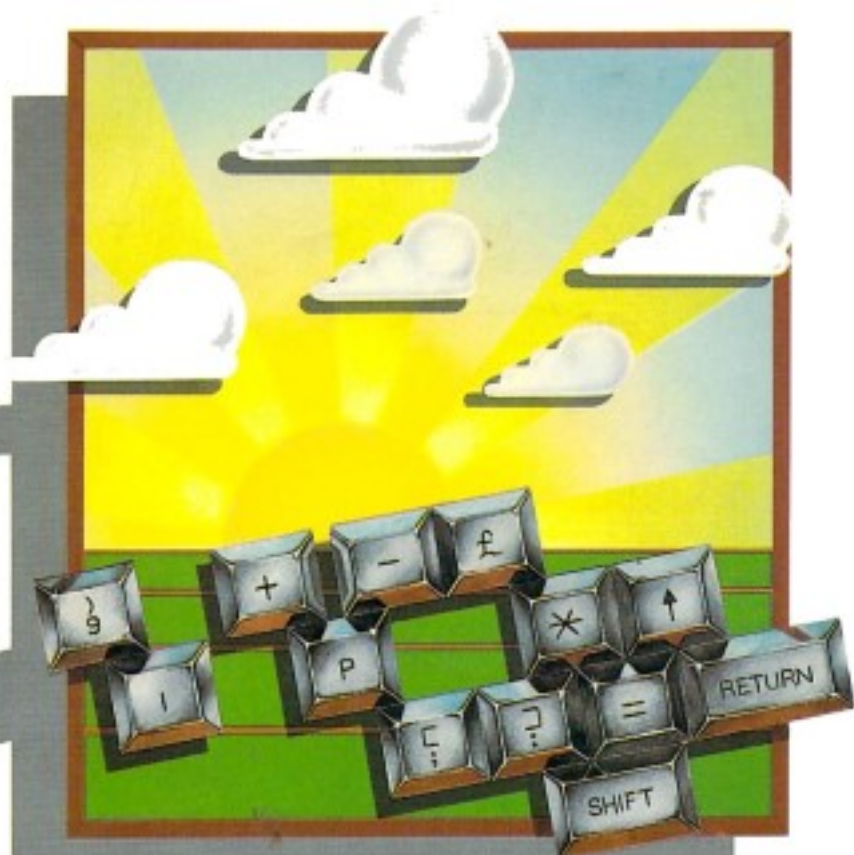


Commodore 64™ Starter Book

Christopher A. Titus
David G. Larsen
Jonathan A. Titus



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In most cases, these books provide both text material and experiments, which permit one to demonstrate and explore the concepts that are covered in the book. These books remain among the very few that provide step-by-step instructions concerning how to learn basic electronic concepts, wire actual circuits, test microcomputer interfaces, and program computers based on popular microprocessor chips. We have found that the books are very useful to the electronic novice who desires to join the "electronics revolution," with minimum time and effort.

Jonathan A. Titus, Christopher A. Titus, and David G. Larsen
"The Blacksburg Group"



**The Commodore 64™
Starter Book**



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**The Commodore 64™
Starter Book**

by
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and
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PREFACE

Reading this book and learning about your Commodore 64™* computer will be an interesting, rewarding, and fun experience. We've used a common-sense approach to computers, and have included many experiments, questions, and problems that you can do on your own. *No computer experience is necessary.* You'll start using your Commodore 64 computer right away, exploring the keyboard and display and then going on to other topics.

This book is simple to understand, whether you have a specific use for a computer or you just want to know more about what a computer can do. To make computers easy to understand, we've avoided many of the terms and words that "computer experts" seem to use to confuse the rest of us. Where special words seem to fit we'll tell you about them.

After reading this book and doing most of the experiments, you will be able to:

- Use the keyboard and the display.
- Use 20 simple program commands and know what they do.
- Use the special control keys on the keyboard.
- Know what kinds of information the Commodore 64 computer can use.
- Know how labels are used to locate information.
- Use the computer to add, subtract, multiply, and divide values.
- Know how computers make decisions.
- Control the display of information on the TV screen in color and in "reverse."
- Know how "loops" are used in programs to control the computer.
- Know how the computer uses words and sentences.
- Use the Commodore 64's digital clock.
- Use the computer to make special sounds.
- Know how large amounts of information are saved in the computer.
- Know how to test and evaluate programs for your computer.
- Know how to care for and protect your computer.

*Commodore 64 is a trademark of Commodore Electronics Limited.

- Know how to type in and correct programs.
- Know how to add useful remarks and comments to programs.
- Know about some special math operations.

Our purpose is to give you a good understanding of what computers can do, and how they do it, without forcing you to become a computer expert. Since a computer is told what to do by using step-by-step instructions, or a *program*, you will see how a computer is *programmed* to do specific things. You will type in the programs shown in the experiments and you'll get a chance to try a few short programs of your own. Although you will learn about computer programs and some of the instructions they use, you won't be a programming expert when you finish this book. In fact, to use most small computers, you don't have to be a programming expert.

These days, small computers are easy to use, so you don't have to know all the details of exactly what is going on inside the computer box. If you had to be an expert at everything you did, you'd have to be a pump, water, and soap expert just to use a washing machine. Most of us just want to know enough to load the clothes, dump in the soap, and press a button. Computers can be used the same way; load a program and run it.

You'll work with your Commodore 64 computer by using its keyboard and a TV set. Programs and information will be typed in on the keys and the computer will display information on the TV screen. The Commodore 64 displays things in different colors, so a color TV set is recommended, but a black-and-white TV is fine, too. We have used a standard Commodore 64 computer, just as it comes out of the box, without add-ons or accessories, and it's all you'll need to use this book.

If all of a sudden the people around you started using a foreign language, it would be very hard to understand them. Your computer has the same problem. It wants you to talk to it in a language called BASIC, and as you'll see, it is fairly easy to understand. Most people learn a language by using simple words and sentences: "Open the door," or "Where is the school?" You'll learn about the BASIC language the same way: using simple commands to do simple things.

Besides reading the text and doing the experiments, we want you to explore the computer on your own, too. There are problems at the end of most chapters, and if you are interested in programming, or learning more about what the computer can do, you can

try and solve them. Solutions to selected problems are provided in Appendix D. You won't bother the computer by pressing the wrong keys or by programming it incorrectly. You may get some interesting sounds and displays, and things may not come out the way you expected, but **YOU CAN'T HURT THE COMPUTER** unless you get mad at it and give it a kick.

Here's a quick overview of what is included in this book. In *Chapter 1* you'll turn on your computer and learn about the keyboard and the display. Since these two parts of the computer let it "communicate" with you, they are very important. You will see how you can put letters, numbers, and special symbols on the TV screen, and how the color of the display can be changed.

Once you have used the keyboard and the display, you are ready to learn what a computer really does. It is simpler than you think, as you'll find out in *Chapter 2*. You will learn about a couple of BASIC instructions that you can use to get information into and out of the computer, and you'll find out about the two types of information that the Commodore 64 can use.

Simple arithmetic is very important to a computer, and *Chapter 3* shows you the four basic math operations of addition, subtraction, multiplication, and division, and how to get the computer to easily do them. Since everyone makes mistakes, several of the "correction" keys will be described, too.

Chapter 4 gives you a good understanding of how programs can control what the computer does. You'll find out how the computer can make simple decisions, and how decisions tell the computer what to do next. Although we think of computers as doing very complicated things, they can only make very simple decisions. You will also learn more about numbers, how the computer uses them, and how it can "dream up" a number for you, much like a throw of dice.

More "computer power" is described in *Chapter 5*. You'll see how the computer can be told to do something a specific number of times. Computers can store large quantities of information, and you'll find out how to do it in this chapter.

Computers can also work with names, addresses, and other "words." *Chapter 6* shows you how this type of information can be put into the computer and used in different ways. The Commodore 64 has its own digital clock, and you will learn how to use it to keep track of time and to turn on an "alarm."

Some special math operations, such as logarithms and trig operations, are described in *Chapter 7*. We've provided some interesting

history, so this isn't a dull, dry chapter. However, if you aren't interested in these operations and don't have a use for them, you can skip ahead to *Chapter 8* and learn how to control the TV screen and the information that it displays. Moving the cursor, changing the color, printing in reverse, and doing other interesting things with the TV display are all described for you.

The Commodore 64 can also create interesting sounds that can be used in many types of programs, and it can sound like musical instruments, too. You will learn how to control these sounds in *Chapter 9*, and many experiments give you a chance to try some of the Commodore 64's sound effects.

The first nine chapters give you a detailed introduction to your Commodore 64 computer, how it works, and what you can do with it. Most of the things you learn about BASIC programs can be used on other computers, and there are many books that will take you further into learning BASIC so that you can become a good programmer, if you want to. The last two chapters in this book discuss some of the accessories for your Commodore 64 and what you can do with them, and how to take care of your computer, both hardware and software.

In *Chapter 10*, we'll tell you about the cassette unit, the VIC-1525 graphic printer, the joystick, and plug-in program and memory cartridges. In *Chapter 11*, you will learn how to care for your computer, from simple inexpensive steps you can take, to how to get service for the computer, should it ever fail. We will also tell you about computer programs, or "software," how to review it, what to look for, what to avoid, and so on.

We want to thank Mr. Rik Andrews of Holdrens, Inc., Roanoke, Virginia, for loaning us a VIC-1525 printer that was used in preparing Chapter 10. Rik's help was invaluable. We also want to thank Mr. Bob Veltri, Blacksburg, Virginia, for working with us and doing most of the photography work included in this book. We also appreciate the continued support of our many friends at Howard W. Sams & Co., Inc.

Although we have mentioned some specific equipment, books, magazines, and suppliers in this book, these are not necessarily endorsements of them. Check carefully to be sure that your purchases do what you want them to and that you get your money's worth.

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This book is dedicated to our families, both near and far.

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CHAPTER 1

GETTING TO KNOW YOUR COMMODORE 64

Before you can get your Commodore 64 to do useful and helpful things, it's important for you to be familiar with the keyboard and the display. To get started, just sit down in front of your computer and continue reading. If you don't have your computer handy, you can still read through the chapters, using the illustrations as guides. We hope that you will go back later and do the experiments.

GETTING STARTED

The first thing you need to do is to check the various connections to the computer, so it will be ready when you turn it on. The basic computer system is shown in Fig. 1-1. Let's look at the power module first. It's the large, heavy plastic box that has two wires coming out of it, and it's shown in Fig. 1-2. One of the wires has a standard two-prong plug on the end, and it is plugged into a wall or floor outlet to get power. The other wire is somewhat thicker, and it has a 7-pin connector on the end. This connector is pressed into the 7-pin receptacle marked POWER on the right side of the keyboard case. This power connection is shown in Fig. 1-3.

A cable assembly connects the computer and your television, or TV, as shown in Fig. 1-4. The Commodore 64 works with either a

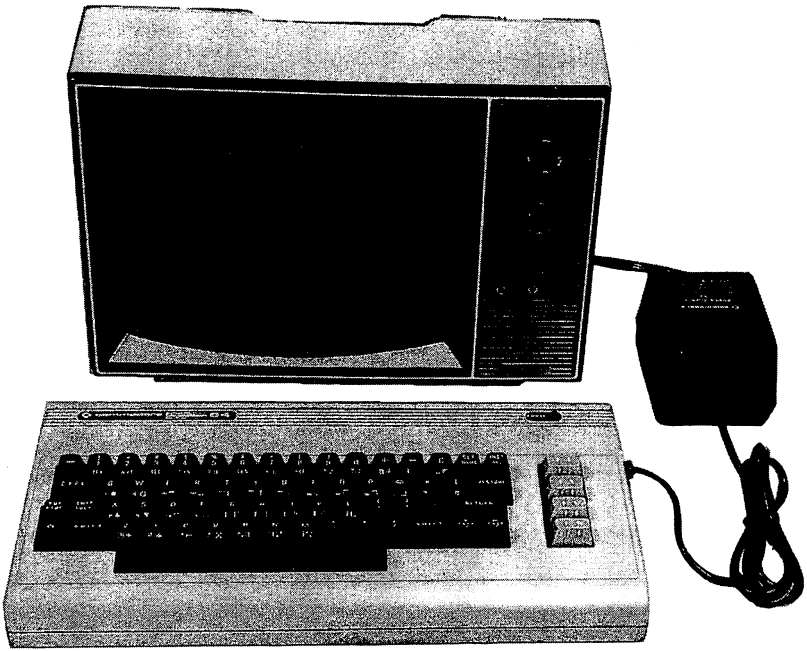


Fig. 1-1. The basic Commodore 64 computer system—computer, power module, and TV set.

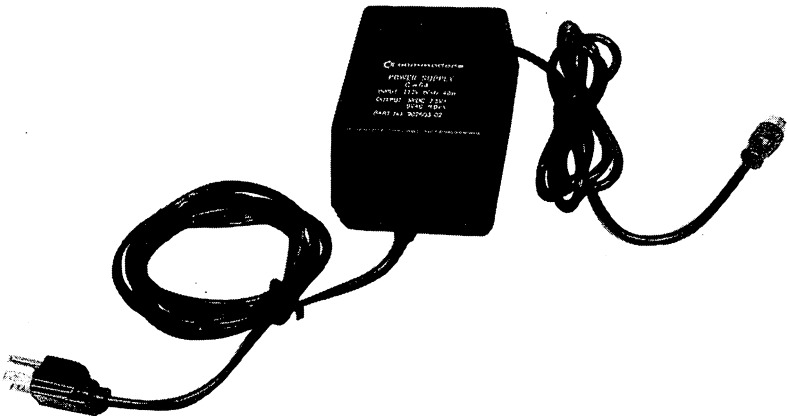


Fig. 1-2. The Commodore 64 power module.

color or black-and-white TV set, and the connections are the same for both. The computer is connected to the VHF antenna screws on

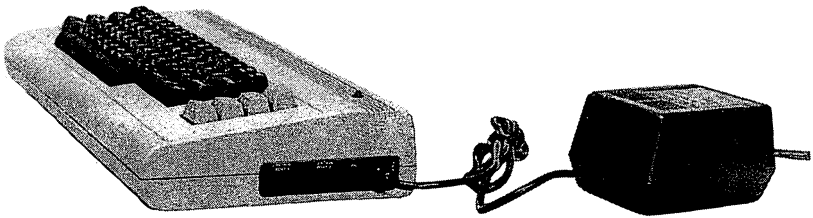


Fig. 1-3. The power module connected to the Commodore 64.

