item in a billing should not be greater than the billing total.
7. Validity tests. A specific type of identification number can be assigned to a certain numerical range or it can contain specific alphanumeric characters. Then, if the microcomputer encounters a number inappropriate for the type of operation being processed, it can issue an error message. For example, in inventory control one type of transaction code (an identification number) may signify deliveries to stock, and another may signify disbursements from stock.

In addition, you may want to have checks to inform you of special situations. If the amount of a customer's order greatly exceeds his average order, you will want to know this so you can check his credit. If the amount on a receiving report greatly exceeds that ordered, you will want to know so that you can check for errors. The special situation checks you use depend on the nature of your business.

Can Your Microcomputer Handle An Emergency?

Good software should be capable of handling a number of different special situations. For instance, if incorrect or inconsistent data is entered, the accounting system should not jam or lose control. Instead, it should issue an error message and either wait for operator intervention or proceed to the next task. Likewise, if power to the microcomputer fails, or if the operator makes an error, the accounting system should be capable of informing the operator of the status of the files after the system is restored to operation. As another example, the billing function requires large numbers of statements to be printed at one time. What if the printer runs out of paper or the ribbon breaks? It might be necessary to print the entire billing from the beginning unless the system has the capability to restart printing from any specified point in the billing.

Security is Important

A microcomputerized accounting system, like a manual accounting system, requires that certain security measures be taken in order to prevent financial loss. Access to the microcomputer room should be restricted as should the number of people allowed to operate the microcomputer. Many business microcomputer systems have key locks to prevent operation by unauthorized persons. Some software requires entry of a code number before important files can be accessed or modified. These code numbers should be known only to authorized personnel, and they should be changed regularly to prevent unauthorized access.

To maximize security the documents and reports that constitute the audit trail must be accurately maintained, and

they must be routinely inspected by accounting experts from outside your business. You should use SEGREGATION OF DUTIES within your business. This means that one employee should not be allowed to perform all functions connected with the microcomputer. For instance, one person should enter data into the holding files, another should check the accuracy of the entered data, and a third person should operate the microcomputer system. None of these people should have access to listings of the accounting programs. Otherwise, it might be possible to make program modifications that would defeat your accounting system. While this degree of segregation of duties might be impractical in a small business, the small businessman should take all possible steps to insure the security of his accounting system.

Manuals Help You Use Your System

Before you computerize your business, you will want to obtain full documentation of microcomputer hardware and software. This documentation is divided into several parts. The system manual describes the system hardware, its maintenance, and repair. The program manual describes in detail the software package including any custom modifications. It provides a complete listing of all programs. The operator's manual provides the necessary instructions to run the microcomputer system and to respond to emergency situations. The controls manual contains a description of the controls procedures used to minimize input errors and a description of the internal error detection procedures used by the microcomputer system itself. It also contains a description of procedures used to check the accuracy of accounting data.

This documentation serves a number of different functions. It provides the information necessary for management review of the system, and it aids in the education of new employees. It also establishes standard operating procedures and specifies emergency procedures in case the microcomputer system malfunctions. (Good systems with service readily available should be down no more than one day per year.) This documentation is essential if the software package is to be modified. Outside accountants will wish to refer to it.

This documentation is an important business record and should be treated as such. Extra copies should be kept outside your business. For security reasons access to it should be limited to those with a genuine need-to-know. The system operator, for instance, should have access only to the operator's manual. Most accountants will insist on these safeguards.

Important Precautions For Operation Of Your Microcomputer System

Operation of a microcomputerized accounting system requires a number of precautions just as does operation of a manual system. All important data files should be backed up. Usually this involves making a copy of a floppy disk. Then, if your microcomputer system is destroyed or damaged or if the operator makes a major error causing the loss of vital data, your business can continue operation. Some users prepare three copies of all important files: one is retained in the business, one is kept in the home of the owner, and the third is stored in a safe deposit box. You may also want to consider fire and theft insurance for your microcomputer system.

A good microcomputerized accounting system should prepare reports and printouts of all vital data. These hardcopies will be essential if it is necessary to reproduce lost disk data files, and they will enable your managers to review business activity without interferring with daily operations. Also your auditors will prefer to use hardcopies.

For maximum reliability of operation, the microcomputer system should be placed in a special room with controlled temperature, humidity, and dust particle level. Some components of a microcomputer system are particularly delicate and must be treated with care.

A hard disk drive is one such component. The head of a hard disk drive floats on a cushion of air above the surface of the magnetic disk. If dirt particles adhere to the disk, they may upset this air cushion causing an interruption in data storage and retrieval. The head may even crash into the disk causing permanent damage. Sources of dust or lint should be excluded from the microcomputer room. Smoking generates large numbers of

small particles. For this reason smoking should not be permitted near the microcomputer system.

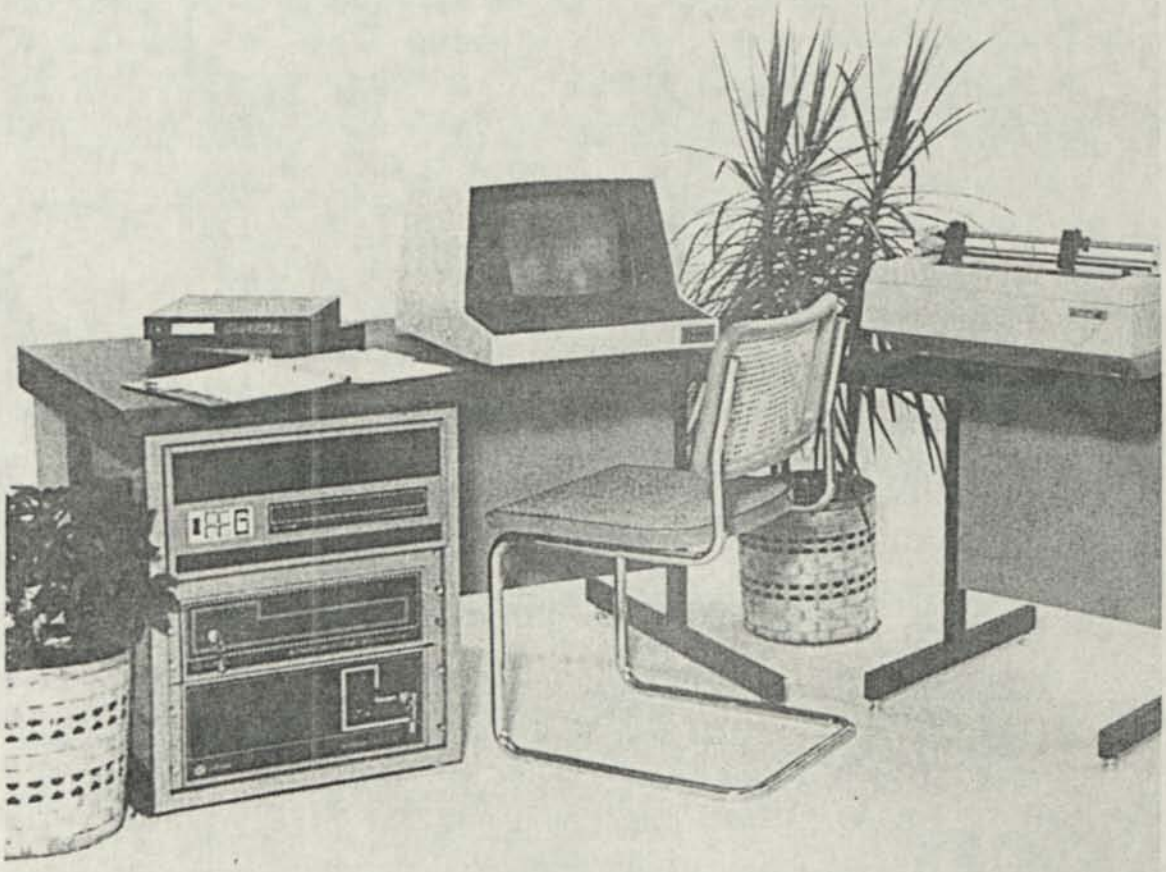
Floppy disks should also be handled with care. They too are sensitive to dust, dirt, and smoke particles. Care should be taken not to touch the surface of a floppy disk. A fingerprint contains enough oil to cause disk malfunction. Also care should be taken not to bend or fold a floppy disk as this may damage the magnetic recording surface. Don't write directly on the disk envelope with a pen or pencil as this may produce indentations in the disk.

Stray magnetic fields can cause the loss of data recorded on a magnetic disk. Magnetic fields can be generated by electronic equipment. The speaker in a transistor radio generates a magnetic field as does a soldering iron. Tools often acquire magnetization. So all these objects should be kept away from magnetic disks. Disks should not be stacked as the magnetic field from one disk may affect another disk. Special disk storage containers are available that keep disks separated and shield them from external magnetic fields.