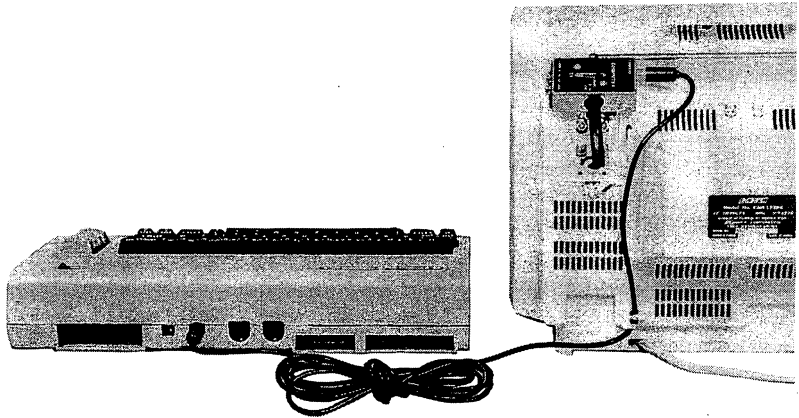


Fig. 1-4. The TV set and computer cable connections.

the back or side of the TV case through the TV/COMPUTER switch box supplied with the computer. When using the computer, be sure that this switch is in the COMPUTER position. When you are finished using the computer, switch back to the TV position so that you can use the TV to watch a regular show.

There is a small switch on the back of the Commodore 64 case, next to the TV cable connector, and it lets you switch the computer display to either channel 3 or channel 4 on the TV set. The channel-3 setting is toward the large cartridge slot and the channel-4 setting is toward the TV connector. You can try either setting to see which channel gives you the best display.

Now it's time to turn on the computer. The computer's power switch is on the right side of the keyboard, next to the power wire, as seen in Fig. 1-5. Push the switch up to the ON position. The red light marked POWER on top of the keyboard should be lit when the computer is on. Turn on your TV and set it to channel 3 or 4.

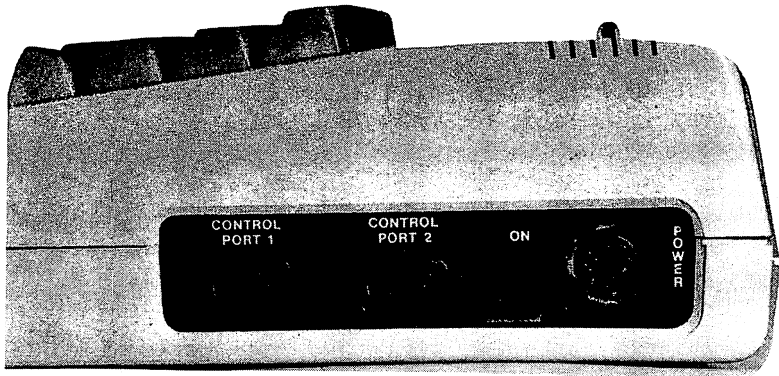


Fig. 1-5. Location of the ON/OFF power switch.

Give the computer a few seconds to get started. If you don't see anything on channel 4, switch the TV to channel 3. Be sure the TV/COMPUTER switch is in the COMPUTER position. In case of difficulty, or for more information about the cables and connections, refer to the computer guide supplied with your computer.

When the computer is first turned on, you'll see a large, dark-blue square area with a light-blue border around it that goes to the edge of the TV screen. On a black-and-white TV, you'll just see that the large, central area is darker than the border. The computer will display a message at the top of the square area, including the word READY. We're not interested in the other information. You will also see a small, flashing square, or *cursor*, on the screen, which is a "place marker," telling you where the computer is. We'll just show the cursor as a black square ■.

THE KEYBOARD

Now that your computer has been turned on, let's take a close look at the keyboard, since it's the most important and most-used part of the Commodore 64 computer. You may have used some of the keys when playing games or when using the computer for other things, but you may not know exactly what the keys do. Even if you have used a typewriter or other computer, all of the letters, numbers, words, and symbols can be confusing.

There are two types of keys on the Commodore 64, *action keys* and *printing keys*, as shown in Fig. 1-6. The 50 *printing keys* are in

PRINTING KEYS

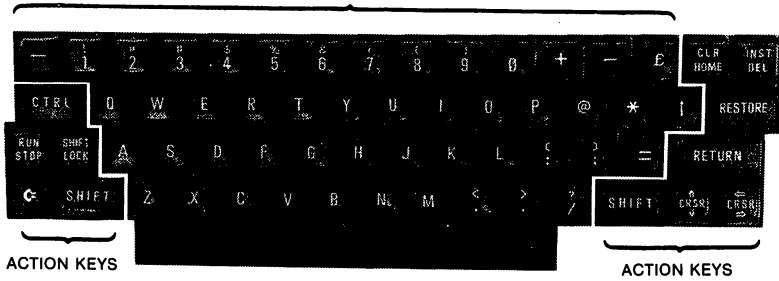


Fig. 1-6. The Commodore 64 keyboard showing the *action* and *printing* keys.

the middle of the keyboard, and there are five *action keys* on the left and seven *action keys* on the right of the keyboard. (We will look at the four tan “F” keys later on in the book.) The printing keys are used to really “print” something on the TV screen, while the action keys tell the computer to do something, such as GO TO CAPITAL LETTERS, LIKE THIS. Of course, the computer won’t actually print things on the screen, it just *displays* them for you, but “print” is a handy word, so we’ll use it.

PRINTING KEYS

First, let’s look at the tops of the *printing keys* in the center of the keyboard, as shown in Fig. 1-7. We’ll look at the special symbols on the front side of these keys later.

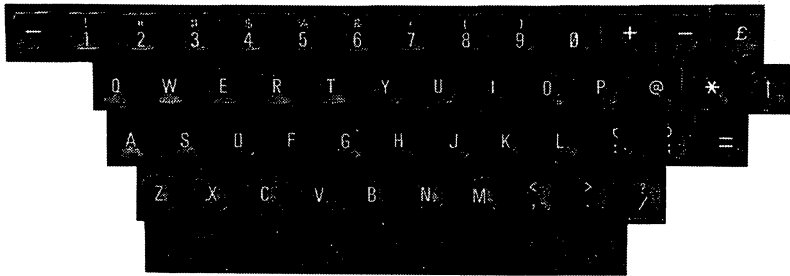


Fig. 1-7. The Commodore 64 printing keys.

If you haven’t used a keyboard like this before, the first thing you will see is that the letters are not in alphabetic order. You think of the alphabet as ABCDEFG . . . , but the letters on the Commodore 64 keyboard are scrambled. It may take a while to get

used to, but this type of standard keyboard is used on almost all computers.

The 26 letters, A to Z, are located in the bottom three rows, and toward the center of the keyboard, as shown in Fig. 1-7. You'll see that the capital, or upper-case letters, are the only ones shown on these key tops.

The top row of keys is shown in Fig. 1-8, and the keys are in



Fig. 1-8. The 10 number keys.

order, "1" through "9," with the "0" key just to the right of the "9" key. The key tops for keys "1" through "9" have other symbols on them, too. For example, the "4" key also has a dollar sign (\$) on it. We'll talk more about this shortly.

Besides the letter and number keys, there are other *printing keys*, such as those for the asterisk (*), comma (,), semicolon (;), question mark (?), and period (.). Some of these keys also have two symbols, one above the other on the key tops.

Experiment No. 1-1. Simple Typing

Now you will have a chance to use the computer and type some numbers and letters on the TV screen. If your computer is turned off, turn it on. Once the computer displays the word READY on the TV screen, press the "F," "G," "H," and "J" keys one at a time. They are in the center of the keyboard. Don't press any of the "action" keys. What happens as you press the four letter keys? You should see the letters, F, G, H, and J displayed on the screen just as they are pressed, or "typed" on the keyboard. Type a few more letters or some numbers until your typing reaches the right side of the display.

What happens when the letters and numbers you are typing reach the right side of the screen? What happens as you keep typing them? When your typing reaches the right side of the screen, and you keep typing, the cursor moves down and starts a new line at the left side of the screen.

The RETURN key is located on the right side of the keyboard. Press it several times until the cursor is on the bottom line. The computer may display a message such as SYNTAX ERROR on the TV screen. This isn't important right now. Just continue to press

the RETURN key until the cursor is on the bottom line. If you get too energetic, you may find that the information on the top of the TV screen moves up, off the screen. This isn't important, either.

Once the cursor is on the bottom line of the display, type in letters until the cursor reaches the right side of the TV screen. You can use several fingers to quickly do the typing. What happens when the cursor reaches the bottom right-hand corner and you type a few more letters? The display seems to move up, providing "clean" lines for you to use. The computer automatically moves the display up one or two lines. The cursor moves up, too.

The long bar at the bottom of the keyboard is the "space bar." Does it print anything when you press it? It doesn't print anything, but it leaves a space, so that your typing doesn't LOOKLIKETHIS. What happens if you hold the space bar down? The computer continues to leave spaces and the cursor moves for as long as you hold the space bar down. Do any of the other "printing" keys work this way? None of the other "printing" keys have this repeating action.

ACTION KEYS

The *action keys* cause the computer to do special things and some of them change the way in which things are displayed on the TV screen. You've seen that some of the printing keys have two symbols on their tops. For example, the "4" key has a dollar sign (\$) above the 4. In Experiment 1-1, you found that you could print the numbers on the TV screen, but you couldn't print the symbols. The SHIFT key is the *action key* that lets you print the "top" symbol on each of the "printing" keys. There are two SHIFT keys, both in the bottom row of keys, with one at each end. You may use either one if a SHIFT action is needed, since they both do the same thing.

The SHIFT key must be pressed down and held down while the other key is pressed to get its "top" symbol displayed on the TV screen. If you don't hold the SHIFT key down, the regular, or "bottom," symbol will be typed. Since the SHIFT key must be pressed and held down when it's used, we'll call this action *press-and-hold*, or *press/hold* for short. After a little practice, you will remember when you need to use the SHIFT key.

Whenever an action key is noted in this book, its legend will be in upper-case, or capital letters; for example, the SHIFT key. If the

word "key" is not used, the name of the key will be found in brackets: [SHIFT].

Experiment No. 1-2. The SHIFT Key

The SHIFT key is important, since it lets you "shift" between the different characters that can be displayed on the TV screen. In this experiment, you will see how it can be used.

Once your computer has been turned on, press the SHIFT key. Can you see anything happening on the TV screen? No, the SHIFT key doesn't do anything by itself. Press the SHIFT key and hold it down while you press the 10 number keys, "1" through "0." Now release the SHIFT key. You should see the symbols:

! " # \$ % & ' () 0

displayed on the TV screen. The zero key is not "changed" by the SHIFT key, and you'll see that there is no symbol above the "0" on the key top. You MUST hold down the SHIFT key for as long as you want to type the shifted or "top" symbols. Try using the SHIFT key with the two keys to the right of the "L" key and the three keys to the right of the "M" key, as shown highlighted in Fig. 1-9. These keys will let you print the special symbols:

[] < > ?

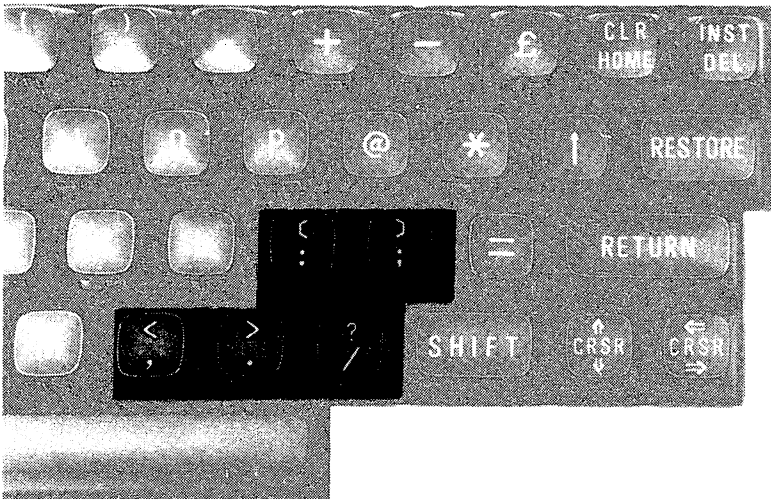


Fig. 1-9. Some of the special symbol printing keys.

All of the keys used so far pop right back up after you remove your finger from them. The SHIFT LOCK key on the left side of the keyboard (Fig. 1-6) is different. If you press it, it will stay pressed until you press it again, to pop it back up. Press the SHIFT LOCK key and it goes down, press it again and it comes up. When it is pressed in, the computer acts as though the SHIFT key is being pressed all the time. Press the SHIFT LOCK key just to see how it operates. When it is pressed in, type some of the numbers. Now press the SHIFT LOCK key again so that it springs up. Type some numbers again. Did you see what happened?

When the SHIFT LOCK key is pressed in, the "top" symbols on the *printing keys* with two symbols are displayed on the TV screen. When the SHIFT LOCK key is in the "up" position, the "bottom" symbols on the keys are displayed.

Now let's look at three other action keys, as highlighted in Fig. 1-10. The first of these is in the upper right-hand corner, and it is marked:

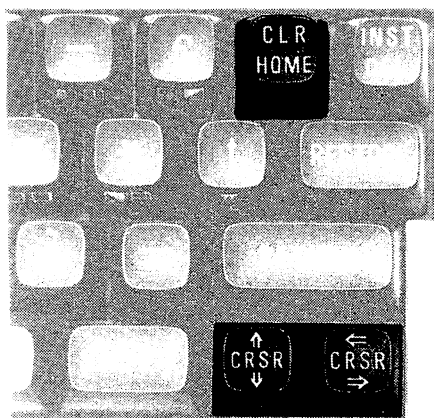


Fig. 1-10. The CLR/HOME and CRSR action keys.

CLR HOME

This key is used to do two things: it lets you move the cursor back to its home base in the upper left-hand corner of the TV display area, and it lets you clear the display area. The other two action keys are in the bottom right-hand corner, and they are both marked CRSR. You can see in Fig. 1-11 that there are left and



Fig. 1-11. The two cursor action keys.

right arrows on one, and up and down arrows on the other. The two CRSR keys let you control the motion of the cursor. Here are two experiments that will show you how these three action keys work.

Experiment No. 1-3. Going Home and Clearing Out

This experiment explores the uses of the CLR/HOME key. Before you get started, check the SHIFT LOCK key to be sure that it is in the up position. You can press it to check the different positions. Just leave it up when you're finished.

If you don't have many numbers, letters, or symbols on the TV screen, type several of the printing keys so that some are displayed. A few are all you need. Now, press the CLR/HOME key. What happens to the cursor, and where does it go? The cursor goes to its home base, which is in the upper left-hand corner of the large square display area on the TV screen. Is anything erased or cleared from the TV screen when the cursor goes to its home position? No, the unshifted CLR/HOME key just moves the cursor to its home base.

Letters, numbers and other things displayed by the computer on the TV screen are called *characters*, so instead of saying numbers, letters, or symbols, from now on we'll just say they are "characters." Is the cursor now "on top of," or superimposed on a character? This will depend on what you have displayed on your TV screen. If the cursor is "on" a character, you'll see that the character isn't erased. Instead, when the cursor is off, the character is displayed normally. When the cursor is on, the character is "printed" on the cursor.

Now that you have a few characters on the screen, let's clear the TV screen. The CLR/HOME key is used for this, since it has two operations. The normal operation, HOME, places the cursor in its home position. The second operation, CLR, clears the screen. To clear the TV screen, you must press/hold the SHIFT key and then press the CLR/HOME key.

Press the SHIFT key and, while holding it down, press the CLR/HOME key. Now, let the SHIFT key pop up. What happens to the

characters displayed on the TV screen? Where does the cursor go? The screen is cleared, and the central display area is "erased." The cursor is moved back to its home position in the upper left-hand corner of the TV screen. When the CLR operation is done, the TV screen is cleared *and* the cursor is moved.

Can you think of another way to clear the screen? If you keep the space bar pressed down long enough, everything will be "pushed up" off the screen. This can take over a minute, and it leaves the cursor at the bottom of the screen. Using the CLR/HOME key is easier and quicker.

Experiment No. 1-4. Moving the Cursor

Use the CLR/HOME key to clear the screen. Remember to use the SHIFT key, too. Press the ASDFGHJKL keys located in the middle of the keyboard to put these nine characters on the screen. The keys are all in a row, from left to right on the keyboard. Now use the CLR/HOME key to put the cursor at its home base. If you cleared the screen, you pressed the SHIFT key and the CLR/HOME key. Go back and type the characters again. Use the CLR/HOME key without pressing [SHIFT] to get the cursor back to its home base.

Now that you have a few characters on the screen, use the space bar to move the cursor to the letter J in your line on the screen. What happens as you press the space bar? The cursor can be moved with the space bar, but it erases characters as it passes over them. Actually, it doesn't erase them, it just puts a space in their place. The computer "sees" spaces as though they are characters, even though it doesn't print anything on the TV screen.

The two CRSR keys at the bottom right-hand corner of the keyboard, shown previously in Fig. 1-11, let you move the cursor without erasing or changing the display. The four arrows, two on each key, show the directions in which the cursor can be moved; up, down, right, or left.

Clear the screen with the SHIFT and CLR/HOME keys and use the two CRSR keys to move the cursor down and to the right so it is near the center of the TV screen. The arrows on the bottom of the key tops show the direction the cursor will move. The SHIFT key must be used to get the cursor to move in the direction shown on the top of the CRSR key tops. This should be fairly easy to do, but you may need to practice using the CRSR keys. Don't worry if the cursor goes in the wrong direction. Remember that you can always move the cursor back to its home position by using the

CLR/HOME key. Try and move the cursor back to the home base by using the SHIFT and the two CRSR keys. Can you do it? Just take your time and get used to the operation of the keys. *The CRSR keys are repeating keys*, just like the space bar. You can press them once and move the cursor one position, or you can hold them down and the cursor will move for as long as the CRSR key is pressed. Of course, you'll need to use the SHIFT key, too, to make the cursor go up or to the left.

Clear the screen again using [SHIFT] and [CLR/HOME], and type about 10 or 12 characters on the screen. Can you use the CRSR keys to put the cursor on top of, or superimposed on, any of the characters? Try it. When the cursor is "on top of" a character, the cursor and the character flash, as shown in Fig. 1-12. "On top of" doesn't mean that the cursor is above the letter.

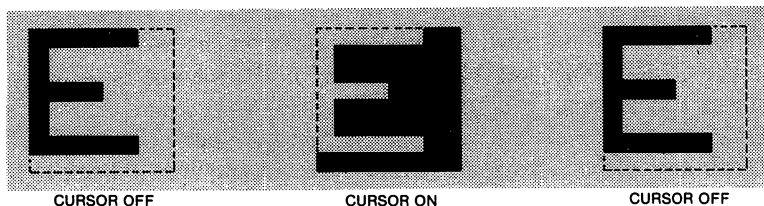


Fig. 1-12. Putting the cursor on a character makes it seem to "flash."

The CRSR keys can put the cursor anywhere on the screen, within the central square area. The cursor does not erase characters when it is moved with the CRSR keys. You'll soon find out how you can use the CRSR keys to go back and make changes to the characters and other information shown on the TV screen.

Now that you have had a chance to try the CLR/HOME and the two CRSR keys, you will be able to use these keys when you need them, or when you're asked to clear the screen, send the cursor home, or move the cursor in an experiment. It will take some practice to get used to some of the special keys, but this is true for all of the computer operations. The keyboard has some other features, and we will look at these next.

YOUR ERASER

Everyone makes mistakes, so it's a good idea to have an eraser handy. The Commodore 64 has a special key that can be used to "erase" mistakes, and this is the INST/DEL key located on the keyboard, as shown in Fig. 1-13. When this key is pressed, the cur-

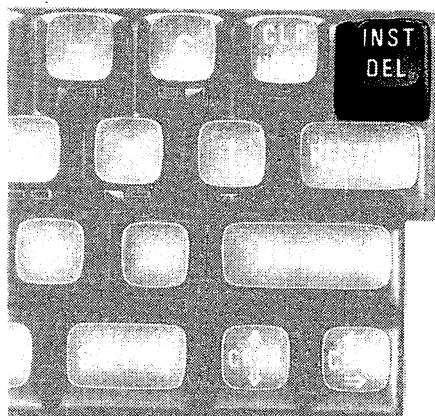


Fig. 1-13. The INST/DEL key located in the upper right-hand corner of the keyboard.

sor moves to the left, erasing characters as it goes. This key can be used when you are typing and discover a mistake. You can simply “back up,” erase, and then continue typing.

We do not expect you to be an expert at using the INST/DEL key after you read this section and do an experiment. We just want you to know how this key can be used.

Experiment No. 1-5. The INST/DEL Key

In this experiment, you will find out how you can “erase” mistakes by using the INST/DEL key. Use the CLR/HOME key to clear the TV screen. Remember to use the SHIFT key, too, or you will simply move the cursor to its home position. Once the TV screen has been cleared, type the following:

THIS IS THE COMMODORE 64■

Leave the cursor so that it is just to the right of the number 4 in COMMODORE 64. Let's assume that you wanted to type, THIS IS YOUR COMMODORE 64 instead of THIS IS THE COMMODORE 64. You can go back and correct the information typed on the TV screen by using the INST/DEL key. Press the INST/DEL key once. What happens to the cursor? Is anything erased from the TV screen? The cursor moved one space to the left. Since it was placed just to the right of the 4 in COMMODORE 64, the 4 was erased, leaving THIS IS THE COMMODORE 6■ on the TV screen. Press the INST/DEL key 16 more times. What is left on

the TV screen now? You should see only **THIS IS** on the TV screen. Now type a space and then type **YOUR COMMODORE 64**. You should now have this on the TV screen:

THIS IS YOUR COMMODORE 64

Since the cursor is now to the right of the 4 in **COMMODORE 64**, press the **INST/DEL** key and hold it down, but release it after a few seconds. What happens to the cursor now? The cursor moves to the left for as long as the **INST/DEL** key is pressed. It erases characters as it goes. When it reaches the left side of the TV screen, it will go on to the line above, if there is one, and will continue to erase whatever is there. When the cursor is moved back to the upper left-hand corner (home) with the **INST/DEL** key, it will go no further.

Clear the screen and move the cursor down four lines. Now type the following:

ERASE THIS LINE

Now press the **INST/DEL** key and hold it down. What happens? The line just typed is erased and the cursor goes from the left side of the screen to the right side of the screen, but on the line above. If you keep the **INST/DEL** key pressed long enough, the cursor will move right back to its home position.

You can use the **INST/DEL** key to “erase” information on the screen whenever you wish. Just remember that it backs up and “erases” to the left of the cursor. The **INST/DEL** key also has an insert (**INST**) operation that is used to make “openings” in groups of characters so that other characters can be added with a minimum of retyping.

You can use the **CRSR** keys to place the cursor in the middle of a line of characters, then the **INST/DEL** key can be used to erase and open spaces for changes. Here is another experiment that will show you how the **INST** and **DEL** operations can be used together.

Experiment No. 1-6. Deleting and Inserting

What happens when the **INST/DEL** key is used to erase something in the middle of a line of characters? How do you insert characters? You’ll see how it’s done in this experiment. Clear the screen and move the cursor down four lines. Type the following and leave the cursor to the right of the **D**, as shown:

SEE HOW HE JUMPED

Move the cursor to the left so that it is superimposed on the J in JUMPED, making the J seem to “flash” in the cursor block. Use the SHIFT key and the left-hand CRSR key to do this. Once the cursor is on top of the J, press the INST/DEL key once. What happens to the characters on the TV screen? The space between HE and JUMPED is erased, so the line now looks like this:

SEE HOW HEJUMPED

with the cursor still on the J. Now press the INST/DEL key two more times. What happens now? Can you describe what the INST/DEL key does when it is used in the middle of a line of characters? The line is now SEE HOW JUMPED, with the cursor still on top of the J in JUMPED. When the INST/DEL key is pressed, it “erases” a character to its left. Any character under it, and characters to its right are moved over to the left to take up the space left by the “erased” character.

Now we want to insert the word THEY, so that the line of characters looks like this:

SEE HOW THEY JUMPED

The insert operation on the INST/DEL key can be used to “open” spaces in a line of characters so that changes can be made. How many spaces would be needed in the line SEE HOW JUMPED to make it SEE HOW THEY JUMPED? You need five spaces, four for the letters in THEY and one for the space between THEY and JUMPED. To “open” five spaces, press/hold the SHIFT key and press the INST/DEL key five times. Don’t hold the INST/DEL key down, since it is a repeating key, and too many spaces will be “opened.” What happens to the display on the TV screen? When the SHIFT key is pressed and held and the INST/DEL key is pressed, the cursor stays in its place, but it “opens” spaces to its right. The characters to the right of the cursor are pushed to the right, one space at a time, “opening” spaces in the line of characters. Now that there are five spaces, you can simply type THEY. Remember to press the space bar once for the space between THEY and JUMPED. Does the TV screen now display, SEE HOW THEY JUMPED? If not, you may want to go back and try this experiment again, since it takes some practice to get used to the operation of the INST/DEL key. As you will see later on, the INST/DEL key can be used for making corrections and changes in computer programs, too. You don’t have to be a master of the INST/DEL key right now.

DRAWING PICTURES

Many of the *printing keys* can be used to draw pictures, make up game characters, draw graphs, and put graphic information on your TV screen. When reading a book such as this, photographs, drawings, charts, and figures illustrate important things, or show something that would take many extra words. The same thing is true for the computer. It is often easier to have the computer “draw” simple pictures, graphs, and shapes than it is to have the computer list columns of numbers or letters. Look at Fig. 1-14. It is easier to see

HEATING BILLS FOR 1982-1983*

JUN	\$ 50	██████████
JUL	\$ 55	██████████
AUG	\$ 40	██████████
SEP	\$ 55	██████████
OCT	\$ 70	██████████
NOV	\$ 150	██████████
DEC	\$ 190	██████████
JAN	\$ 220	██████████
FEB	\$ 250	██████████
MAR	\$ 180	██████████
APR	\$ 110	██████████
MAY	\$ 75	██████████

*INCL. HOT WATER & DRYER

Fig. 1-14. Graphic and tabular information tell the same story: high heating bills in the winter.

the increases in heating bills by looking at the chart rather than the list of costs. The Commodore 64 computer can display many different shapes, lines, and figures on the TV screen, and these can be put together to make complex “drawings” of all sorts.

You probably noticed that all of the letter keys, A through Z, have two special graphic symbols on the front of them. Five of the other *printing keys*, +, -, #, @, and * have special symbols on them, too. These symbols can be seen on the front of the keys in Fig. 1-15. All of these graphic symbols can be “printed” on the TV screen.

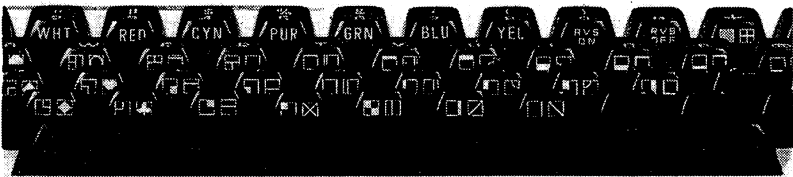


Fig. 1-15. The special graphic symbols are found on the front of the keys.

The special *graphic symbols*, or *graphic characters*, are displayed on the TV screen by using the SHIFT key or a new *action key* we'll call GRAPHICS. The GRAPHICS key is shown in Fig. 1-16, along with the two SHIFT keys. When you look at your key-



Fig. 1-16. The GRAPHICS key is in the lower left-hand corner of the keyboard.

board, you'll see that the legend on the GRAPHICS key looks like a large letter "C" with a small flag or equals sign attached to it; C=.

If you press the SHIFT key and one of the keys having a pair of shapes or symbols on its front, the right-hand shape will be displayed on the TV. If your computer is turned on, press/hold the SHIFT key and press the "Z" key and then the "S" key. You should see a diamond and a heart displayed on the TV screen.

The GRAPHICS key works the same way as the SHIFT key. It must be pressed and held when you want to display the left-hand graphic symbol on the front of a key. Again, if your computer is turned on, press/hold the GRAPHICS key and press the "+" key and then the "B" key. You'll see a part of a "flag" and a square full of "dots" displayed on the TV screen.

Experiment No. 1-7. Drawing Things

Use the CLR/HOME key to clear the screen. Press the SHIFT key and hold it down. Now, press some of the keys with the graphic symbols on the front. You should see the shapes, lines, and other

special symbols displayed on the TV screen. The cursor moves one space to the right, just as it did when you were typing numbers and letters in some of the earlier experiments. The CLR/HOME and CRSR keys may be used to clear the screen, put the cursor at its home base, or place the cursor anywhere you want it.

Clear the screen again, press the GRAPHICS key and hold it down. Now press some of the keys with the graphic symbols on the front. You should see that you are printing the left-hand figure shown on the key onto the screen. You can release the GRAPHICS or the SHIFT keys at any time to print the "normal" characters on the screen.

The lines and shapes can be combined to make interesting figures and designs. For example, clear the screen and move the cursor away from the edges of the screen. Press the SHIFT key and then press the "U" and "I" keys. Let the SHIFT key come up again, and move the cursor down one space and to the left two spaces. You'll have to use the SHIFT key with the CRSR keys to move the cursor where you want it. You can probably do this without any more help. Now, press the SHIFT key and then press the "J" and "K" keys. What shape did you draw? You should find that you have drawn a circle on the screen. What happens when you press the SHIFT key and then the "W" key? A smaller circle appears.