SUMMARY

The precautions mentioned in the previous sections are highly desirable for all microcomputer business systems. Because of the size or level of complexity of your business, you may decide not to implement all of them. A microcomputerized accounting system requires at least as many precautions as a manual system. You wouldn't think of leaving your journals and ledgers unguarded. So lock up floppy disks containing important files when they are not in use. A microcomputerized business system is similar to but different from a manual system. Be sure to give some thought to how the differences will affect your business.

12



SELECTING A MICROCOMPUTER SYSTEM FOR YOUR BUSINESS

Once you have determined your business computing requirements, the next step is to select the software best suited to these requirements, select a microcomputer system compatible with your software, and then select the necessary peripherals. You may choose a complete microcomputer system offered with software, or you may assemble a system from components and acquire the needed software elsewhere. In either case you should keep in mind the availablity of user training and factory support of service. In addition, you may want to consider the availability of software for your future requirements.

This chapter will examine a number of different microcomputer systems in terms of their cost versus the business functions they can reasonably be expected to perform. All of these systems can use any of the common microprocessors. The difference in cost and performance is made by random access memory capacity and peripherals such as printers and disk drives.

MICROCOMPUTER SYSTEMS UNDER $1000

Systems in this category will have semiconductor memory ranging from 4K to 16K. The system will use 4K BASIC or extended BASIC depending on available RAM. In this cost range some microcomputer systems offer the advantage of permanent storage of the BASIC interpreter in read only memory (ROM).

These microcomputers do not need to have their BASIC interpreter loaded each time the microcomputer is turned on. This feature enables use of all the RAM purchased with your microcomputer for program and data storage. In summary, system components in this price range will include:

- Microcomputer
- Video terminal (9" or 12" screen)
- 4K to 16K RAM
- BASIC either in ROM or loaded from audio tape cassette
- Audio tape cassette data storage
- Some software support

The Radio Shack TRS-80 microcomputer shown in Figure 6-2 lies in this price range. Figure 6-4 shows the TRS-80 payroll software package, which contains the program on tape cassette plus extra cassettes to record employee payroll data. This program will cover payroll records for up to 12 employees, but it does not offer full-size hardcopy printouts.

MICROCOMPUTER SYSTEMS UNDER $2500

In this price range the data storage capacity is increased to 80 kilobytes or more by the introduction of disk storage, and a small hardcopy printer is added. This printer will have limited capabilities. The printing speed will be low, and the number of characters printed on each line will be limited. While the printer will lack the capabilities necessary for serious business applications, it can create printed records of data that can be extremely useful. The SWTPC PR-40 alphanumeric printer shown in Figure 9-11 is one such printer. It can print a line of 40 characters on 3-7/8-inch wide paper. The TRS-80 screen printer shown in Figure 6-5 is another. It prints at extremely high speed, but it requires a special 4-inch wide paper. A minifloppy disk system is likewise useful. It not only increases available data storage capacity, but it also decreases the time necessary to load data into the microcomputer. Loading time for accounting software is reduced from 6 to 7 minutes to slightly over 20 seconds. With only one disk drive, it is not possible to make copies of disks

containing important business information. So important files must be either printed out or copied onto tape cassettes in order to guarantee that they will not be lost in case of disk drive failure. For this microcomputer system, inventory control can handle up to 400 stock items, and payroll capability is increased from 12 employees to 25 employees. There is a corresponding increase in the capabilities of the accounting procedures. Our system now includes:

- Microcomputer
- Video terminal (12" screen)
- 16K RAM
- Extended BASIC
- Audio tape cassette data storage
- Single minifloppy disk drive (80 kilobytes or more data storage capacity)
- Limited hardcopy capability
- Increased availability of accounting software

This system is a significant improvement on the lower cost system, but there are still many limitations within this cost range. As an example, transfer of your payroll to standard forms and check blanks requires a minimum extra cost of $1300 for a printer plus the cost of specially printed business forms.

MICROCOMPUTER SYSTEMS UNDER $4000

This cost range includes the minimum system for full-application small business use. This cost range is the first to include 32K RAM, 12K BASIC in ROM, dual minifloppy disk drives for a minimum of 160 kilobytes total random access memory, and a printer satisfactory for business applications. The printer is essential for word processing and almost all accounting procedures. For this reason it should be selected with the same care as you use to select the other components of your microcomputer system. This level system is ideal for medical and legal offices, retail stores with annual sales under $100,000, and for virtually every kind of service business. Our business system now includes:

- Microcomputer
- Video terminal (12" screen)
- 32K RAM
- Dual minifloppy disk drives (160 kilobytes or more data storage capacity)
- Printer for hardcopy on printed business forms
- Good accounting software support
- Payroll to 50 employees
- Inventory to 800 stock items

This system will meet the requirements of most small businesses. However, the RAM and disk data storage capabilities are the bare minimum needed for accounting reports and inventory control. Of course, many small businesses will not need the number of accounting reports and inventory printouts described in Chapter 11, and then this level system will be ideal.

MICROCOMPUTER SYSTEMS UNDER $7000

In this cost range the available RAM remains at 32K, but the change from dual minifloppy disk drives to dual floppy disk drives increases the data storage capability to between 500 kilobytes and 1 megabyte. The system now features:

- Microcomputer
- Video terminal (12" screen)
- Dual floppy disk drives (500 kilobytes or more data storage capacity)
- Printer
- Payroll to 50 employees
- Inventory management to 1800 stock items
- Increased accounting capability

MICROCOMPUTER SYSTEMS UNDER $10,000

Systems in this cost range will have mircrocomputer RAM increased to 48K. Dual floppy disk drives will give a total data storage capacity of over 500 kilobytes. All payroll functions are subsequently increased to the level of 100 employees with full

payroll capability for withholding, quarterly returns, and W-2 forms. Inventory management is now capable of handling 4000 stock items with full profit-or-loss status reporting. The microcomputer system includes:

- Microcomputer
- Video terminal (12" screen)
- 48K RAM
- Dual floppy disk drives (500 kilobytes or more data storage capacity)
- High-capability printer
- Complete software for accounting, payroll, and inventory management
- Payroll capabilities up to 100 employees
- Accounting procedures to a gross business income of $1,000,000

Remember that accounting procedures and employee reporting requirements will differ from business to business. For this reason the figures given for payroll capability will vary as will the maximum number of stock items that can be handled by an inventory management system.

MICROCOMPUTER SYSTEMS UNDER $20,000

In this cost range we are actually on the dividing line between microcomputers and minicomputers. Most systems in this category will offer a wide range of data storage options. They also will provide full accounting capabilities for businesses with gross incomes to $5,000,000 per year and payroll coverage up to 250 employees. A system at this level will contain:

- Microcomputer
- Time-sharing capability with multiple video terminals
- 64K RAM
- Hard disk drive (data storage capacity to 50 megabytes)
- High-capability printer
- Inventory management to 36,000 stock items
- Payroll capability to 250 employees
- Word processing for correspondence and reports

The Chapter 12 heading photograph illustrates the Altair Business System with hard disk data storage and printer. This system can handle accounting, payroll, and inventory control within the limitations set forth above.

Table 12-1 summarizes the relationship between system cost and performance. In a given price range there is considerable tradeoff between the performance of the various components of the system. For example, disk drive storage capacity depends strongly on whether a single-density or double-density data storage format is used. System performance for business applications depends strongly on the particular software

Table 12-1. Cost Versus Performance for Typical Microcomputer Systems.

Cost of System	$1000	$2500	$4000	$7000	$10,000	$20,000
RAM	4K to 16K	16K	32K	32K	48K	64K
Data Storage Peripherals						
Type	tape cassette	mini-floppy disk	dual mini-floppy disks	dual floppy disks	dual floppy disks	hard disk
Capacity		80KB to 400KB	160KB to 800KB	500KB to 1MB	500KB to 1MB	2MB to 50MB
Printer	none	limited capability	medium capability	medium capability	full capability	full capability
Payroll Capability (Employees)	12	25	50	50	100	250
Inventory Control (Items)		400	800	1800	4000	36,000
Accounting Capability (Annual Sales)			$100,000	$500,000	$1 million	$5 million

package used. Thus, the numbers given in Table 12-1 are to be used only as guidelines.

HOW TO SELECT A SYSTEM

The selection of the best microcomputer system for your business will depend on your individual requirements, the number of employees, and the amount you can invest in computerization of your business functions. The microcomputer systems mentioned in this book have been presented to give an insight into the nature of the microcomputer and its peripherals and to give the reader some first-hand knowledge of what is available. If you are uncertain how to proceed, here are a few suggested steps:

- Consult your accountant in order to determine your specific accounting needs.
- Determine if word processing, mailing list preparation, and inventory management are necessary to your business. If not, these functions may be deleted.
- Survey the software market to see if software is available and suitable for your business needs.
- Having determined the availability of appropriate software, select the system compatible with the software. This includes required RAM, disk capability, and compatability of the software/microcomputer data transfer rates.
- Check on the manufacturer's overall reputation, and confirm the manufacturer's support capability for employee training on the exact system you will purchase, and confirm the quality of service and the location of the local service center. Also check the quality and the extent of system documentation (manuals).
- Check availability and delivery date offered for the system you have selected. If your system must be built after you have placed your order, the delay could be detrimental to the implementation of your microcomputerized business procedures. The normal time between placement of your order and installation of the system should not exceed 6 to 7 weeks.
- When you and your budget are satisfied, place your order and arrange for employee operational training.