Here is a more complicated figure you can create. Clear the screen and move the cursor so it's near the center of the TV screen. Press/hold the GRAPHICS key and type the letters "NBB." Release the GRAPHICS key and move the cursor down one line and three spaces to the left. Press/hold the GRAPHICS key and type the letters "NBB" again. Release the GRAPHICS key and move the cursor down one line and to the left three spaces. Press the GRAPHICS key and the "N" key. Move the cursor down one line and to the left one space. Press the GRAPHICS key and the "N" key. You should have the checkered winner's flag in the center of your TV screen.

It won't take you long to learn how to use the graphic symbols, since it's more fun to draw things than it is to simply sit and type numbers and letters. You can move the cursor anywhere on the screen that you want to, and you can clear the screen as needed. Here are a few things to keep in mind as you draw figures and shapes with the special graphic symbols:

1. You can move the cursor "over" anything on the screen with-

out destroying it. If you want to change something, simply use the cursor controls to get to the character or symbol and retype it.

2. When you clear (CLR) the screen, your graphic artwork or typing will be erased and you won't be able to get it back.
3. When the cursor reaches the bottom border, you can move it "down" another line, but this will cause everything on the screen to move "up" a line. The top line will be pushed up "off" the TV screen and lost. The display is said to "scroll" up.

COLOR FUN

When the computer is turned on, the color of the central area on the TV screen is dark blue, and the cursor is light blue. If you have a color TV set, you can change the color of the cursor and the characters that are to be printed. If you have a black-and-white TV set, you will see the color changes as shades of grey. The color of the cursor is changed by using the number keys, "1" through "8." You can see in Fig. 1-17 that these keys have three-letter color names on the front of them, and these colors are also shown here:

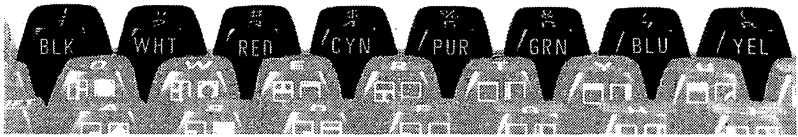


Fig. 1-17. The color codes are on the front of the number keys, 1 through 8.

KEY	COLOR
"1" BLK	Black
"2" WHT	White
"3" RED	Red
"4" CYN	Cyan (light blue)
"5" PUR	Purple
"6" GRN	Green
"7" BLU	Blue
"8" YEL	Yellow

The control key, marked CTRL, is used to change the cursor's color, and it is shown highlighted in Fig. 1-18, right below the "1" key. If you press and hold the CTRL key and one of the color keys, the color of the cursor will change to the color noted on the key. When you release the color key, the cursor will stay the color you

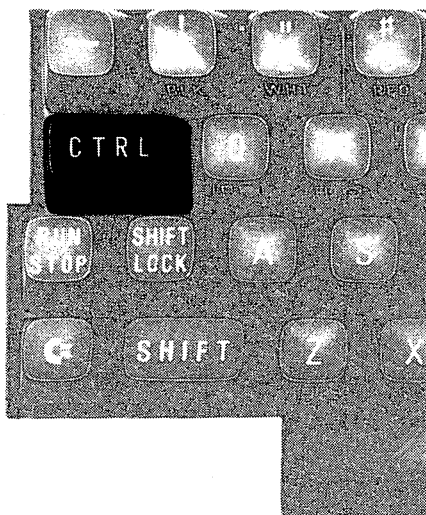


Fig. 1-18. The CTRL key is at the upper left side of the keyboard under the "1" key.

have selected, unless you change it by pressing the CTRL key and one of the other color keys.

Experiment No. 1-8. The Color Connection

In this experiment, you will find out how to change the color of the cursor and print things on the screen in different colors. Unfortunately, most of the colors don't show up well on the dark-blue background.

Clear the screen. Press/hold the CTRL key and press the "1" key to change the cursor to black. Now type the word, BLACK. You should see BLACK printed in black letters on the screen. Can you change the color to white? Press/hold the CTRL key and press the "2" key, the one with the WHT notation on the front. Now, type the word WHITE. Change the color to red (RED) and type the word, RED. Change the color to cyan (CYN), which is a very light blue, and type CYAN. Change the color to purple (PUR) and type PURPLE, change it to green (GRN) and type GREEN, and finally change it to yellow (YEL) and type YELLOW. Do you have all of the colors spelled out now?

On our color TV set, only the words WHITE, CYAN, and YELLOW, printed in those colors, looked good. The other colors were

on the TV screen, but the letters were difficult to read. Some colors just don't look good together.

If you have a black-and-white TV set, you will see that the white, cyan, green, and yellow "colors" look light grey. It is difficult to tell much of a difference between them.

Even when you have changed the color, you can still use all of the *printing keys*, including the special graphic characters. You can change the color at any time to put green dots, purple triangles, red squares, and other colorful figures on the TV screen. Many of these are used in games, educational programs, and other programs where it is useful to use colors for emphasis or special effects. When you change from one color to another, the characters already being displayed on the TV screen are NOT changed.

There are eight other colors that you can control from the keyboard using the number keys, 1 through 8, but the GRAPHICS key controls them, instead of the CTRL key. These colors will be described in Chapter 8. Since you found that some color combinations don't look very good, we'll also tell you about some of the color combinations to avoid in your displays.

The computer can also "reverse" its display to highlight words, numbers, or special symbols. You can turn the "reverse" on and off, using the reverse-on (RVS ON) and reverse-off (RVS OFF) keys, found on keys "9" and "0," as shown in Fig. 1-19. The

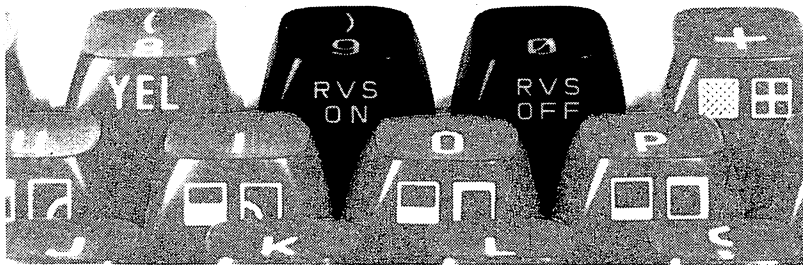


Fig. 1-19. The "9" and the "0" keys also turn the reverse printing on or off.

reverse operation is controlled by the CTRL key, as are the color keys.

Experiment No. 1-9. Printing in Reverse

Clear the screen and change the color to white. Try to do this without help, and without going back in this chapter. If you need help, press/hold [SHIFT] and press [CLR/HOME]. Now, press/hold [CTRL] and press [WHT] (the "2" key). That should do it.

To reverse the printing, press/hold the CTRL key and then press the RVS ON key (the "9" key). Do you see any changes on the screen? No, nothing has been printed yet. Type the word, TEST. What do you see on the TV screen now? The word TEST is printed on the screen. The letters are the color of the big square area on the TV screen (blue) and they are printed *on* the color you selected (white).

Change the color to cyan (press/hold [CTRL] and press [CYN]). The cursor should now be cyan, or light grey on a black-and-white TV. Type TEST again. What do you see on the screen? The letters are the same color as the large square area, but they are printed on a *cyan*, or light-blue background.

Press-and-hold the CTRL key and press the RVS OFF key. This will turn off the reverse printing, so that information is printed normally on the TV screen. When you pressed the CTRL and RVS OFF keys, did you notice a change on the TV screen? There is no change, since you haven't printed anything yet. Type the word TEST again. What is displayed on the TV screen? The word TEST is printed in cyan letters on the normal dark blue background. You can experiment with reverse printing for the other colors, too, but most of them will not show up too well.

When the reverse printing is turned off, the areas that were printed in reversed colors *stay that way*. They do not change. When the reverse printing is turned on with the CTRL and "9" keys, the characters already printed on the TV screen are not changed. Only the characters typed *after* the change in the display format are reversed.

We haven't talked about the color blue (BLU), found on the "7" key. What do you think would happen if you change to this color? If you decide to try it, you'll see that the cursor disappears. When the printing color is changed to blue and the background color is blue, you won't be able to see any of the characters you type. Blue characters on a blue background don't show up.

If you haven't already changed the cursor to the color blue, you can do it now. Type some characters and then change to the color white. Has the cursor moved from where it was when you changed to blue? Yes, it has, since it has printed blue characters on the blue background, even though you can't see the characters you've typed in. Remember that changing to the color white doesn't change those characters already typed to white. They stay the way they are, including the blue characters you typed in (and still can't see).

SECRETS

We didn't talk about the RESTORE or RUN/STOP keys in this chapter, and we didn't say much about the RETURN key, either. These aren't secret keys, but they don't have much to do with the keyboard or TV display. These are *action keys* that control the operation of the computer. We will talk about them in another chapter.

QUESTIONS

1. How do you set up the computer to use channel 3 on the TV set for its display?
2. What types of keys are there on your Commodore 64, and what kinds of things do they do?
3. What does the SHIFT key do?
4. What two operations does the CLR/HOME key do?
5. Why do you use the CRSR keys?
6. Do any of the keys "repeat" their action if they are held down for a while? Which keys do this?
7. What does the INST/DEL key let you do?

8. What does the GRAPHICS key look like, and what does it do?
9. How can you change the colors of the things you are typing on the TV screen?
10. What color do you get when you press the SHIFT key and the "6" key?
11. If you type several words and then change the color of the cursor, is the color of the previously typed words changed, too?

FOOD FOR THOUGHT

If you look at all the graphic symbols, you'll see that there isn't a symbol for a solid block, the size of the cursor. However, you can display a solid block of color (not the cursor) on the TV screen. How can this be done?

CHAPTER 2

USING A SMALL COMPUTER

WHAT CAN YOUR COMPUTER DO?

Now that you're familiar with the keyboard, you're ready to start using your Commodore 64 computer for more than typing and drawing, but what exactly do computers do? If you think about computers in a very general way, you'll find that they simply *process information*. In fact, computers were originally called *electronic data processors*. Here are some ways in which computers are used: traffic-light control, bank accounting, cash register, calculator, spacecraft, or satellite control.

Computers have to get the information they're going to process and they have to do something with it when they are finished, so they also *transfer information*. Computers have two main functions; processing and transferring information.

Let's look at the satellite computer shown in Fig. 2-1 to see if computers really work this way. The satellite's computer gets information from various sensing devices that tell it where it is, how fast it's going, and so on. This information is processed and then transferred to various devices; to the rocket motors to reposition the satellite, and to a radio transmitter to send the new position back to an earth station. The principle is the same; information is transferred and processed.

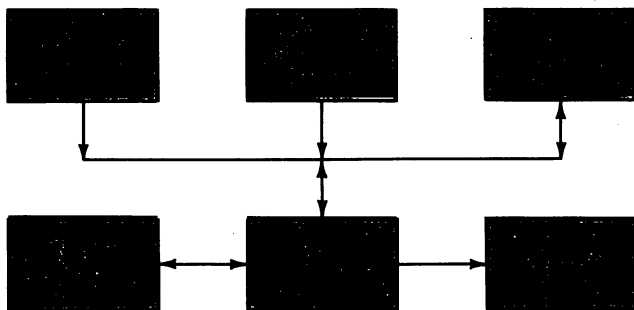
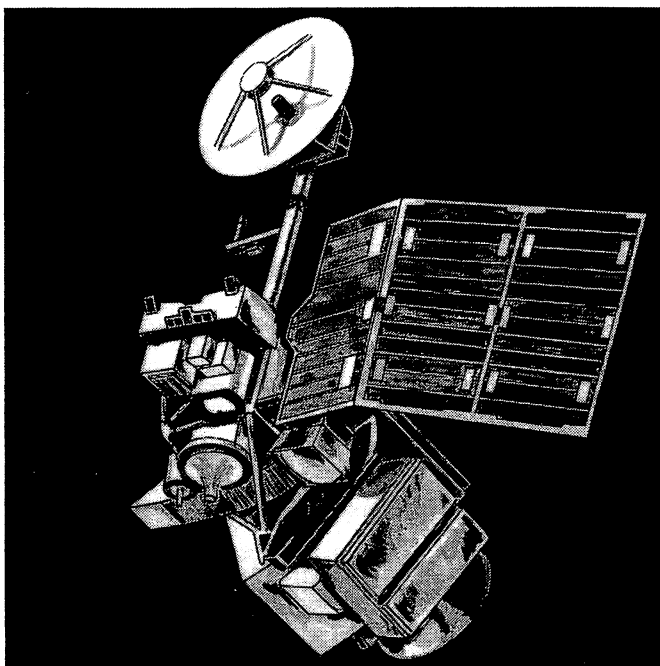


Fig. 2-1. Block diagram of a simple satellite computer system.

It's a bit awkward to talk about information being transferred to and from a computer, so the words *input* and *output* are commonly used. For example, information is input to the computer and after it is processed, it is output to a printer or a TV screen. In almost all cases, input refers to *input to the computer*, while output refers to *output from the computer*. The devices that put information into the computer are simply *input devices*, and the keyboard on your computer is a good example of one. Devices that receive informa-

tion from the computer are *output devices*, and the TV screen is a good example.

These devices are often put under the heading of input/output devices and are called I/O devices for short. Here are examples of some I/O devices that can be easily connected to your Commodore 64 computer:

I/O DEVICE	USE
Game Paddle	INPUT
Printer	OUTPUT
Game Cartridge	INPUT
Disk	INPUT and OUTPUT
Cassette	INPUT and OUTPUT

The disk and cassette I/O devices can be both input and output devices, storing information from the computer and later transferring it back to the computer. The I/O devices are often called *peripherals*, and you will see this word used to describe all types of I/O devices.

You'll need to give the computer only a few simple instructions to get it to input or output information and we will describe these later in this chapter.

SIMPLE PROGRAMS

Now that you have an idea of what your Commodore 64 can do, you can write some simple programs, but there's no reason to get high blood pressure or sweaty palms over them. You have already used the computer to do some simple keyboard operations, and you may have played some games or used the computer for something else. It's really pretty easy. Here's a bit of history to ease you into programming your Commodore 64.

Just as we think and communicate using the English language, the Commodore 64 is set up to think and talk in a language called BASIC. We'll just call it BASIC from now on. BASIC was developed at Dartmouth College between 1963 and 1964, and its purpose has been to provide beginners with a simple, easy-to-understand way to use computers. BASIC *is* basic, and it gives you an ideal way to start using your Commodore 64 computer.

You can't destroy your computer by programming it the wrong way. You may not get the answer you want, or the computer may tell you that you've done something wrong, but you can't destroy it. You're the computer's master, too. You can always "pull the

plug," walk away and take a break. In fact, it's a good idea to do that every once in a while.

GETTING STARTED

Your computer can be set up to process information for hours at a time, but if you can't get information in or out, the processing doesn't do you any good. So, your first step in programming is learning how to get the computer to input information and to output it, too. There are two "words" in BASIC that you can use to tell the computer that it is to input and output information. They are INPUT and PRINT. In almost all computer languages, these are called *commands*, since you use them to command the computer to do something.

In the Commodore 64 computer, you use the INPUT command to get information from the keyboard. You use the PRINT command to put information on the TV screen so you can see what the computer has done. These commands are easy to use and you'll get a chance to try them very soon.

You will write simple BASIC programs using individually numbered instructions, or steps, for the computer. This lets you and the computer keep track of where you are and where you are going. In BASIC programs, each operation or command is put in a separate "sentence" or *line*. The lines are numbered in sequence with *line numbers*, much like the numbered steps in instructions for assembling a bicycle. Here is a simple BASIC program that will give you an idea of what's ahead:

```
10 INPUT ALPHA  
20 PRINT ALPHA
```

In this simple program, line numbers 10 and 20 are used to guide the computer through the program, one line at a time. Lines 11 through 19 aren't "missing," they just haven't been used in this program. The computer simply goes from one line number to the next highest one, so after finishing the command at line 10, it goes to the command at line 20. Most people who write computer programs in the BASIC language use line numbers that are multiples of 10, starting with 10; 10, 20, 30, and so on. You don't have to number your lines this way, but most programmers do. The following program will do the same thing as the preceding one:

```
12 INPUT ALPHA  
130 PRINT ALPHA
```

What does this simple program do? Here's a general description: The first thing it does is to command the computer to get a value from the keyboard (INPUT ALPHA). We have told the computer that we want this number to be called ALPHA, so we can easily identify it later on in the program. Once the value has been typed in and labeled ALPHA, the computer prints it on the TV screen.

Experiment No. 2-1. A Simple Input/Output Program

In this experiment, you'll learn how to use the keyboard to type a short program into the computer. Turn on your computer. If it is on, turn it off, wait a few seconds and turn it back on. This will give you a fresh start, clearing the computer and the screen.

You type in programs one letter or number at a time. Use the RETURN key on the right side of the keyboard to tell the computer when you have finished typing in each line. We'll show the RETURN key in brackets, [RETURN], so you'll know when to press it. Don't worry if you make a mistake. We'll show you how to correct it in a minute. Here is the short program. Type in each line, and press the RETURN key at the end of each line:

```
10 INPUT ALPHA [RETURN]
20 PRINT ALPHA [RETURN]
```

The RETURN key tells the computer that you have finished an operation. You'll find that using the RETURN key becomes second nature, but we'll tell you when to press it in the first few experiments to get you started. Remember, you don't type the word "RETURN," you just press the RETURN key.

Now you will check to be sure that your program has been typed into the computer correctly. You can ask the computer to "list" your program on the TV screen so that you can review it and check for any errors. This is called "listing your program."

To list a BASIC computer program on the TV screen, simply type the word LIST and press [RETURN]. Go ahead and type LIST [RETURN]. What happens on the TV screen? You should now see your program displayed on the TV screen. This type of display is called a "listing." Check the listing displayed on the TV screen with the previous program to see if you have typed in the program correctly. If you have made mistakes while typing the program, don't worry, they are easy to correct.

If you slipped and used an incorrect line number, when you list your program it might look like this:

```
10 INPUT ALPHA
29 PRINT ALPHA
```

You can remove line 29 from your program by typing just the line number followed by [RETURN]; that is, 29 [RETURN]. You can also retype any line that is incorrect. You don't have to erase it first. Just start with the same line number, retype the information and press the RETURN key. The computer automatically replaces the old line in your program with the new one.

Now, retype any incorrect lines and erase any incorrect line numbers. You can retype incorrect lines as many times as needed until you get them right. You can also list your program as many times as you want to check it. Before going on, be sure your program looks like this:

```
10 INPUT ALPHA
20 PRINT ALPHA
```

Change line 10 by typing this into the computer:

```
10 INPUT ALFA [RETURN]
```

Type LIST [RETURN] and see what has happened to your program. You should see the following listing on the TV screen:

```
10 INPUT ALFA
20 PRINT ALPHA
```

Could you get line 10 back to: 10 INPUT ALPHA? It's not difficult to do, simply retype the correct line and press [RETURN]. Let's put another line in the program and change line 10 at the same time. Type in the following:

```
10 INPUT ALPHA [RETURN]
36 INPUT COUNT [RETURN]
```

Now list the program by typing LIST [RETURN]. The program listing should look just like this:

```
10 INPUT ALPHA
20 PRINT ALPHA
36 INPUT COUNT
```

When lines are typed in from the keyboard, the numbered lines can be typed in any order. The computer automatically sorts them out and will print them in the correct order when you list the program. Just remember to use the RETURN key when you finish typing each line.

Do you remember how to get rid of the command at line 36? You can simply type 36 [RETURN]. Do this, and then list the program on the TV screen by typing LIST [RETURN]. You should see only lines 10 and 20 in the listing:

```
10 INPUT ALPHA
20 PRINT ALPHA
```

In this first programming experiment, you have already learned quite a bit. You have:

- Typed in a simple computer program.
- Used several different line numbers.
- Corrected errors in line numbers.
- Added and deleted lines.
- Learned how to list a program on the TV screen to see that it is correct.

Leave your computer on if you're going to go ahead to the next section. Otherwise, you can turn it off. Remember that you will not "hurt" or "destroy" the computer by typing in incorrect lines or commands. The computer may not understand what you're asking it to do, and it will let you know quickly. You can't hurt it through errors in your programs either.

Experiment No. 2-2. Running Your Program

Now you will learn how to tell the computer to run or "do" a simple two-line program, and you will learn how the RUN command is typed in from the keyboard. So far, you've simply typed in a program and checked it to be sure it was typed correctly. If the following program is not in your computer, type it in now:

```
10 INPUT ALPHA
20 PRINT ALPHA
```

When typing in a program, remember to press the RETURN key after you finish each line:

```
10 INPUT ALPHA [RETURN]
20 PRINT ALPHA [RETURN]
```

How do you get the computer to run the program? What do you think will happen when the program is run? You start a BASIC program by typing RUN [RETURN]. You would type the three letters R, U, and N, and press the RETURN key. Don't get confused by the RUN/STOP key on the left side of the keyboard. This

key has a special use, but it doesn't start programs. DON'T USE IT!

When a program is started with a RUN command, the computer goes to the lowest line number and starts to do the things that you have told it to, one line at a time. In this case, the computer goes to line 10 and starts an INPUT operation. You'll probably remember that an INPUT command asks you to type in information from the keyboard.

Before you run your program, clear the screen. Do you remember how to do this? (Press/hold [SHIFT] and press [CLR/HOME].) Type RUN [RETURN]. What happens on the screen? Your screen should look like this:

```
RUN
? █
```

The question mark and flashing cursor show that the computer is waiting for you to type in information from the keyboard. In this case, the computer is waiting for you to type in a number, or value. To get a value into the computer, you simply type in the numbers you want to enter and then press the RETURN key; for example, 1239 [RETURN].

Type in the three-digit number, 345. Does anything happen? You must press the RETURN key to tell the computer that you've finished typing information. Once you have typed in your number and pressed the RETURN key, your screen should look like this:

```
RUN
? 345
  345
```

```
READY
█
```

The computer has input the value with the INPUT ALPHA command, and it has printed it with the PRINT ALPHA command. The label ALPHA was used to identify the value for the computer. The value we chose for this experiment was 345. Any numeric value (within the computer's range) could have been typed in with similar results. There is nothing special about the choice of 345.

Run the program again by typing RUN [RETURN]. Now type in a number of your choice between zero and a million. Don't forget to press [RETURN] to tell the computer that you have finished

typing your value. Did the computer display the value properly? It should have.

The READY message and the flashing cursor let you know that the computer is ready for your next "command." You could tell it to run a program again, print a listing of a program, or accept some lines typed in for a new program.

Do you think the computer "used up" your program? You can ask the computer to list your program to see if it's still there. Go ahead and type: LIST [RETURN]. Is the program still in the computer? It should be.

Experiment No. 2-3. Bad Data

Now you will program the computer to input a value labeled ALPHA. When the computer "asks" for the value, you will see what happens if you try and trick it by typing in something else. If the following program is not in your computer, type it in from the keyboard:

```
10 INPUT ALPHA
20 PRINT ALPHA
```

If you are unsure of how to do this, go back and do Experiment No. 2-1, then do this experiment.

Clear your screen and run the program. (Hint: Simply press/hold [SHIFT] and press [CLR/HOME]. Now type in: RUN [RETURN].) Let's try and fool the computer. Since the computer expects you to type in a value; that is, several numbers, what do you think will happen if you type in letters instead?

When you have started the program and the question mark can be found on the TV screen near the flashing cursor, type in the characters, WAS, and press the RETURN key. What shows up on the TV screen after you press the RETURN key? The computer prints:

```
RUN
? WAS
?REDO FROM START
? ■
```

This message tells you that your letters, "WAS," were "thrown out" by the computer, because it expected you to type in a value, instead. It knows that "WAS" isn't a value, so it gives you another chance to input a number.

Now type in 5.8.9. [RETURN]. What is displayed on the TV screen? The information you typed in, 5.8.9., isn't a value, so another REDO message appears and the computer gives you another chance to type in a value.

Type in \$456 [RETURN] and see what happens. The REDO message appears again. Is this what you expected? Maybe you thought the computer would accept \$456 as a value. Is \$456 a number? It looks like four hundred and fifty-six dollars to you and me, but the computer throws it out. Why? The dollar sign is a short-hand notation that is used by *people* in place of the word "dollars." The computer doesn't know that a dollar sign represents money. In fact, it doesn't "know" that a \$ is a dollar sign. To the computer, it's just another *non-numeric character*.

So far, the computer works only with values, so you can't type in 15 POUNDS, 34 OUNCES, or 1250 SWISS FRANCS. It will only work with 15, 34, 1250, or some other value. Remember, the computer wants you to type in values with *only the digits 0 through 9*. You can also use one decimal point and either a plus (+) or minus (-) sign, but that's all. Here are some examples:

.00987 -987.084 +345 42 -0.081

Notice that no %, #, \$ or other special symbols are used with these values. If they are, the computer will not accept your information. The plus sign in front of 345 is not really needed, since +345 and 345 are the same. As far as the computer is concerned, the following are *not values*:

#7 \$47.98 15%

LABELS, LABELS, EVERYWHERE

Although you may not have realized it, the computer used a "label" to identify the values you typed in in the experiments you just did. Labels are very important, since they let the computer keep track of its information. Can you imagine walking into a drug store that didn't have labels on any of the bottles or packages? How would you find the aspirin? It would be confusing. What about having a checking account with a bank that didn't use names or account numbers?

"I'd like to cash a check, please."

"Which account is yours, madam?"

computer to print the number of eggs you sold. It's not difficult at all.

What do you think the computer would do if you forgot to give a value to the label, CARTONS? The computer would look at the label, CARTONS, and find that there was no value attached to it. Without a value for CARTONS the computer would tell you that it couldn't figure out the number of EGGS. You couldn't figure it out either. The computer wouldn't say, "HOW MANY CARTONS, DUMMY?", but it might say "ERROR . . .". So, you can see how important labels are.

COMMODORE 64 LABELS

In the Commodore 64 computer, labels can have up to 255 characters, but *the first character must be one of the letters of the alphabet, A through Z*. The characters that follow the first letter can be numbers or letters, and you can use spaces as in EGGS PER CARTON to make labels readable. It's not too easy to read EGGSPERCARTON. Which of the following labels could be used in your Commodore 64 computer?

DAYS	EGG ROLLS	MARKER
MOTHS	ACCOUNT NUMBER	DATE OF TEST
30TH	7A	ACT3

Except for 30TH and 7A the other labels are fine. These two don't follow the rule of using a letter to start a label.

It's more meaningful to use the label, EGG ROLLS, for the number of egg rolls sold than to use the totally unrelated label, MCW. Someone looking through a program is going to wonder what MCW stands for. There's not much question about the label, EGG ROLLS. Meaningful labels serve a purpose, allowing you to clearly identify things.

However, *the Commodore 64 computer uses or "sees" only the first two characters in a label*. This means that in the preceding list, while you see ACCOUNT NUMBER and ACT3, the Commodore 64 sees the two-character label, AC, for both. The same is true for the labels, EGGS and EGGS PER CARTON. Avoid choosing labels with the same first two letters, or the Commodore 64 will think they are the same thing! This just happens to be the way the Commodore 64 operates. Larger computers can use many more characters in their labels, simplifying things a lot. Well, you can't have everything in a small computer.

Since the Commodore 64 uses only the first two characters, how would you get around this in the egg-counting problem we discussed before? Try the following:

```
CARTONS = 14
AMT PER CARTON = 12
EGGS = AMT PER CARTON * CARTONS
```

Now there is no conflict between the first two letters in any of the labels. The computer sees:

```
EG as the label for EGGS
AM as the label for AMT PER CARTON
CA as the label for CARTONS
```

This seems to be fine, and it brings us to two programming rules:

Rule 1. Make your labels meaningful.

Use meaningful labels for things. If you use labels such as YT for eggs, QW for eggs per carton, and P for cartons, your calculation will look like this:

```
YT = QW * P
```

With these labels, it's not easy to see what you're doing.

Rule 2. Avoid using the numbers 0 and 1, or the letters O or I in labels.

The numbers 0 and 1 are easily confused with the letters O and I, and if you look at a label quickly, it's easy to be confused. For example, VO; is it vee-oh or vee-zero? It may be difficult to tell.

Experiment No. 2-4. Short Labels

This experiment will show you that the computer really uses only the first two characters in the label to identify information.

In the following program, the label BETA is used to identify a value, but the Commodore 64 will use only the first two letters, BE, to identify information. Let's try and confirm this.

Type the following program into your computer. Don't forget to use the RETURN key at the end of each line:

```
10 INPUT BETA
20 PRINT BETA
```

List the program on the TV screen to check that it has been typed in correctly. Run the program and test it by typing in 234 or

any other three-digit number. You should see the 234 or your three-digit number printed on the screen, followed by the READY message.

If an error message, or something else unexpected, is displayed on the TV screen, check your program again. You can list a program on the TV screen at almost any time, but you can't list it when the computer is waiting for you to input information. That is, when the flashing cursor is "waiting" after a question mark on the TV screen.

Once the two-line program has been run and tested successfully, change line 20 to:

```
20 PRINT BE
```

Remember, you just type in the new line 20, as shown, and press the RETURN key. The new line is substituted for the "old" line 20 in the program. List your program, and it should look like this:

```
10 INPUT BETA  
20 PRINT BE
```

Run this program and type in a value. Does the computer operate the same way it did when the PRINT BETA command was used at line 20? It should, since the Commodore 64 computer uses only the first two letters of a label to identify the information. This means that you shouldn't try and use the labels BETA and BE for different pieces of information in a program, since the computer will think they are the same. Be careful!