GLOSSARY OF TERMS

Access time The period of time between a request for information and its availability.

Accumulator A register used to hold data for processing in arithmetic, logical, and I/O operations.

Address The numeric designation of a specific memory location.

Address modes The ways in which a microcomputer addresses registers and memory in order to access and manipulate data. The number of available address modes is a measure of the power of the microprocessor.

Address register A location in a CPU for the storage of an address value.

ALGOL ALGOrithmic Language. A high-level computer language used extensively in Europe.

Algorithm A set of procedures for solving a problem.

Alphanumeric A descriptive term for a set of characters consisting of alphabetic, numeric, and special characters.

Application program A program written for a specific user application. Contrast with utility program.

Arithmetic logic unit (ALU) The part of a microprocessor that performs mathematical or logical operations.

Array An arrangement of elements (numbers, memory cells, etc.) in rows and columns.

ASCII American Standard Code for Information Interchange. A commonly used seven-bit code used for representation of letters, numbers, and symbols. An eighth bit is often added as a parity check. See Appendix I.

Assembler A program used to translate coded instructions prepared by the programmer into binary machine language.

Asynchronous device A device whose speed of operation is not controlled by any other device.

Base 1. A reference value. 2. Part of a transistor. 3. The radix of a number system. For instance, the binary number system uses a base of 2.

BASIC Beginner's All-purpose Symbolic Instruction Code. A high-level programming language often used with microcomputer systems.

Baud A unit of rate of data transfer usually equivalent to one bit per second.

Baudot code A standard 5-bit code used to represent alphanumeric characters. Special "shift" and "unshift" commands allow the code to represent about sixty symbols. This code is encountered in older equipment.

Binary Descriptive of a number system with a base of 2. It uses only two digits: 0 and 1. See Appendix I.

Binary coded decimal (BCD) A binary numbering system for coding decimal numbers as groups of four binary bits each. See Appendix I.

Bit BInary digiT. One binary digit is usually represented by "1" or "0" or by "ON" or "OFF". A binary number is an ordered sequence of binary bits. See Appendix I.

Block diagram A diagram of a system or component of a system that uses geometric figures to denote the principal parts and identify their functional relationship.

Bootstrap A program used to initialize a microcomputer when it is turned on. This program permits other programs to be brought into the microcomputer.

Buffer An isolation circuit used to prevent interaction between the driving circuit and the driven circuit.

Buffer storage Any device that temporarily holds data during data transfer usually between internal and external forms of storage.

Bug A mistake in a microcomputer program causing it to give erroneous results.

Bus One or more conductors grouped together for the transmission of data or power. The S-100 bus is a group of 100 such conductors used to carry data and control signals in a microcomputer.

Byte A sequence of eight binary bits used to represent one character of information. Most microcomputers manipulate data one byte at a time. A 4K memory can store 4096 bytes or characters of data.

Cathode ray tube (CRT) CRT's are used in TV sets to display images. In microcomputer systems they are used to display letters, digits, symbols, punctuation marks, and plots of data. A video display terminal contains a cathode ray tube.

Central processing unit The part of a microcomputer that contains the addresses registers, arithmetic logic unit, and timing signal generator.

Character A letter, digit, symbol, or punctuation mark used to represent data or operational instructions.

Clock A device that generates a periodic signal used to synchronize the operation of the different parts of a microprocessor.

COBOL COmmon Business Oriented Language. A high-level computer language used for data processing in business.

Compiler A program that translates a high-level language program into binary machine language, which is generally stored for subsequent execution.

Computer An electronic data processing machine that can automatically perform arithmetic and logical operations according to a program of instructions.

Computer language A set of rules and symbols for communication of instructions and information to a computer. A statement in a high-level computer language translates into many machine instructions BASIC and FORTRAN are two such high-level languages in common use.

CP/M Control Program (For) Microcomputers. A commonly used microcomputer operating system.

Cursor A cursor is an electronically generated symbol (usually a line or a square) appearing on the screen of a video display terminal to indicate where the next character will appear.

Data Information as produced by a microcomputer or information suitable for input to a microcomputer.

Data processing The manipulation of data by the execution of a sequence of instructions. Synonymous with information processing.

Debug To detect, locate, and eliminate mistakes in a program or a malfunction in a microcomputer's electronic circuits. Similar to the term troubleshoot.

Decimal Descriptive of a number system with a base of 10.

Decimal digit One of the numbers 0 through 9.

Decimal point The radix point in decimal representation. See Appendix I.

Direct memory access (DMA) Refers to the transfer of data between memory and external peripherals such as magnetic data storage disks. The CPU does not participate directly in the transfer, and so the data transfer rate can be quite high.

Diskette A flexible disk coated with magnetic material used as a data storage medium. Synonymous with the term floppy disk.

Dump To copy or print out the contents of a microcomputer's memory or to transfer data from memory to an external storage medium.

Duplex The simultaneous transmission of data in two directions on different data lines. Compare with half duplex.

EBCDIC Extended Binary Coded Decimal Interchange Code. A standard 8-bit code used for representation of letters, numbers, and symbols used especially by IBM. See Appendix I.

Edit To modify data by inserting, changing, or deleting characters.

Erase To wipe out information stored on a CRT display, in microcomputer random access memory, or in other storage media.

Execute To carry out the program instructions.

Exponent A number that represents the power to which the base is raised. Exponents are used in the representation of numbers by scientific notation.

Extender board A plug-in extension board used to facilitate troubleshooting a circuit board.

Firmware Computer instructions stored in read-only memory.

Fixed point arithmetic A method of calculation in which the microcomputer does not keep track of the position of the radix point. Compare with floating point arithmetic.

Flag A bit used for identification or as a signal to indicate the occurrence of some condition or event.

Flip-flop An electronic circuit having two stable states. It has the capability of being changed from one state to the other state by an external control signal and then remaining in that state after the signal is removed. Flip-flops are often used as memory elements.

Floating point arithmetic A method of calculation in which the computer keeps track of the position of the radix point. Compare with fixed point arithmetic.

FORTRAN FORmula TRANslation language. A high-level computer language used frequently for scientific calculations.

Direct memory access (DMA) Refers to the transfer of data between memory and external peripherals such as magnetic data storage disks. The CPU does not participate directly in the transfer, and so the data transfer rate can be quite high.

Diskette A flexible disk coated with magnetic material used as a data storage medium. Synonymous with the term floppy disk.

Dump To copy or print out the contents of a microcomputer's memory or to transfer data from memory to an external storage medium.

...ous transmission of data in two directions on ... half duplex.

... Code. A ...

Function A characteristic operation, movement, control, or command related to microcomputer operation or to data input by the keyboard.

General purpose computer A computer that is designed to be used in a wide variety of applications.

Half duplex Two-way data transmission along a data channel with data transfer occurring alternately in each direction.

Hardcopy A printed paper copy of a program or its results produced by a printer attached to a microcomputer. A hardcopy capability is essential for business applications of a microcomputer.

Hard sectoring A method of dividing magnetic disks into sectors by the use of index holes positioned around the center of the disk. Compare with soft sectoring.

Hardware The physical parts of a microcomputer as contrasted with computer programs (software). Compare with software and firmware.

Hexadecimal A number system with a base of 16 using 16 digits (0 through 9 and A through F). See Appendix I.

Index register A CPU register used in the calculation of the effective address of an instruction.

Input/output interface The electronic circuitry used to enter data into a microcomputer and/or used to transfer processed data out of the microcomputer into peripherals such as external data storage devices or printers.

Instruction Information that specifies a specific microcomputer operation and that gives the values or addresses of its operands.

Instruction register The instruction register holds the instruction currently being executed by the microprocessor.

Instruction set The group of instructions executable by any designated microprocessor. The number and type of these instructions is a measure of the power of the microprocessor.

Interface 1. Microcomputer hardware specifically designed to link two or more microcomputer devices so as to permit transfer of data between them. 2. To install such a link.

Interpreter A program that translates each high-level language program statement into executable binary machine instructions each time the high-level statement is encountered during the execution of the user's program. Interpreters are slow and inefficient, but offer considerable convenience. Most versions of BASIC for microcomputers are offered as interpreters rather than compilers. Compare with compiler.

K An abbreviation for the prefix kilo. In the microcomputer field it is often used to denote the number of kilobytes of random access memory.