THE COMPUTER INFORMATION DIET

Your Commodore 64 computer can process or "work on" two general types of information. The first type of information is simply a *value*, and you have already seen that the computer can input and print a value. Later you will see how the Commodore 64 can add, subtract, multiply, divide, and use the values in other ways. The Commodore 64 can work with some very large and small numbers, probably larger and smaller than you can imagine right now.

Suppose that you want the Commodore 64 to keep a list of names and phone numbers. How does the computer work with a name such as Stew Watson? It's pretty obvious that a name such as this can't have a value, so this brings us to the second type of information that the computer can process; groups of characters, just like the ones in this sentence. You'll remember that we talked about

characters in Chapter 1, and you learned that characters are simply symbols such as A through Z.

The computer “sees” Stew Watson’s name as a group of characters: S, T, and so on. Once the computer has groups of characters, it can see if two names match, it can put characters together to form sentences, and it can search a mailing list for all your friends in Washington, DC. There are lots of useful things you can do with groups of characters, and computers use them every day. Since *groups of characters* is a bit of a mouthful, the word *string* is used to identify these groups.

The following list contains both “values” and “strings.” Try and figure out which group each belongs in. You can circle your answers or use a sheet of paper.

Smith	String or Value
12.87	String or Value
Green paint	String or Value
23	String or Value
Main Street	String or Value
24060	String or Value

Smith, Green paint, and Main Street are all strings. It’s not easy to tell if 12.87, 23, and 24060 are values or strings. The 24060 looks like a ZIP or mail code. Maybe it’s not really twenty four thousand and sixty, but two-four-oh-six-oh. Since the computer lets you put labels on things, it really won’t be that difficult to tell the strings and values apart.

TYPES OF INFORMATION AND LABELS

Labels are used to identify information, and they are also used to tell the computer what *type of information* is going to be processed. If you want to give labels to values, just use letters and numbers in the label. The first character in a label must be a letter, A through Z. For example:

BALANCE = 234.76
TEST NUMBER = 70
M32 = 34689
MILLI = 0.001

Just remember that the longer labels are for *your* convenience; the Commodore 64 sees them as the first two characters:

BA = 234.76
TE = 70
M3 = 34689
MI = 0.001

When the computer is going to process strings of characters, labels are also used, but you put a dollar sign (\$) at the end; for example, TEST\$. The dollar sign is a signal to the computer that the label is assigned to a string, and not to a value. Here are a few examples:

NAME\$ = "BOB EBBS"
DATE\$ = "SEPTEMBER 17, 1948"
TEST\$ = "TESTING, 1, 2, 3."

The Commodore 64 sees the string labels as the first two characters *and* the dollar sign:

NA\$ = "BOB EBBS"
DA\$ = "SEPTEMBER 17, 1948"
TE\$ = "TESTING 1, 2, 3."

In a previous example, the *value* 70 was assigned to the label, TEST NUMBER. Would this conflict with the use of the label, TEST\$, for a *string*?

TEST NUMBER = 70
TEST\$ = "TESTING 1, 2, 3."

No, there is no conflict, since these are *two different types of information*, and the computer sees the label, TE, identifying a value and a different label, TE\$, identifying the string.

TE = 70
TE\$ = "TESTING 1, 2, 3."

Note that string labels always end with a dollar sign. This information tells the computer that your string is simply a collection of characters and not a value, even though numbers may be used quite properly in a string of characters, as shown. (NOTE: The closing quote mark at the end of a string is not required, but we think it makes good sense to use it. The closing quote mark clearly shows where the string ends. We will use both quotes throughout this book.) Here are some examples of labels and the information assigned to them. Can you tell which ones are in the proper form, and which ones are not?

- (a) SAMPLE = 34.8972
- (b) GUN = "M-16 RIFLE
- (c) NUMBER OF NAMES = 45
- (d) CITY\$ = "HAMILTON"
- (e) LENGTH = 12
- (f) TIME\$ = ONE O'CLOCK
- (g) DOLLARS = ONE
- (h) DIRECTION = "ONE WAY"

Here are the answers:

- (a) Correct.
- (b) Incorrect. The label, GUN, needs to be GUN\$, and we recommend a quote mark at the end of the string: GUN\$ = "M-16 RIFLE"
- (c) Correct.
- (d) Correct.
- (e) Correct.
- (f) Incorrect. The ONE O'CLOCK must be put in quotes to be a string: TIME\$ = "ONE O'CLOCK"
- (g) Incorrect. It's hard to tell if it's supposed to be DOLLARS = 1 or DOLLARS\$ = "ONE"
- (h) Incorrect. The DIRECTION label needs a dollar sign at the end: DIRECTION\$ = "ONE WAY"

Experiment No. 2-5. Inputting Strings

If the Commodore 64 computer is to work with strings, there must be some way to input them. In this experiment, you'll see how labels for strings can be used in INPUT commands.

You can use the computer to input strings of characters in place of values. All you have to do is use a label for a string in the INPUT command in place of a label for a value. This tells the computer what type of information is to be typed in from the keyboard. Type in the following program:

```
10 INPUT TY$
20 PRINT TY$
```

You now have the label TY\$ set up to identify the *string* that is to be input by the INPUT TY\$ command at line 10. The PRINT command at line 20 uses this label to locate the string to be printed on the TV screen. The dollar sign at the end clearly identifies the string type of label.

Clear the screen and run the program. When the question mark and flashing cursor appear, type in:

COMPUTER FUN

Did you forget to press the RETURN key after typing COMPUTER FUN? If so, press it now. What does the computer print on the TV screen? You should see this on your screen:

```
RUN
? COMPUTER FUN
COMPUTER FUN
```

READY.

II

Run the program again and type in another short string of your own. Is it displayed on the TV screen? It should be.

Run the program again and type in the numbers 12345. What is displayed on the TV screen? Did you expect an error message or a REDO message because you typed a number? The computer simply displays 12345. There is no error message, nor a REDO message, because the computer simply treats 12345 as a string of five characters, which just happen to be digits. We used the string "September 17, 1948" in one of our examples earlier in this chapter. The date has no "value," it's just a string of characters to the computer. This means that you must distinguish between strings and values when you use labels in your programs.

Experiment No. 2-6. Mixed Labels

The Commodore 64 computer can input and use strings and values in the same program. The proper labels are all that are needed. Type the following program into your computer:

```
10 INPUT XP
20 INPUT TR$
30 PRINT TR$
40 PRINT XP
```

Run the program. When the first question mark appears, type in a value. When the second question mark appears, type in your last name. What happens when you press the RETURN key after typing in your name? The computer prints your name and then it prints the value you typed. The computer was able to label each piece of information so it could use it later. The type of label used

lets the computer tell whether it is to work with a value or a string. Change lines 20 and 30 to:

```
20 INPUT XP$
30 PRINT XP$
```

The complete program should now look like this:

```
10 INPUT XP
20 INPUT XP$
30 PRINT XP$
40 PRINT XP
```

Run the program and again type in a value after the first question mark, and then a string of five or six letters after the second question mark. Are the string and the value displayed as you expected? They should be. To the Commodore 64, XP and XP\$ are two *different* labels, one for a string (XP\$), and the other for a value (XP).

If you were trying to use the computer, it would be very difficult to know when to type in a value and when to type in a string in response to the question mark and flashing cursor. Now you'll learn how programs can be made easier to use.

INTELLIGENT QUESTIONS AND ANSWERS

In the previous program examples and experiments, you used simple programs that input information from the keyboard and then displayed it on the TV screen. When the computer was waiting for you to input information, it displayed a question mark and the flashing cursor:

? █

When you see this on the TV screen, there's no way of knowing what the computer is waiting for. Maybe it needs your name (a string), or perhaps it's waiting for your bank account total (a value); who knows? Imagine that a friend has sent you a check-account program to run on your Commodore 64. Your friend promises that the program will quickly and painlessly balance your checkbook. This sounds great. You type in the long program and run it. The computer responds with the ? █ display. What's next, the number of checks, the starting balance, or something else? You would need a complete instruction book just to run the checkbook program.

To help you use the computer, you can put special messages in

the INPUT and PRINT commands, along with the usual labels for values and strings. These messages will be displayed on the TV screen when the computer is doing INPUT and PRINT commands so that you'll know what you are to type in, and what is being "printed" on the TV screen. When messages are used, you can get this type of display on the TV screen:

```
POUNDS OF CLAMS CAUGHT TODAY? 480
COST PER POUND IN DOLLARS? 3.40
GROSS INCOME = $ 1632
YOUR WEEKLY CATCH = 1257 POUNDS
```

This display is much more meaningful than seeing the following on the TV screen:

```
? 480
? 3.40
1632
1257
```

It is much easier to see what is happening in the first example. Someone has caught 480 pounds of clams and sold them for \$3.40 per pound. The gross income was \$1632. The computer program is also keeping track of the weekly total catch. In the second example, the same information is typed in, processed, and displayed, but without the messages the user doesn't know what the computer is requesting or displaying.

It is easy to "build in" messages in INPUT and PRINT commands, so that "questions" are asked, or "answers" are printed. Here are some examples of how the computer can be programmed to provide this extra information:

```
INPUT "TYPE A STRING"; TYS
PRINT "EGGS SOLD = " EGGS
INPUT "NUMBER OF STUDENTS"; NS
PRINT "NAME FOUND IS " NAMES
```

In each of these examples, a message has been put into the command. These messages are enclosed in quotes, and they have absolutely no effect on the INPUT or PRINT operations. The computer simply puts the information between the quote marks on the TV screen as an aid. You can put almost anything you want in these messages to make the computer easier to use.

There are just a few things to remember when these types of messages are to be used. First, *the message must be placed*

between quote marks. Second, for INPUT commands, there must be a semicolon (;) between the message and the label. A semicolon is not used for the PRINT commands. The INPUT and PRINT commands shown above with messages in them follow these rules.

Let's look at an example. If the following INPUT command is used in a program:

```
INPUT "TYPE YOUR NAME"; NAME$
```

the computer will print, TYPE YOUR NAME, on the TV screen as part of the keyboard input process. Now, you know what you are supposed to type in when you see the flashing cursor on the screen. In fact, it will look like this:

```
TYPE YOUR NAME? █
```

The question mark is placed right after NAME, and the cursor shows you that the computer is ready to accept information from the keyboard. Using the messages in INPUT commands certainly makes the computer easier to use. The same thing can be said for the PRINT commands, since messages are used to tell you what is being displayed on the screen.

You can also put messages in PRINT commands by themselves. They are used simply to print information on the TV screen. No labels are used with these PRINT commands, since they don't print anything but the "message." Here is an example:

```
100 PRINT "CHECK ACCOUNT PROGRAM"  
120 PRINT "COPYRIGHT 1984"  
140 PRINT "ELIZABETH SCOTT"
```

If these lines are used in a program, they will print the information between the quotes on the TV screen to identify the program and its author. In the TYPE YOUR NAME example shown previously, you might want to remind the user to press the RETURN key when typing information. You could put a message in several PRINT commands to print this reminder on the screen at the start of the program:

```
10 PRINT "WHEN ENTERING YOUR INFORMATION"  
20 PRINT "TO THE COMPUTER, DON'T FORGET TO"  
30 PRINT "PRESS THE RETURN KEY WHEN YOU"  
40 PRINT "ARE FINISHED."
```

You can also print other things, such as:

```
100 PRINT "*****"  
120 PRINT "* TEST PROGRAM *"  
140 PRINT "*****"
```

In later chapters, we will tell you about some of the other interesting things that you can do with the PRINT commands.

Experiment No. 2-7. Printing Messages

Since messages are helpful to computer users, they are important parts of almost every computer program. Now you will see how they can be used in a practical program. Type in the following program and use the LIST command to check it:

```
10 PRINT "STRING INPUT TEST"  
20 INPUT "TYPE YOUR NAME"; NAME$  
30 PRINT "SO YOU'RE " NAME$
```

Leave a space between the E in YOU'RE and the last quote mark in line 30. Now run the program. Don't forget to press the RETURN key after typing your name. What is displayed on the TV screen? You should see something like this:

```
STRING INPUT TEST  
TYPE YOUR NAME? JIMMY  
SO YOU'RE JIMMY
```

READY.

Change line 30 to:

```
30 PRINT "SO YOU'RE" NAME$
```

Be sure that the closing quote mark comes right after the E in YOU'RE. Run the program and type in a name. What does the display look like? It should look something like this:

```
SO YOU'REJIMMY
```

The extra space at the end of YOU'RE in the message is used to space the message and the string. You can use extra spaces to center and align information in the messages on the TV screen.

The use of messages in PRINT and INPUT commands makes programs meaningful and easy to use. Without using messages, it is almost impossible to know what you are supposed to do with a program, or how to use it. In the programs that will be discussed

and developed in the following chapters, you'll see that messages are used extensively.

CONCLUSION

You have seen quite a bit of new information about computers in this chapter, particularly if this is your first time using a small computer. You have seen that computers can process information and transfer it in and out. The Commodore 64 computer can process both values and strings, and in this chapter you saw how labels can be used to identify information that the computer is to use. Labels were used to distinguish between actual values to be processed and strings of characters.

Although no information was "processed" in any of the experiments, you learned how INPUT and PRINT commands can be used to tell the computer to get information from the keyboard and to display, or print, it on the TV screen. You also found that the Commodore 64 uses only the first two letters in a label, and that it can be confused by labels such as BEACH and BEETS, since the first two letters are the same. In the last section, you found that the INPUT and PRINT commands can be expanded to include messages that can be printed on the TV screen so that the input and output processes give the user guides as to what is happening.

In the next chapter, we will introduce you to the actual processing of information within the computer, and we will also tell you how you can control the operation of the computer. Some new keyboard operations will be introduced, too.

QUESTIONS

Here are some questions that you can answer to check your understanding of the ideas presented in this chapter. The answers are provided in the back of the book.

1. What types of information can be used with the Commodore 64?
2. What are the two general types of operations that all computers perform?

3. Which of the following would be considered valid labels for information in the Commodore 64 computer?

LABEL	\$LABEL	DO NUTS	SPAGHETTI
TYPES\$	3 1 S T		
	STREET	A1TESTS	EGGS\$
CHT\$	SPEND\$	3STATE\$	SPELLER

4. If the valid labels in the above list were all used in one computer program, would there be any conflicts? If there are conflicts, what are they?