Keyboard A panel of keys used to enter data into a microcomputer. Depression of any key closes a switch causing a numeric code to be generated that is characteristic of that key. Most microcomputer keyboards resemble typewriter keyboards although the position of some keys may differ.

Language A set of characters, digits, letters, and symbols and the set of rules specifying their use for the manipulation of data. See computer language.

Line printer An output peripheral that prints an entire line at one time. Compare with serial character printer. A line printer is usually faster than a serial character printer.

Load To transfer data from an external data storage device into a microcomputer.

Loader A program used to load an object program into random access memory prior to execution.

Loop A sequence of instructions repeated until the loop is terminated.

Machine language Only machine language programs can be directly run on a microcomputer. Programs written in higher level microcomputer languages must first be converted to machine language in order to perform the computations called for by the program.

Magnetic disk Floppy disks and minifloppy disks are forms of magnetic disks. Physically, they are plastic disks coated with ferric oxide or other magnetic films on which data can be stored by selectively magnetizing areas of the surface.

Magnetic tape A flat flexible tape coated with magnetic material. Audio cassette recorders/players and reel-to-reel tape recorders use magnetic tape as a data storage medium.

Memory Any device used to store data. Memory devices are compared in terms of storage capacity, access time, cost, and data volatility.

Microcomputer A small computer employing a microprocessor such as the Intel 8080A or the Zilog Z-80 as the central processing unit. Usually the computational capabilities and information storage capacity are less than those of a minicomputer or computer.

Microprocessor Electronic circuitry on a single integrated circuit chip that can perform data manipulation. Also called the microprocessing unit (MPU).

MODEM MOdulation/DEModulation device. It allows computers, terminals, and other digital devices to communicate over telephone circuits or other data lines. Most modems use a tone modulation scheme to transmit and receive data.

Monitor A program that contains the software routines required to operate a microcomputer. These routines include the I/O routines but do not include high-level functions such as file handling.

Motherboard A circuit board used in some microcomputers. Other circuit boards are plugged into the motherboard, and the motherboard furnishes power and various data buses to each circuit board.

Octal A number system with a base of 8 using 8 digits (0 through 7). See Appendix I.

Paper tape Continuous strips of paper used to store data in the form of punched holes. A hole represents a "1" bit, and no hole represents a "0" bit. Paper tape is used as a permanent storage medium for microcomputer programs.

Parallel Descriptive of the simultaneous transfer of a group of binary bits. Parallel transmission of 8 bits of data to represent a single character requires 8 data lines. Contrast with serial. Parallel data transmission is usually faster but more expensive than serial data transmission.

Parity A method of checking the accuracy of transmission of binary numbers by using a single bit to indicate whether the total number of 1's or 0's is odd or even. If one bit has changed state, an error will be detected.

Peripheral An external accessory connected to the microcomputer and used for the input, output, or storage of data. CRT displays, keyboards, line printers, magnetic storage devices and their interfacing hardware are considered to be peripherals.

PL/I Programming Language I. A high-level computer language introduced by IBM.

PL/M A high-level programming language introduced by the Intel Corporation for microcomputer use. PL/M is similar to PL/I.

Port A communication channel between the central processing unit and a peripheral.

Program A set of computer instructions or high-level language statements directing the computer to perform specific operations.

Program counter The program counter holds the address of the next instruction to be fetched from memory. It is automatically incremented after each fetch cycle. Also called the instruction counter.

Program error Any error in a program that prevents the microcomputer from performing the intended computations or logic operations.

RAM See random access memory.

Random access memory (RAM) A medium of data storage. The storage locations in random access memory can be read out or changed in value in any order. The random access memory used in most microcomputers employs semiconductor integrated circuits.

Raster A pattern of closely spaced parallel lines visible on the face of a CRT. These lines are produced when the CRT's electron beam is scanned over the tube face in a regular manner in order to produce an image covering the face of the CRT.

Read only memory (ROM) A permanent semiconductor memory medium containing data that can be read but not altered. It is often used to store a bootstrap program or an interpreter program.

Register A location for the temporary storage of data. Microcomputer registers are usually part of the central processing unit.

Real time clock An electronic circuit that provides a real-time reference to the microcomputer. A real time clock is useful for applications that require an accurate knowledge of the time of day or the elapsed time.

ROM See read only memory.

Serial Descriptive of the transfer of data bits in sequential order—one bit after another. Contrast with parallel.

Serial character printer A peripheral that prints one character at a time to form a line of characters. Compare with line printer.

Soft sectoring A method of dividing magnetic disks into sectors using a single index hole and software. Compare with hard sectoring.

Software Computer programs and related documentation usually designed for specific applications and stored on cassette tape, punched paper tape, or floppy disk. Contrast with firmware and hardware.

Source code The assembly language or high-level language version of a program as prepared by the programmer. It is converted to an object code for execution by the computer. The object code consists of machine instructions.

Stack A section of memory in some microcomputers where data is stored on a last-in first-out basis.

Stack pointers Stack pointers hold information used to control storage and retrieval of data in the stack.

Subroutine A computational procedure or logic routine that can be used by another program or routine.

System A group of components linked together to perform specific tasks under the direction of the system software and the system user.

Terminal A peripheral device used to communicate between the user and a microcomputer. Examples are a video terminal and a printer terminal. Both have a keyboard for user input.

Test data Data developed to test the accuracy and adequacy of a program.

Text editor A text editor is a utility program that allows a user to edit the format of data. For instance, a text editor can be used to change, add, or delete the lines of a program.

UART Universal Asynchronous Receiver-Transmitter. A device that interfaces parallel data with a serial device.

Utility program A program that performs utility functions such as loading a program from a peripheral, listing a program, or some other routine manipulation of data.

Word A group of binary digits that occupy one storage location within microcomputer memory. The number of bits of data that a microprocessor manipulates at one time is the word length for that microprocessor.

GLOSSARY OF ACRONYMS

AC	Alternating Current
A/D	Analog-to-Digital
ALU	Arithmetic Logic Unit
ANSI	American National Standards Institute
ASCII	American Standard Code for Information Interchange
BCD	Binary Coded Decimal
BPS	Bits Per Second
CAI	Computer-assisted Instruction
CMOS	Complementary Metal Oxide Semiconductor
CP/M	Control Program (For) Microcomputers
CPS	Characters Per Second
CPU	Central Processing Unit
CRT	Cathode Ray Tube
D/A	Digital-to-Analog
DC	Direct Current
DIP	Dual In-line Package
DMA	Direct Memory Access
DOS	Disk Operating System
DVM	Digital Voltmeter
EBCDIC	Extended Binary Coded Decimal Interchange Code
EDP	Electronic Data Processing
EIA	Electronics Industry of America

EPROM	Erasable Programmable Read Only Memory
FET	Field Effect Transistor
FF	Flip-flop
IC	Integrated Circuit
I/O	Input/Output
LED	Light Emitting Diode
LSB	Least Significant Bit
LSI	Large Scale Integration
MHz	Megahertz
MODEM	Modulator-Demodulator
MOS	Metal Oxide Semiconductor
MPU	Microprocessor Unit
MSB	Most Significant Bit
MSI	Medium Scale Integration
NBCD	Natural Binary Coded Decimal
OEM	Original Equipment Manufacturer
PROM	Programmable Read Only Memory
RAM	Random Access Memory
RFI	Radio Frequency Interference
ROM	Read Only Memory
RTL	Resistor-Transistor Logic
SSI	Small Scale Integration
TTL	Transistor-Transistor Logic
TTY	Teletypewriter
UART	Universal Asychronous Receiver Transmitter
VLSI	Very Large Scale Integration
VOM	Volt-ohm Meter

APPENDIX I
NUMBER SYSTEMS, CODES AND PROGRAMMING LANGUAGES

In this appendix we describe some of the number systems used in connection with computers and microcomputers, and we show how to convert from one number system to another. Finally, we describe some of the commonly used codes for representing letters, numbers, and symbols as a sequence of binary bits, and we discuss some of the commonly used programming languages.

THE DECIMAL NUMBER SYSTEM

A number system is identified by its base or radix. The radix is the number of characters or digits used to represent quantities in that number system. The decimal system has a radix of 10 because we use the ten digits 0 through 9. When a number or series of digits is written with a subscript number, the subscript identifies the base of the number system used to express the number.

In computer programming several different conventions are used to distinguish between the number 0 and the letter O. In the first convention, the most common, a slash is placed through the number 0 (for instance, Ø). In the second convention the slash is placed through the letter O. In the third convention the number 0 is written as a very narrow symbol, and the letter O is written as a very wide symbol—perhaps even rectangular. As the exchange of an O for a 0 is a serious programming error, it

is important to know the convention used by your equipment and to be able to distinguish the difference between the two symbols on your video terminal or on a printout.