5. Find the errors in the following labels or information. What are they?

- (a) TEST = \$56
- (b) TIME = "TEN OF FIVE"\$
- (c) TM = 56.89
- (d) LINK\$ = NUMBER OF TESTS
- (e) SEEDS = 78
- (f) LINES = "10 LINES PER INCH

6. The following PRINT and INPUT commands have messages in them. Which ones are incorrect? What is wrong with them?

- (a) INPUT "YOUR NAME, PLEASE", NAME\$
- (b) PRINT "TEST RESULTS
- (c) PRINT "BALANCE IN ACCT ="; BAL
- (d) INPUT " TODAY'S SPECIAL "
- (e) INPUT "ENTER THE YEAR"; YR\$
- (f) PRINT "THIS IS A COMMODORE 64"

7. If you type in a program line with the wrong line number, how do you "erase" it from your program?
8. If you make an error typing in a line in your program, how can you correct it?
9. Describe how you start a program once it has been typed into the computer.
10. Describe how to list a program that is already in your computer.

FOOD FOR THOUGHT

The following are provided as things to think about. You may not know the answers, but you can try and think out a logical answer for each. You can also try and run programs on the computer to see what happens.

1. If you run the following programs, what will happen?

(a) 10 INPUT NAMES\$
20 PRINT NA

(b) 10 PRINT NA
20 INPUT NA

(c) 10 PRINT NA
20 INPUT NAMES\$

```
(d) 10 INPUT "TEST VALUE"; VLU
     20 PRINT VLU
     30 PRINT VLU
     40 PRINT "      " VLU
```

2. If the labels TEAM SPORTS, TEAMS, and TEETH\$ are all used in a program, will there be any conflicts? Between which ones? Why?

CHAPTER 3

NUMBER CRUNCHING

In the previous chapter you learned how the computer keeps track of information by assigning labels to it. You also learned that the Commodore 64 computer can operate on numbers, or values, as well as work with strings of characters. In this chapter, we will concentrate on how the computer uses values, and you'll see how to make the computer do simple arithmetic operations such as addition and subtraction. You will also find out how the computer can do several things at once, and how programs can be made more efficient.

SIMPLE ARITHMETIC

The Commodore 64 can do many interesting things with numbers, but in this chapter, we'll concentrate on the simplest arithmetic or math operations: addition, subtraction, multiplication, and division. Your Commodore 64 can do many other complicated things with numbers and values, but we'll leave these for later. The four simple operations are a good place to start.

The four basic math operations are very common and we use them frequently without even thinking about them. You can quickly add a few prices to see if you have enough money, and you can multiply the kids at a birthday party by the cookies each will

eat to see if you have enough. Even though you don't think about it, you're doing simple, and even complicated, math in your head.

Unfortunately, a computer can't just run off a simple calculation without first having been "told" exactly what to do. This is called "programming" the computer, since you set up a step-by-step program of things for it to do. Computers don't know anything about the cost of groceries or how many cookies kids eat at parties, so every piece of needed information must be put into the computer right at the start.

SETTING UP THE PROBLEM

Here are a few examples that show how simple math problems can be set up. You can probably think of many others:

$$\begin{array}{r} 235 \\ + 68 \\ \hline \end{array} \quad \begin{array}{r} 290 \\ - 79 \\ \hline \end{array} \quad \begin{array}{r} 30 \\ \times 9 \\ \hline \end{array} \quad \begin{array}{r} 4782 \\ 71 \\ \hline \end{array}$$

In these problems, the two values are put one over the other, but you could just as easily have written them on a line like this:

$$235+68 = ? \quad 290-79 = ? \quad 30 \times 9 = ? \quad 4782 / 71 = ?$$

It may not be easy for you to solve the second set of problems in your head, or on paper, since the columns of digits aren't lined up.

In the Commodore 64, math problems are set up in almost the same way, but there are two slight differences: (1) a label is used to identify the "answer," and (2) the problems are "reversed," with the label for the answer on the left side. Here's an example:

$$\text{SUM} = 43+3421$$

When the computer finishes this addition problem, it gives the label "SUM" to the answer, which is 3464. Remember that the word used as the label, SUM, is not equal to 3464. The computer simply needs a label so it can identify the answer if you want to use it sometime later. There is nothing special about the label, SUM. You can choose almost any label you like: ANSWER, RESULT, Q9, or something else. Remember, the Commodore 64 uses only the first two letters, or letter and number, in a label.

Now that you have a way of identifying the answer from the simple addition problem, what can you do with it? Why don't we use the computer to display the answer on the TV screen? A PRINT command can be used to do this, and you probably remember from Chapter 2 that it would look something like this:

PRINT SUM

By using both a math and a PRINT operation, you can put together a simple program for the Commodore 64. Here it is:

```
50 SUM = 43+3421
60 PRINT SUM
```

Remember that line numbers are *always* used in BASIC programs for the Commodore 64.

A NEW OPERATION

Before you do the first experiment in this chapter, we want you to know about a *new* command that will save you time when you want to clear the computer and get it ready for a new experiment or program. In a few of the experiments, you were told to turn your computer off and to turn it back on again. This “wiped out,” or erased, old programs, clearing the computer so a new program can be typed in and used. Whenever the computer’s power is turned off, your BASIC-language programs are lost. Although this is a way of clearing the computer for new programs, it isn’t really practical.

You can clear the computer for a new program by typing the word “NEW” and pressing the RETURN key, [RETURN]. The NEW command completely clears the computer, erasing all traces of your program. Although it doesn’t happen very often, if you accidentally type in the NEW command, you’ll have to retype your program.

Experiment No. 3-1. A Simple Math Program

This experiment will show you how a simple math problem can be set up and programmed into your Commodore 64 computer. You’ll also run the program to see what it does. This experiment will help break down some of the mystery of how computers are programmed.

With the computer turned on, type NEW [RETURN]. What happens? The computer just responds with the READY message to let you know that it is ready for your next command, or for a new program. Type in the following short program. The plus sign is in the upper row of keys, near the right side of the keyboard.

```
50 SUM = 1590+398
60 PRINT SUM
```

List the program on the TV screen to be sure that you have typed it correctly. Just type the word LIST and press the RETURN key. If there are any errors in your program, retype the corrected lines. Don't forget to press the RETURN key at the end of each line.

Now run the program. (Remember, you just type the word RUN and press the RETURN key.) What is displayed on your TV screen? If you listed the program to check it, and then ran it, you will see something like this:

LIST

```
50 SUM = 1590+398
60 PRINT SUM
READY.
RUN
1988
```

The result of the addition should be displayed on the TV screen (1988). Is this what you found? If your program is working properly, the result should be displayed. List your program again to be sure it's still in the computer. Now, type NEW [RETURN]. What is displayed when you list the program again? The program is no longer in the computer, since the NEW command told the computer to "erase" it and get ready for a *new* program. Use the NEW command whenever you need to completely "erase" old programs, or when you're told to clear the computer for a new experiment.

Experiment No. 3-2. More Math Fun

The program in this experiment will show you how the other three math operations can be used to do a subtraction, a multiplication, and a division problem. Type NEW [RETURN] to clear the computer for this experiment. Type the following program into your computer. It is the same kind of program you used in the previous experiment.

```
50 QX = 1590+398
60 PRINT QX
```

Use the LIST operation to list the program on the TV screen so you can check it to be sure it is correct. How would you substitute this subtraction problem for the addition problem used in the program?

```
371-83 = ?
```

The following program line could be used:

```
50 QX = 371-83
```

The same label, QX, is used, even though a subtraction is being done. This means that the label can be almost anything you choose. You might have chosen another label, for example, CT:

```
50 CT = 371-83
```

but you would have to change the PRINT part of the program so that it uses the same label, too. Just continue to use QX as your label, since it saves time.

Put the following program line in your program. Just type it in. It will replace the "old" line 50 in the program:

```
50 QX = 371-83
```

Run the program. Is the correct answer displayed? What is it? The correct answer, 288, should be displayed on the TV screen. Now put the following program line in your program:

```
50 ZIP = 371-83
```

What do you think will happen if you run the program now? Go ahead and run the program and see what is displayed on the screen. Is this what you expected? The answer displayed is zero. Is that the result of 371-83? Something must be wrong. List your program and check it. It should look like this:

```
50 ZIP = 371-83
```

```
60 PRINT QX
```

In this program, the result of the subtraction is labeled ZIP, while the PRINT command prints the value that has been labeled QX. Two *different* labels are used, one for the subtraction and one for the PRINT command. When you tell the Commodore 64 to RUN a program, it first clears all the labels to zero. Since QX hasn't had a new value assigned to it, the PRINT QX command at line 60 just prints the zero on the TV screen. To correct the program, simply type in:

```
60 PRINT ZIP
```

Now run the program. Is the answer from the subtraction displayed correctly? It should be. Now change program line 60 back to:

60 PRINT QX

and continue with the experiment.

Let's try multiplication and division. The computer uses a slash mark (/) for division and an asterisk (*) for multiplication. Try to write a two-line program to solve each of the following problems, one at a time. Use the label QX for the answer to each problem.

360/15 (Answer: 24)

34*56 (Answer: 1904)

The following programs can be used, one at a time. For the division problem, you would use:

```
50 QX = 360/15
```

```
60 PRINT QX
```

And for the multiplication problem, you would use:

```
50 QX = 34*56
```

```
60 PRINT QX
```

Suppose that you wanted the computer to solve a different multiplication problem. How would you get the new numbers into the program so that the computer could use them? Right now, the only way would be to put new instructions at line 50 in the program. For example, if you wanted to multiply 58 by 1295, you would have to change line 50 to:

```
50 QX = 58*1295
```

and you would have to run the program again to get the answer displayed on the TV screen.

As you saw in these experiments, getting the computer to do simple math problems isn't difficult, and the computer can do them quickly. However, it is going to be difficult to use the computer if you have to change the *program* whenever you want to do a math operation with new values. Can you think of a way to get around this?

USING LABELS IN MATH PROBLEMS

You may not remember it, but two values were multiplied in one of the examples in Chapter 2. Here is how the multiplication looked:

```
EGGS = AMOUNT PER CARTON*CARTONS
```


In this example, *labels* have been used instead of the actual values. The computer is being told to get the value labeled AMOUNT PER CARTON and multiply it by the value labeled CARTONS. When the values have been multiplied, the computer labels the answer EGGS.

No matter what, *the number of eggs will always be found by multiplying the number in each carton by the number of cartons.* Even though the numbers may change from day to day, the problem is always solved the same way. All of the math operations can use labels this way. In the following examples, the problems stay the same, but different values can be used:

MONEY = SAVINGS+CHECKING
PAY = WAGE-TAXES
DAYS = HOURS/HRS PER DAY
COST = CAKES*PRICE PER CAKE

In each of these examples, the labels were chosen with care so that there would not be conflicts between the first two letters in each label. Remember that the Commodore 64 only "sees" or uses the first two letters in a label. So, the preceding examples are actually "seen" by the computer as:

MO = SA+CH
PA = WA-TA
DA = HO/HR
CO = CA*PR

When you use labels in a problem, you face another job. How do you get your values into the computer so the problem can be solved? The INPUT command is used in the program to "ask" for these values, so they can be typed in from the keyboard.

GETTING YOUR VALUES — THE INPUT COMMAND

It is easy to use the INPUT command to "ask" for values from the keyboard. Now a simple multiplication program can be set up, and it looks like this:

```
30 INPUT A
40 INPUT B
50 ANS = A*B
60 PRINT ANS
```

The two numbers are input at lines 30 and 40. One is labeled A

and the other is labeled B. These values are multiplied at line 50, and the answer, ANS, is printed on the TV screen by the PRINT command at line 60. Here's what it looks like when it is run:

```
RUN
? 34
? 12
408
```

READY.

This program isn't particularly useful, unless you just want to sit and fool with the computer. Here is a useful program that uses a multiplication operation:

```
30 INPUT HOURS
40 INPUT WAGE
50 PAY = HOURS*WAGE
60 PRINT PAY
```

When you run this program and type in two values, it looks like this on the TV screen:

```
RUN
? 34
? 12
408
```

READY.

You can probably see that *the two sample programs do exactly the same thing*: input two numbers, multiply them, and display the answer. The only difference is that in the second example, meaningful labels have been used so you can see what is being calculated. However, the *computer programmer* is the only one who sees these labels; the *computer user* doesn't. It would be much more meaningful to use "messages" in the INPUT and PRINT commands so that the information to be input and displayed is meaningful to the *operator*. Here is a better program:

```
30 INPUT "HOURS WORKED"; HOURS
40 INPUT "HOURLY WAGE"; WAGE
50 PAY = HOURS*WAGE
60 PRINT "WEEKLY PAY IS $"PAY
```

If you run this program, here's what is displayed on the TV screen:

```
RUN
HOURS WORKED? 40
HOURLY WAGE? 5.50
WEEKLY PAY IS $ 220
```

```
READY.
```

Experiment No. 3-3. Your Calculator

Although you won't be writing long programs in this book, you will see how to write a simple one in this experiment. It is a math program that will add, subtract, multiply, and divide two numbers, all at the same time. At least it will seem to be happening at the same time. Type `NEW` and `[RETURN]` to clear the computer for this experiment.

Two numbers are to be input to the computer. The first number typed in will be labeled `A` and the second number typed in will be labeled `B`. Use `INPUT` commands and "messages" to get the user to type in the two values from the keyboard. Write your program lines below, starting with line 10:

10 _____

20 _____

What do your program lines look like? They should look something like this, but the messages you put between the quote marks may be different:

```
10 INPUT "FIRST NUMBER"; A
20 INPUT "SECOND NUMBER"; B
```

Now write four program lines to calculate the following:

$S = A + B$, $T = A - B$, $Q = A * B$ and $R = A / B$.

30 _____

40 _____

50 _____

60 _____

Your program lines should look like this, although they may be in a different sequence:

```
30 S = A+B
40 T = A-B
50 Q = A*B
60 R = A/B
```

Now, write four more program lines to print the results. Use "messages" so that the user will know which operation was performed:

```
70 _____
80 _____
90 _____
100 _____
```

Your complete program should now look like this:

```
10 INPUT "FIRST NUMBER"; A
20 INPUT "SECOND NUMBER"; B
30 S = A+B
40 T = A-B
50 Q = A*B
60 R = A/B
70 PRINT "A+B = " S
80 PRINT "A-B = " T
90 PRINT "A*B = " Q
100 PRINT "A/B = " R
```

Check the program lines you wrote in the spaces provided and make any corrections needed. Now type in your program, list it on the TV screen, and correct any errors. You may use any meaningful messages you like between the quotes.

Run your program and check to see if it operates as you would expect. You may want to use a calculator to check the results quickly.

In this experiment, you wrote a simple program to do math with two numbers. Although the program wasn't too complicated, it did show you several things:

1. The computer can do math operations quickly.

2. You can type in numbers from the keyboard using an INPUT command and a label.
3. Problems can be set up using labels.
4. Messages are useful in telling the user what is to be typed in or what has been displayed.
5. Programs can be easy to write.