In order to represent very large or very small numbers, it is often convenient to use a mathematical shorthand called the powers-of-ten notation. In any number system each digits position in a number carries a weight factor that determines the magnitude of a digit in that position. In the decimal system the positional weights for positive exponents are 1 (units), 10 (tens), 100 (hundreds), and so forth. The following is a list of the powers of 10 for positive and negative exponents:

$10^0 = 1$	$10^{-1} = 0.1$
$10^1 = 10$	$10^{-2} = 0.01$
$10^2 = 100$	$10^{-3} = 0.001$
$10^3 = 1000$	$10^{-4} = 0.0001$
$10^4 = 10{,}000$	$10^{-5} = 0.00001$
$10^5 = 100{,}000$	$10^{-6} = 0.000001$
$10^6 = 1{,}000{,}000$	$10^{-7} = 0.0000001$
$10^7 = 10{,}000{,}000$	$10^{-8} = 0.00000001$
$10^8 = 100{,}000{,}000$	$10^{-9} = 0.000000001$
$10^9 = 1{,}000{,}000{,}000$	$10^{-10} = 0.0000000001$

The magnitude of a number is evaluated by considering the specific digits and the weights of their positions. For example, the decimal number 1234 can be expressed as:

$$(1 \times 10^3) + (2 \times 10^2) + (3 \times 10^1) + (4 \times 10^0) =$$
$$(1 \times 1000) + (2 \times 100) + (3 \times 10) + (4 \times 1) =$$
$$1000 + 200 + 30 + 4 = 1234_{10}$$

In order to represent decimal fractions we use weights that are negative powers of 10:

$$10^{-1} = \frac{1}{10} = 0.1 \qquad 10^{-2} = \frac{1}{100} = 0.01$$

The radix point (decimal point for base 10 numbers) separates the integer part of the number from the fractional part with the integer part to the left of the radix point and the fractional part of the number to the right. Thus the number 234.56_{10} can be expressed as:

$$(2 \times 10^2) + (3 \times 10^1) + (4 \times 10^0) + (5 \times 10^{-1}) + (6 \times 10^{-2}) =$$
$$(2 \times 100) + (3 \times 10) + (4 \times 1) + (5 \times 1/10) + (6 \times 1/100) =$$
$$200 + 30 + 4 + 0.5 + 0.06 = 234.56_{10}$$

In this example the left-hand digit (2) is the most significant digit (MSD) because it carries the greatest weight in determining the value of the number. The right-hand digit (6) is called the least significant digit (LSD) because it has the least effect on the value of the number.

THE BINARY NUMBER SYSTEM

The binary number system, which is used for the representation of data in a microcomputer, is the simplest of all number systems using positional notation. The binary number system utilizes only two states or elements, which are commonly represented by the digits 0 and 1. In a microcomputer, data is represented by a series of binary digits called bits. The term is derived from a contraction of the words *b*inary and dig*it*. Microcomputers operate on groups of 8 bits each, called bytes. As in the decimal system each bit position of a binary number carries a particular weight, which determines the magnitude of that position. The weight for the binary number system is a power of the base 2. A partial listing of the powers of 2 is as follows:

$2^0 = 1$	$2^{-1} = 0.5$
$2^1 = 2$	$2^{-2} = 0.25$
$2^2 = 4$	$2^{-3} = 0.125$
$2^3 = 8$	$2^{-4} = 0.0625$
$2^4 = 16$	$2^{-5} = 0:03125$
$2^5 = 32$	$2^{-6} = 0.015625$
$2^6 = 64$	$2^{-7} = 0.0078125$
$2^7 = 128$	$2^{-8} = 0.0039062$
$2^8 = 256$	$2^{-9} = 0.0019531$
$2^9 = 512$	$2^{-10} = 0.0009766$
$2^{10} = 1024$	$2^{-11} = 0.0004883$
$2^{11} = 2048$	$2^{-12} = 0.0002441$

Then the binary number 101010_2 can be evaluated as follows:

$$(1 \times 2^5) + (0 \times 2^4) + (1 \times 2^3) + (0 \times 2^2) + (1 \times 2^1) + (0 \times 2^0) =$$
$$(1 \times 32) + (0 \times 16) + (1 \times 8) + (0 \times 4) + (1 \times 2) + (0 \times 1) =$$
$$32 + 8 + 2 = 42_{10}$$

Thus to convert from binary to decimal, add together the weights of the positions in the binary number where 1's occur. The weights of the integer and fractional positions are summarized in Figure AI-1:

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0		2^{-1}	2^{-2}	2^{-3}
128	64	32	16	8	4	2	1	•	.5	.25	.125

Figure AI-1.

A decimal number can be converted to a binary number through successive divisions by the base 2. When you divide by 2, the remainder will always be 1 or 0. The remainders become the binary number.

EXAMPLE Convert the decimal number 30 to binary notation.

$30 \div 2 = 15$	with remainder	0 LSB
$15 \div 2 = 7$	"	1
$7 \div 2 = 3$	"	1
$3 \div 2 = 1$	"	1
$1 \div 2 = 0$	"	1 MSB

The binary number is 11110_2. This procedure is continued until a quotient of zero results. The last remainder becomes the most significant bit. Note that the remainders are collected in REVERSE order.

EXAMPLE Convert the number 256_{10} to binary notation.

$256 \div 2 = 128$	with a remainder of	0 LSB
$128 \div 2 = 64$	"	0
$64 \div 2 = 32$	"	0
$32 \div 2 = 16$	"	0
$16 \div 2 = 8$	"	0
$8 \div 2 = 4$	"	0
$4 \div 2 = 2$	"	0
$2 \div 2 = 1$	"	0
$1 \div 2 = 0$	"	1 MSB

The binary number is 100000000_2.
MSB

To convert a decimal fraction to binary notation, multiply the fraction successively by the base 2, and record and subtract any integers produced as an overflow. This process is continued until the desired number of binary bits are obtained.

EXAMPLE Convert 0.125_{10} to its binary equivalent.

0.125 x 2 = 0.250 with overflow 0 MSB
0.250 x 2 = 0.500 " 0
0.500 x 2 = 1.000 " 1 LSB

The binary number is 0.001_2.

EXAMPLE Convert 0.03937_{10} to its binary equivalent.

0.03937 x 2 = 0.007874 with overflow 0 MSB
0.007874 x 2 = 0.157480 " 0
0.157480 x 2 = 0.314960 " 0
0.314960 x 2 = 0.629920 " 0
0.629920 x 2 = 1.259840 " 1
0.259840 x 2 = 0.519680 " 0
0.519680 x 2 = 1.039360 " 1 LSB

The rounded-off binary number is 0.0000101_2.

THE OCTAL NUMBER SYSTEM

The octal number system uses a base of 8. The following is a partial listing of the powers of 8:

$8^0 = 1$	$8^{-1} = 1/8 = 0.125$
$8^1 = 8$	$8^{-2} = 1/64 = 0.015625$
$8^2 = 64$	$8^{-3} = 1/512 = 0.0019531$
$8^3 = 512$	$8^{-4} = 1/4096 = 0.00024414$
$8^4 = 4096$	$8^{-5} = 1/32,768 = 0.000030517$
$8^5 = 32,768$	$8^{-6} = 1/262,144 = 0.0000038146$
$8^6 = 262,144$	$8^{-7} = 1/2,097,152 = 0.00000047683$

Then the octal number 703_8 can be expressed as follows:

$$(7 \times 8^2) + (0 \times 8^1) + (3 \times 8^0) =$$
$$(7 \times 64) + (0 \times 8) + (3 \times 1) =$$
$$448 + 3 = 451_{10}$$

Table AI-1 compares decimal, octal, and binary numbers.

Table AI-1 Comparison of the Decimal, Octal, and Binary Number Systems for some Small Integer Values.

Decimal	*Octal*	*Binary*	*Decimal*	*Octal*	*Binary*
0	0	0	11	13	1011
1	1	1	12	14	1100
2	2	10	13	15	1101
3	3	11	14	16	1110
4	4	100	15	17	1111
5	5	101	16	20	10000
6	6	110	17	21	10001
7	7	111	18	22	10010
8	10	1000	19	23	10011
9	11	1001	20	24	10100
10	12	1010			

Conversion from the decimal to the octal number systems is accomplished in the same manner as conversion from the decimal to the binary number systems. However, there is one exception—the base is now 8 instead of 2.

EXAMPLE Convert 249_{10} to the octal number system.

$249 \div 8 = 31$ with remainder 1 LSD
$31 \div 8 = 3$ " 7
$3 \div 8 = 0$ " 3 MSD

The octal number is 371_8.

To convert from decimal fractions to octal fractions, multiply the fraction by the octal base 8, and record and subtract any integer overflows.

EXAMPLE Convert 0.135_{10} to its octal equivalent.

$0.135 \times 8 = 1.080$ with overflow 1 MSD
$0.080 \times 8 = 0.640$ " 0
$0.640 \times 8 = 5.120$ " 5
$0.120 \times 8 = 0.960$ " 0
$0.960 \times 8 = 7.680$ " 7 LSD

The rounded-off octal fraction is 0.10507_8.

THE HEXADECIMAL NUMBER SYSTEM

The hexadecimal number system uses a base of 16. The numbers 0 through 15 are represented by single digits or letters. Zero through nine are represented by 0 through 9, and 10 through 15 are represented by the letters A through F. Thus, the number 10 is A, 11 is B, and so on. For example, $2C_{16}$ is a hexadecimal number.

The following is a partial listing of the powers of 16 in base 10 notation:

$16^0 = 1$	$16^{-1} = 1/16 = 0.0625$
$16^1 = 16$	$16^{-2} = 1/256 = 0.003906$
$16^2 = 256$	$16^{-3} = 1/4096 = 0.00024414$
$16^3 = 4096$	$16^{-4} = 1/65{,}536 = 1.5258 \times 10^{-5}$
$16^4 = 65{,}536$	$16^{-5} = 1/1{,}048{,}576 = 9.5367 \times 10^{-7}$
$16^5 = 1{,}048{,}576$	$16^{-6} = 1/16{,}777{,}216 = 5.9604 \times 10^{-8}$
$16^6 = 16{,}777{,}216$	$16^{-7} = 1/268{,}435{,}456 = 3.7252 \times 10^{-9}$

Then the hexadecimal number $2C_{16}$ can be expressed as follows:

$$(2 \times 16^1) + (C \times 16^0) =$$
$$(2 \times 16) + (12 \times 1) =$$
$$32 + 12 = 44_{10}$$

Table AI-2 compares the decimal, hexadecimal, and binary number systems.

Conversion from the decimal to the hexadecimal number system is like the conversion to the octal or binary number systems except that the decimal number is divided by the base 16.

EXAMPLE Convert 156_{10} to its hexadecimal equivalent.

$156 \div 16 = 9$ with remainder $12 \equiv$ C LSD
$9 \div 16 = 0$ " $9 \equiv$ 9 MSD

The hexadecimal number is $9C_{16}$.

To convert a decimal fraction to its hexadecimal equivalent, the decimal fraction is successively multiplied by 16 and the overflow is recorded.

Table AI-2. Comparison of the Decimal, Hexadecimal, and Binary Number Systems for some Small Integer Values.

Decimal	*Hexadecimal*	*Binary*
0	0	0
1	1	1
2	2	10
3	3	11
4	4	100
5	5	101
6	6	110
7	7	111
8	8	1000
9	9	1001
10	A	1010
11	B	1011
12	C	1100
13	D	1101
14	E	1110
15	F	1111
16	10	10000
17	11	10001
18	12	10010
19	13	10011
20	14	10100
21	15	10101
22	16	10110
23	17	10111
24	18	11000
25	19	11001
26	1A	11010
27	1B	11011
28	1C	11100
29	1D	11101
30	1E	11110
31	1F	11111
32	20	100000
33	21	100001
34	22	100010
35	23	100011

EXAMPLE Convert the fraction 0.135_{10} to its hexadecimal equivalent.

$0.135 \times 16 = 2.160$	with overflow	$2 \equiv 2$ MSD
$0.160 \times 16 = 2.560$	"	$2 \equiv 2$
$0.560 \times 16 = 8.960$	"	$8 \equiv 8$
$0.960 \times 16 = 15.360$	"	$15 \equiv F$
$0.360 \times 16 = 5.760$	"	$5 \equiv 5$ LSD

The rounded-off hexadecimal number is $0.228F5_{16}$.

CONVERSION FROM THE BINARY NUMBER SYSTEM TO THE OCTAL NUMBER SYSTEM

In the binary number system each group of three bits in a binary number has 8 possible values—the digits 0 to 7. By separating a binary number into groups of 3 digits, you can derive 1 octal digit for each three bit group. As an example, the binary digits 101_2 and 111_2 convert to octal as follows:

$$101_2 = (1 \times 2^2) + (0 \times 2^1) + (1 \times 2^0) = 4 + 0 + 1 \equiv 5_8$$
$$111_2 = (1 \times 2^2) + (1 \times 2^1) + (1 \times 2^0) = 4 + 2 + 1 \equiv 7_8$$

Figure AI-2 shows the conversion of the 6-digit binary number 110101_2 to its octal equivalent. Begin with the least significant digit (LSD) of the binary number. Separate the binary number into groups of 3 binary digits each. Then, as above, convert each group of binary digits to octal digits.

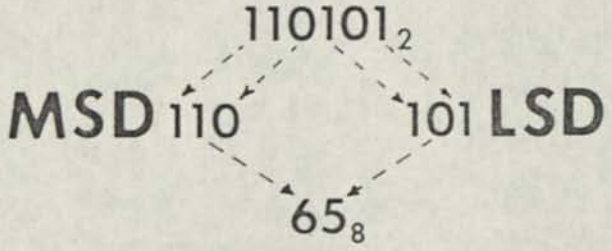


Figure AI-2.

Figure AI-3 illustrates how to convert a binary decimal fraction into its octal decimal fraction equivalent. Again, always start with the division of the binary number into 3-digit groups beginning from the LSD end.

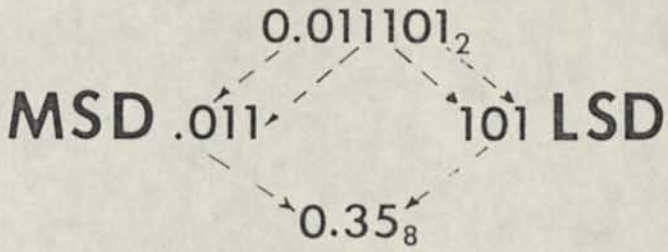


Figure AI-3.

Figure AI-4 shows the conversion of a binary number with an integer part and a fractional part. Remember the radix point separates the fraction from the integer part, and conversion always begins with the least significant digit of either part.

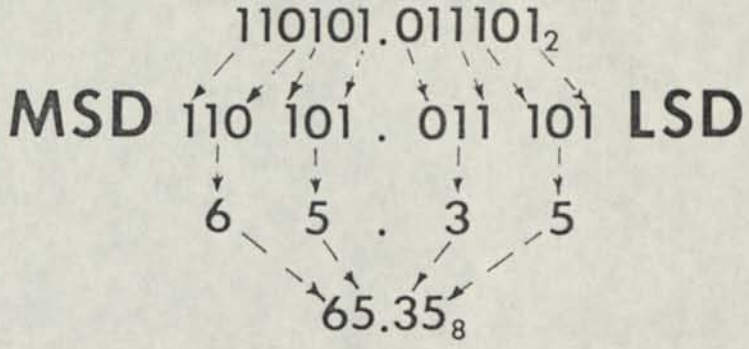


Figure AI-4.

CONVERSION FROM THE BINARY NUMBER SYSTEM TO THE HEXADECIMAL NUMBER SYSTEM

A 4-digit binary number has one of 16 possible values—the digits 0 to 15. So, each 4-digit binary number can be represented by one hexadecimal digit. Then, to convert a binary number to a hexadecimal number, we first divide the binary number into 4-digit binary groups and then convert each binary group to a hexadecimal digit. The division of the binary number into groups of 4 digits each is performed exactly like it is for binary-to-octal conversion. The division must always begin with the least significant digit. Figure AI-5 illustrates an example of binary to hexadecimal conversion:

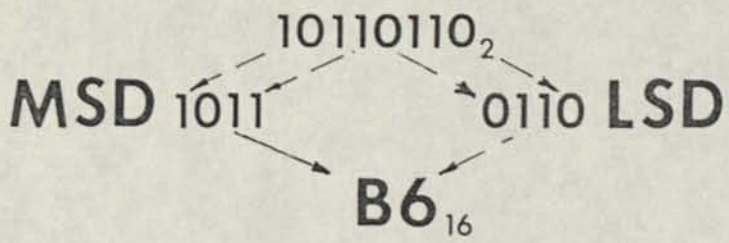


Figure AI-5.

In Figure AI-5 the 4-digit binary number groups are 1011_2 and 0110_2. These convert to hexadecimal as follows:

$$1011_2 = (1 \times 2^3) + (0 \times 2^2) + (1 \times 2^1) + (1 \times 2^0) = 8 + 0 + 2 + 1 = 11_{10} \equiv B_{16}$$

$$0110_2 = (0 \times 2^3) + (1 \times 2^2) + (1 \times 2^1) + (0 \times 2^0) = 0 + 4 + 2 + 0 = 6_{10} \equiv 6_{16}$$

Figure AI-6 shows the conversion process when the binary number does not have enough digits to subdivide the number into groups of 4 digits each with no remainder. Beginning at the LSD end we divide the binary number into two 4-digit groups, but there are three digits left over at the MSD end of the number. The solution is to add a binary 0 to the left of the 3-digit group to make it a 4-digit group. This is shown in Figure AI-6 with the added digit underscored. Then the binary number is converted to its hexadecimal equivalent.

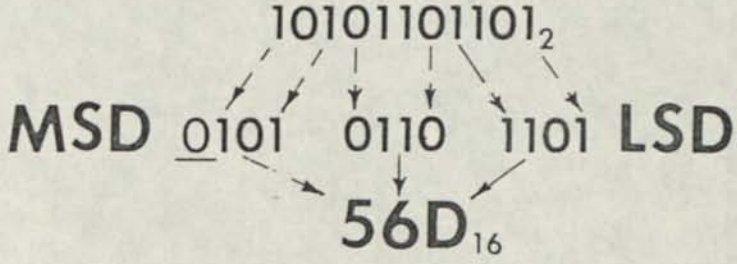


Figure AI-6.

THE BINARY CODED DECIMAL (BCD) CODE

A system of number representation is sometimes used in which each decimal digit is represented by a group of 4 binary

digits. This is the binary coded decimal or BCD code. The BCD code simplifies the man-machine interface, but it is less efficient than the pure binary code because it usually takes more bits to represent a given decimal number. For example, the number 75_{10} in pure binary is 1001011_2. Just 7 bits are required. In BCD the same number is 0111 1010, and 8 bits are required. Each BCD group has the capability of representing any of 16 different states. This is equivalent to the decimal numbers 0 through 15. Six of these states are wasted since the numbers 10 through 15 are not used.

Decimal-to-BCD conversion is simple, but binary-to-BCD conversion is not. In order to convert a binary number to BCD representation, the binary number first must be converted to a decimal number, and the decimal number converted to a BCD number. For example, let's convert 1001011_2 to BCD representation:

$$\begin{aligned} 1001011_2 &= (1 \times 2^6) + (0 \times 2^5) + (0 \times 2^4) + (1 \times 2^3) + \\ &\quad (0 \times 2^2) + (1 \times 2^1) + (1 \times 2^0) \\ &= 64 + 8 + 2 + 1 \\ &= 75_{10} \equiv 0111\ 0101_{BCD} \end{aligned}$$

A space is used between the BCD groups to prevent confusion with pure binary code. Table AI-3 compares the decimal, BCD, and binary representations.

Table AI-3. Comparison of Decimal, BCD, and Binary Number Representations.

Decimal	*8421 BCD*	*Binary*	*Decimal*	*8421 BCD*	*Binary*
0	0000	0000	8	1000	1000
1	0001	0001	9	1001	1001
2	0010	0010	10	0001 0000	1010
3	0011	0011	11	0001 0001	1011
4	0100	0100	12	0001 0010	1100
5	0101	0101	13	0001 0011	1101
6	0110	0110	14	0001 0100	1110
7	0111	0111	15	0001 0101	1111

ALPHANUMERIC CODES

There are several binary codes that are referred to as alphanumeric codes because they are used to represent letters as well as numbers. The most common are ASCII, BAUDOT, and EBCDIC.

ASCII

The American Standard Code for Information Interchange is commonly referred to as ASCII. It is a binary code widely used in microcomputers and terminals. ASCII is a 6-bit code that can represent 64 alphabetic or numerical characters. A 7-bit code called full ASCII or extended ASCII can represent 128 different alphanumeric characters and symbols. It is shown in Table AI-4. As an example, the letter "X" would be 1011000; the symbol "$" would be 0100100.

Table AI-4. The ASCII Code.

COLUMN	0	1	2	3	4	5	6	7
ROW	BITS 4321 765	000	001	010	011	100	101	110	111
0	0000	NUL	DLE	SP	Ø	@	P	\	p
1	0001	SOH	DC1	!	1	A	Q	a	q
2	0010	STX	DC2	"	2	B	R	b	r
3	0011	ETX	DC3	#	3	C	S	c	s
4	0100	EOT	DC4	$	4	D	T	d	t
5	0101	ENQ	NAK	%	5	E	U	e	u
6	0110	ACK	SYN	&	6	F	V	f	v
7	0111	BEL	ETB	'	7	G	W	g	w
8	1000	BS	CAN	(	8	H	X	h	x
9	1001	HT	EM	)	9	I	Y	i	y
10	1010	LF	SUB	*	:	J	Z	j	z
11	1011	VT	ESC	+	;	K	[	k	{
12	1100	FF	FS	,	<	L	\	l	|
13	1101	CR	GS	-	=	M	]	m	}
14	1110	SO	RS	.	>	N	^	n	~
15	1111	SI	US	/	?	O	—	o	DEL

Columns 0, 1, 2, and 7 contain ASCII special control functions, and these are as follows:

NUL	Null	DLE	Data Link Escape
SOH	Start of Heading	DC1	Device Control 1
STX	Start of Text	DC2	Device Control 2
ETX	End of Text	DC3	Device Control 3
EOT	End of Transmission	DC4	Device Control 4
ENQ	Enquiry	NAK	Negative Acknowledge
ACK	Acknowledge	SYN	Synchronous Idle
BEL	Bell (audible signal)	ETB	End of Transmission Block
BS	Back Space	CAN	Cancel
HT	Horizontal Tabulation	EM	End of Medium
LF	Line Feed	SUB	Substitute
VT	Vertical Tabulation	ESC	Escape
FF	Form Feed	FS	File Separator
CR	Carriage Return	GS	Group Separator
SO	Shift Out	RS	Record Separator
SI	Shift In	US	Unit Separator
SP	Space	DEL	Delete

BAUDOT CODE

The ASCII code is used almost exclusively with microcomputer peripheral devices such as video display terminals, paper tape reader/punches, and keyboard terminals. However, some older terminals and printers use the 5-bit Baudot Code. A 5-bit code can only represent 32 different characters. The number of characters is increased from 32 to 60 by assigning two of the 32 to tell when to shift from letter case to figures case, or vice versa. See Table AI-5.

EBCDIC

EBCDIC, which stands for Extended Binary Coded Decimal Interchange Code, is a standard code using 8-bit char-

Table AI-5. The Baudot Code.

Bit Numbers 54321	*Letters Case*	*Figures Case*
00000	Blank	Blank
00001	E	3
00010	Line Feed	Line Feed
00011	A	—
00100	Space	Space
00101	S	Bell
00110	I	8
00111	U	7
01000	Car. Ret.	Car. Ret.
01001	D	$
01010	R	4
01011	J	(Apos)'
01100	N	(Comma),
01101	F	!
01110	C	:
01111	K	(
10000	T	5
10001	Z	"
10010	L	)
10011	W	2
10100	H	Stop
10101	Y	6
10110	P	0
10111	Q	1
11000	O	9
11001	B	?
11010	G	&
11011	Figures	Figures
11100	M	.
11101	X	/
11110	V	;
11111	Letters	Letters

acters. It is used especially by IBM. As an example, the letter "X" would be 11100111; the symbol "$" would be 01011011. See Table AI-6 below.

Table AI-6. The EBCDIC Code.

LEAST SIGNIFICANT 4 BITS \ MOST SIGNIFICANT 4 BITS	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111
0000	NUL	DLE	DS		SP	&	-						{	}	\	0
0001	SOH	DC1	SOS				/		a	j	~		A	J		1
0010	STX	DC2	FS	SYN					b	k	s		B	K	S	2
0011	ETX	TM							c	l	t		C	L	T	3
0100	PF	RES	BYP	PN					d	m	u		D	M	U	4
0101	HT	NL	LF	RS					e	n	v		E	N	V	5
0110	LC	BS	ETB	UC					f	o	w		F	O	W	6
0111	DEL	IL	ESC	EOT					g	p	x		G	P	X	7
1000		CAN							h	q	y		H	Q	Y	8
1001		EM						`	i	r	z		I	R	Z	9
1010	SMM	CC	SM		¢	!	¦	:								|
1011	VT	CU1	CU2	CU3	.	$	,	#								
1100	FF	IFS		DC4	<	*	%	@					⌡		⌐	
1101	CR	IGS	ENQ	NAK	(	)	_	'								
1110	SO	IRS	ACK		+	;	>	=					⌠			
1111	SI	IUS	BEL	SUB	|	¬	?	"								

Control Characters

NUL	Null (All Zeros)	SI	Shift In
SOH	Start of Heading	DLE	Data Link Escape
STX	Start of Text	DC1	Device Control 1
ETX	End of Text	DC2	Device Control 2
PF	Punch Off	TM	Tape Mark
HT	Horizontal Tabulation	RES	Restore
LC	Lower Case	NL	New Line
DEL	Delete	BS	Backspace
SMM	Start of Manual Message	IL	Idle
VT	Vertical Tabulation	CAN	Cancel (Error in Data)
FF	Form Feed	EM	End of Medium
CR	Carriage Return	CC	Cursor Control
SO	Shift Out	CU1	Customer Use 1

IFS	Interchange File Separator
IGS	Interchange Group Separator
IRS	Interchange Record Separator
IUS	Interchange Unit Separator
DS	Digit Select
SOS	Start of Significance
FS	Field Separator
BYP	Bypass
LF	Line Feed
ETB	End of Transmission Block
ESC	Escape
SM	Set Mode
CU2	Customer Use 2
ENQ	Enquiry
ACK	Acknowledgment
BEL	Bell, or Attention Signal
SYN	Synchronous/Idle
PN	Punch On
RS	Reader Stop
UC	Upper case
EOT	End of Transmission
CU3	Customer Use 3
DC4	Device Control 4
NAK	Negative Acknowledgment
SUB	Substitute
SP	Space

Special Graphic Characters

¢	Cent Sign
.	Period, Decimal Point
<	Less-Than Sign
(	Left Parenthesis
+	Plus Sign
|	Logical OR, Absolute
&	Ampersand
!	Exclamation Point
$	Dollar Sign
*	Asterisk
)	Right Parenthesis
;	Semicolon
¬	Logical NOT
-	Minus Sign, Hyphen
/	Slash
¦	Logical OR, Absolute
,	Comma
%	Percent
_	Underscore
>	Greater-Than Sign
?	Question Mark
`	Accent Mark
:	Colon
#	Number sign
@	At Sign
'	Prime, Apostrophe
=	Equal Sign
"	Quotation Mark
~	Tilde
{	Left Brace
}	Right Brace
\	Backslash
|	Logical OR, Absolute
⌐	Hook
⊤	Fork
⌐	Chair

PROGRAMMING LANGUAGES

What is a COMPUTER LANGUAGE and how is it different from English? A computer language is a collection of terms and symbols used together according to specific rules in order to instruct a microcomputer how to perform the desired tasks. There are several levels of programming languages. The lowest level and most difficult to use is MACHINE LANGUAGE. Machine language instructions are written in binary numeric code that can be directly understood by the microcomputer for which it is written. This level of programming is extremely tedious and is rarely performed except by expert programmers.

Here is an example of machine language programming for the Intel 8080A microprocessor:

BINARY CODE	*FUNCTIONS*
00111110	Load the accumulator
00001001	With the number 9
10000010	Add the contents of register D
01011111	Put the sum in register E

The next higher level is called ASSEMBLY LANGUAGE. Programs in this type of language are written as a series of mnemonic words and their operands. These mnemonic words stand for specific microcomputer operations. They are translated into machine language by a special type of program called an ASSEMBLER. This type of programming is usually done only by skilled, advanced programmers.

Here is our previous program in assembly language.

ASSEMBLY CODE	*FUNCTIONS*
MVI A, 9D	Move immediate to accumulator the number 9
ADD D	Add to it the contents of register D
MOV E, A	Move contents of accumulator to register E

A HIGH-LEVEL LANGUAGE is the most powerful type of microcomputer language currently available. BASIC, FORTRAN, and COBOL are high-level languages in common usage. In each of these languages instructions are written using English words and mathematical symbols according to a well-defined grammar. Each of these names is a shortened form of a phrase that describes the function of the language:

BASIC	—	Beginner's All-purpose Symbolic Instruction Code
FORTRAN	—	FORmula TRANslation language
COBOL	—	COmmon Business Oriented Language

Here is our programming example written in BASIC:

LINE NUMBER	*PROGRAM STATEMENT*	*FUNCTIONS*
10	LET A = 9	Sets variable A equal to 9
20	A = A + D	Adds variable D to A; sets variable A equal to the sum

A program called an INTERPRETER converts the user's high-level language instructions directly into a series of machine language instructions that can be carried out by the microcomputer. Most microcomputers offering BASIC use interpreters, and these will be discussed later in more detail.

Each high-level programming language is best suited to solving certain kinds of problems. BASIC is a general-purpose language, and it can be used for many different applications. Just as there are different dialects of English, so there are slightly different versions of BASIC supplied by different microcomputer manufacturers. A program written in BASIC for one microcomputer may not run on another manufacturer's system without modification of the program. Many manufacturers offer several levels of BASIC for their machines. The low-level version is often called "tiny BASIC." It is simple to use and it is a good learning tool. However, it lacks problem-solving power. The high-level version is generally called full or extended BASIC. It has many commands, statements, and functions not found in the simpler version.

FORTRAN is a computer language well adapted to solving mathematical problems. It is older than BASIC and has been better standardized. FORTRAN is not widely available for microcomputers. However, versions of FORTRAN are offered by Cromemco and Microsoft for Z-80 based systems.

COBOL is a business-oriented language. It is useful for manipulating business data in applications such as accounting and inventory control. COBOL is not yet available for most microcomputers. As demand for COBOL increases, some microcomputer manufacturers may offer it.

One innovative manufacturer, the Logical Machines Corporation, offers microcomputer systems called ADAM and ADAM the Younger. These systems can be programmed in a pidgin English, and this somewhat simplifies writing custom software for business applications. Users do not need a formal programming background to adapt their systems to their businesses.

Future developments in the software field undoubtedly will include better programming languages. One such language may be PASCAL (pronounced "Pass-kal"). This language is very powerful, and it eliminates many of the problems encountered by users who write complex programs in BASIC, FORTRAN, and other languages. The United States government may adopt PASCAL as an official language for its software. This standardization would have far-reaching effects in the microcomputer field. Unfortunately, PASCAL is not available at present for most microcomputers, and there are few applications programs written in it for business use.

Since BASIC is the most commonly used language for microcomputers, let's explore how BASIC programs are actually run on a microcomputer. Since most systems have interpreters, we will examine how they work, and then we will compare them with compilers.

An interpreter program performs several functions. First, it usually includes an EDITOR subprogram that helps the user enter, edit, or delete program statements. Regardless of whether the user program is entered from keyboard, tape, or disk, all its statements are stored in a section of microcomputer memory

called the PROGRAM BUFFER AREA. After the interpreter is told to run the program, the interpreter takes the text of the user program, translates it into machine language, and then runs it. This is all done one line at a time. Since the translation process for each statement takes time (usually a few thousandths of a second), some time is lost each time a line is processed. This non-productive time can add up especially if there are many lines in the program or many program loops (sequences of repeated instructions).

In contrast, a COMPILER translates the entire program (that is, all the statements in the program buffer area) in one operation and stores the resulting machine language program. This machine language program can then be executed to produce the intended results. With a compiler the user program is executed much more efficiently. However, each time a program statement is changed, the entire program must be recompiled. With an interpreter any program line may be changed at any time. Another factor is that although a compiler produces a user program that executes faster, the actual compiling process itself takes time. However, the compilation process is performed only once for each version of the program, after which the compiled user program can be run any number of times. In summary, interpreters are slower but generally easier to use. Compilers are more difficult to use, but they produce faster-running programs.

At present, most microcomputers offering BASIC have interpreters. The interpreter program is either stored in ROM (as in the TRS-80, the Apple-II, or the PET), or it can be loaded from bulk memory devices into system RAM (Altair and Heath). Microcomputers with interpreters in ROM can accept BASIC language statements immediately after the system power is turned on. Other machines require some initial start-up operations. Finally, FORTRAN and COBOL are generally not available in interpreter form. They are available as compilers that must be loaded when needed from external tapes or disks.

Software can be divided into two categories: utility programs and applications programs. Utility programs include widely used programs such as monitors, interpreters, symbolic code assemblers, program loaders, compilers, and disk operating

systems. Applications programs, on the other hand, are written for very specific applications such as accounting, inventory control, or games. Applications programs are often written in a high-level language such as BASIC or FORTRAN. Utility programs are often written in assembly language.

APPENDIX II
NAMES, ADDRESSES, AND TELEPHONE NUMBERS

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Microcomputer Investors Association
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Fredericksburg, VA 22401

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Phone: (201) 746-4266

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James A. Gupton Jr. has an extensive background in electronics and technical writing. A veteran of WWII (U.S. Navy), Mr. Gupton attended the Virginia Polytechnical Institute and the North Carolina State University. Mr. Gupton is one of the pioneers in the field of microfilming, and he has made significant contributions to the archival permanence of photographic prints, negatives, and microfilm. For 10 years he engaged in research and development work in electro-optics. This work led to five patents related to high-resolution CRT phosphor screens and printed circuit multi-beam electron guns for computer CRT terminals. Mr. Gupton also has been Chief Engineer of a North Carolina FM broadcast station. He has authored over 200 articles dealing with photography and electronics. His name has appeared on the masthead of over 10 U.S. publications, and his work has been published in five foreign countries. He was a technical editor on the ABM contract at the Western Electric Company. Mr. Gupton has taught electronics in South Carolina, North Carolina, and Virginia. He was head of the Electronics Department at the Florence-Darlington Technical Education Center at Florence, South Carolina. He teaches electronics at the Union County Career Education Center in Charlotte, North Carolina. Mr. Gupton is a member of the SPSE (Society of Photographic Scientists and Engineers) and the NMA (National Micrographics Association). Currently, he is a consultant to the photochemical industry and a contributing editor to Technical Photography magazine.

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by James A. Gupton Jr.

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