ONE LINE FOR MANY

In the math experiments and examples, a program line was used for each operation. Sometimes it is easier to write all of these operations on a single program line with a single line number. This can simplify a program and, in some cases, make it more efficient. You can put several operations on a single line, separating them with a colon (:). The Commodore 64 "sees" the colon as separating each of the operations, so it does each one in turn, from left to right. You will probably see programs that use this technique. Here are some examples:

```
100 RATE = MILES/HRS : PRINT RATE
75 S=TR+QW: INPUT "VALUE";VA : QX = VA + S
```

In the first example, two operations, a division and a print, were put in a single line. In the second example, three operations were put in a line. Extra spaces have been used in these examples so you can clearly see the positions of the colons. Some programmers try and squash everything into as little space as possible, writing a program line like this:

```
75S=TR+QW:INPUT"VALUE";VA:QW=VA+S
```

Not very easy to read, is it? The use of colons sometimes makes programming a bit easier, but it may be difficult to make simple changes in long program lines. There are some special keyboard operations that you can use to change program lines, and you'll read about them shortly.

Experiment No. 3-4. More on a Line

This is a short experiment to show you how colons are used in program lines. You will be able to put several operations on a single program line.

Type in NEW [RETURN] to clear out any remaining programs or program lines. You can use the LIST operation to be sure that

the computer has been "cleaned-out" for your new program. Type in the following program:

```
10 INPUT AZ
20 DX = AZ * 80
30 PRINT DX
```

To keep the program simple, no messages are used in the INPUT or PRINT commands. List the program and check it to be sure that it has been correctly typed in. When you are sure it has been typed in correctly, run the program. What does it do? Does it operate properly? The program multiplies the value you type in by 80 and displays the result. Can you suggest how the complete program could be put on a single line? Use the space provided:

```
10 _____
```

The following program line will work properly:

```
10 INPUT AZ : DX = AZ*80 : PRINT DX
```

Type NEW [RETURN] to clear the computer for this one-line program, and then type in this program line. Run this one-line program. Does it give the same results as the three-line program you used earlier in the experiment? It should, since the same things are being done.

Sometimes when fairly long program lines are used, they will "wrap around," continuing on the following line. For example, if the following program line is used in a Commodore 64 program:

```
1000 PRINT "TEST PROGRAM" : INPUT "FIRST VALUE";
FV
```

it will look like this when the program is listed on your TV screen:

```
1000 PRINT "TEST PROGRAM" : INPUT "FIRST
VALUE"; FV
```

At first, this may look confusing, but the second line is just a continuation of the first, since each line on the TV screen can only hold 40 characters. Just look for the line numbers on the left side of the screen, since they will show you where each program line starts.

As you read this book, you will find a few programs in which several operations are combined on a single line, using colons to separate each one. If these program lines have more than 40 characters

in them, they will simply “end” at the right side of the screen and continue on the line below.

DOING MORE THAN ONE THING AT A TIME

In many programs, the computer does only one math operation per line. There are times when it is useful to *combine* operations so that several are done at the same time. This means that several operations can be “bundled” into one. When the computer is doing many things, this type of “bundling” saves computer time. Here is an example:

In the egg problem described before, the number of eggs sold was simply the number of cartons sold times the number of eggs in each carton. That’s pretty simple, but let’s assume that some eggs are also sold from a basket where customers can help themselves. Now we have to figure out the number of eggs sold in cartons and then add in the loose eggs sold from the basket. It can be done like this:

```
EC = EGGS PER CARTON*CARTONS SOLD
EL = LOOSE EGGS SOLD
TOTAL = EC + EL
```

In this example, EC labels the eggs sold in cartons, and EL labels the loose eggs sold. The total number sold is just EC plus EL. The multiplication and addition operations could be put on a single program line and separated by a colon, but nothing much is gained. It would be better if the operations could be combined. Let’s try using some numbers in this problem so we can see what is happening.

Here’s the problem:

```
TOTAL = EGGS PER CARTON*CARTONS SOLD + LOOSE EGGS
SOLD
TOTAL = 12      *      3      +      4
```

When the math operations are shown this way, it’s a bit confusing, since we don’t know which operation should be done first. Does the computer first multiply 12 and 3 and then add 4, or does it add 3 and 4 and then multiply the sum by 12?

```
TOTAL = 12 * 7 = 84
```

or

```
TOTAL = 36 + 4 = 40
```

As you can see, the answers are different, depending on whether the addition or the multiplication is done first. Actually, this doesn't confuse the computer, since it follows two rules when doing math. Here they are:

1. Multiplications and divisions are done first.
2. Subtractions and additions are done next.

This problem can be solved just as it is written, since the EGGS PER CARTON will be multiplied by the CARTONS SOLD and *then* the LOOSE EGGS SOLD will be added in. Different math operations can be separated by using parentheses, and they can help you see what is happening in a complicated math problem. That's the next subject.

USING PARENTHESES IN MATH PROBLEMS

In complex math operations, you can use sets of parentheses to "contain" individual math operations. The egg example can be written as:

$$\text{TOTAL} = \text{EG} * \text{CA} + \text{EL}$$

or as:

$$\text{TOTAL} = (\text{EG} * \text{CA}) + \text{EL}$$

In this problem, the computer first does the math operation enclosed in the parentheses, then it does the other operation. When parentheses are used, there is no doubt about which operation is done first.

You will see parentheses used frequently in BASIC computer programs. Just remember that the "problem" in the inner set of parentheses is solved first. After that has been solved, the computer moves outward, solving the "problem" placed between the next set of parentheses, and so on. Here's an example of how parentheses are used:

$$? = (3 + ((9*4) / 12))$$

Go to the inside set of parentheses and multiply 9 and 4, which is 36. Remove the parentheses surrounding this part of the problem and you have:

$$? = (3 + (36 / 12))$$

Now go to the inside set of parentheses and divide 36 by 12,

which is 3. Remove the parentheses surrounding this part of the problem and you have:

$$? = (3 + 3)$$

Just add 3 and 3, and you've solved the problem.

If you look at a problem that uses parentheses, how can you tell which set is the inner set? Let's look at the problem that we just went through:

$$? = (3 + ((9*4) / 12))$$

Use your finger or a pencil as a marker and move it from left to right across the problem line. Look at the parentheses as they pass your pointer. We've left out the math operations, but you'll first pass three parentheses that look like this: (((. When you reach one that curves in the opposite direction: (((9*4), you've reached the right side of the inner set. Solve the 9*4 problem between this set of parentheses. You can now "erase" or mark-off this inner set of parentheses and start over again looking for another "inner" set of parentheses. Just continue to do this until all the parentheses have been removed. Then, the problem has been solved.

This may sound complicated, but you can see in the example in Fig. 3-1 that it's not difficult to "break down" the parentheses so

$$\begin{aligned} & ((8 + (((8 \cdot 6) + 12) / 5)) \cdot 6) = ? \\ & ((8 + ((\underbrace{48 + 12}_{60}) / 5)) \cdot 6) = ? \\ & ((8 + (\underbrace{60 / 5}_{12})) \cdot 6) = ? \\ & ((\underbrace{8 + 12}_{20}) \cdot 6) = ? \\ & (\underbrace{20 \cdot 6}_{120}) = ? \end{aligned}$$

Fig. 3-1. Breaking down parentheses in a math problem.

that the problem can be solved. In this example, only five steps were needed to get the answer.

Use paper and pencil to figure out the answers to each of the sample problems shown below:

$$A = (9 + (5*3))$$

$$B = ((6 / 2)*12)$$

$$C = ((4*5) + 4)/3$$

$$D = (((5*8)/4) + 10)*5$$

Here are the answers. $A = 24$, $B = 36$, $C = 8$, $D = 100$. You can check your answers on the Commodore 64 by simply typing in:

```
PRINT (9 + (5*3)) [RETURN]
```

and so on for the other problems. This is using the Commodore 64 as a *calculator* and it lets you do simple math problems quickly. You DO NOT use a line number, so the problem is not saved in the computer for later use. It is solved immediately for you. Use the Commodore 64 as a calculator and check your answers to the preceding problems. You should get $A = 24$, $B = 36$, $C = 8$, and $D = 100$. Of course, the Commodore 64 won't print the "A =" part of the answer, it just displays the value of the answer.

WHAT'S GOING ON HERE?

Although there are more interesting things to learn about in this chapter, we want to tell you about a few things that will make your programming or computer-using experiences better. If you write computer programs, you need to keep track of what you do. We recommend that you buy and use a spiral-bound notebook in which you can write all of your programs, what goes wrong, what works, and so on. Make the notebook readable, so you can go back and see what you've done and where you are, when you're working on a program. Even when you are using programs prepared by others, take notes about problems, times when the program wouldn't run, interesting results, and so on. Notes are important, and keeping them in one place will be helpful.

Good programmers also put helpful notes and comments right in their programs. The computer ignores these remarks and doesn't even "know" they are there. When you *run* a program that contains this information, it is not printed on the TV screen, and can only be read when listing a program on the TV or printer. If you decide to go back and work on a program sometime later, remarks can be useful in telling you what you've done. It is often difficult enough to remember why you did something in a program, but without the frequent use of remarks, it's almost impossible to reconstruct your "trail."

To put remarks in your programs, you simply type in a line number where you want the remark to be put, then type in REM, for remark, followed by a line of remarks or comments. You can use as many REM statements in a program as you like. Here are some examples from different programs:

```
290 REM FEBRUARY 1984 VERSION
20 REM TAX CALCULATION PROGRAM
450 REM THIS SETS UP SPECIAL VALUES
```

You can also put remarks in program lines, along with other operations. Just remember to separate the operations with a colon:

```
1090 TX=RT*GS: REM TAX = RATE*GROSS SALES
```

Good programmers make frequent use of REM lines in a program so that other programmers looking at the *program listing* will have a pretty good idea of what is going on. Some of the program examples in this book will use REM commands to tell you what's going on, if it's not explained in the text. We recommend that you use REM comment or remark lines in BASIC-language programs you write.

YOUR EFFICIENT SECRETARY

In past experiments, you were told to make corrections in program lines by simply retyping the entire line. When complex program lines are used, there is a good chance that you will make even more mistakes when trying to correctly retype a line. To help you correct errors or make changes in programs, a special key is included on the keyboard. This is the INST/DEL key that is located in the upper right-hand corner. The INST stands for insert and the DEL stands for delete. You can use this key along with the SHIFT key to make program changes, even in complex program lines.

Rather than tell you how to use the key, we will show you how to use it in the next experiment.

Experiment No. 3-5. The INST/DEL Key

The purpose of this experiment is to have you investigate the use of the INST/DEL key and see how it can be used to make changes in programs.

Turn your computer on. Type in NEW [RETURN] to clear out any old programs and then type in the following program line:

```
10 PRINT " YOU PEST "
```

You should be able to list your programs without help. If your program is incorrect, retype the line and check it again. Run the program and be sure that YOU PEST is displayed on the TV screen.

We now want to change the program so that **YOUR TEST** is displayed when the program is run. To make the changes, first list the program on the TV screen. Then, use the cursor control keys at the bottom right-hand corner of the keyboard to position the cursor so it is right on top of the **E** in **PEST**. This means that the cursor will surround and flash the **E** character on the TV screen. Remember to use the **SHIFT** key with the **CRSR** keys to move the cursor in the directions shown on the top of the two cursor keys. If you have difficulty, just clear the screen and type in **LIST** again, to get a new listing. To clear the screen press/hold the **SHIFT** key and press the **CLR/HOME** key.

When the cursor is at the **E**, press the **DEL** key once. What happens? Press the **DEL** key again. What happens now? When the cursor is positioned at the **E** and the **DEL** key is pressed once, the **P** in **PEST** is removed, and the letters **EST** move one space to the left. When the **DEL** key is pressed again, the space between **YOU** and **EST** is removed, leaving:

```
10 PRINT " YOUEST "
```

Two characters were removed from the line. Remember that the computer "sees" the space as a character, too. The cursor is still at the **E**.

Press the **RETURN** key. Now, clear the screen and list your program again. It should look like this:

```
10 PRINT " YOUEST "
```

Run the program. What is displayed on the TV screen? You should see **YOUEST** displayed.

Can you generally describe what the **DEL** key does? When the **DEL** key is pressed, the character just to its left is "erased," and the character under the cursor and those to its right move one space to the left, taking up the space of the "erased" character. The **DEL** key can be used to erase characters from anywhere in a program line.

When you ran the program, **YOUEST** was displayed on the TV screen. Since you want to display **YOUR TEST**, you need to insert three characters in the message part of the print command: **R**, space, and **T**.

List your program again and use the cursor keys to position the cursor at the **E** in **YOUEST**. The cursor will flash the **E** on the screen when it is in position. You can use the **INST** key and the **SHIFT** key to "open" three spaces in **YOUEST** for the needed

characters. With the cursor positioned at the E, press and hold the SHIFT key and then press the INST/DEL key three times. What happens? When the SHIFT key is pressed and held, spaces are inserted in YOUEST each time the INST/DEL key is pressed. Now YOUEST has become YOU EST. The cursor remains in place, "pushing" the characters under it to the right. Remember, a space is a character, too. The program now looks like this:

```
10 PRINT " YOU  EST "
```

Since the cursor is next to the U in YOU EST, type in an R, a space, and a T. Now press [RETURN]. What does the program look like? It should look like this:

```
10 PRINT " YOUR TEST "
```

Clear the screen and list it to be sure the changes have been made. Then, run it to be sure it prints YOUR TEST as you would like it to.

The insert/delete key (INST/DEL) is very useful in helping you make changes in programs. To make changes, simply list the program and position the cursor where it is needed. To delete characters, simply press the DEL key and the cursor will "erase" characters to its left. *The changes made to a program line with the INST/DEL key only go into effect when you press the RETURN key.*

To make additions, again place the cursor where it's needed and press the INST key as many times as there are characters to be inserted. Remember that the cursor moves the character under it to the right, "opening" spaces for new characters. Remember, too, that spaces are characters.

When changes have been made, remember to press the RETURN key to tell the computer that you have completed the changes. It is a good idea to list the changed program again to check and be sure the changes are as they should be.

You can also use the DEL key as an "eraser" to "back up" the cursor and make changes in a program line as you are typing it. This is useful if you catch a mistake before pressing the RETURN key at the end of a command or program line. Once you press the RETURN key, you'll have to use the cursor and INST/DEL keys to make the correction, or retype the complete line.

For example, you want to list a program and you type LISR instead of LIST. If you catch the error before pressing the RETURN key, you can use the INST/DEL key to back up and

“erase” the R in LISR. You can then type in the T at the end, so LIST is spelled correctly. Press the RETURN key and the program will be listed for you.

It takes a while to get used to the operation of the INST/DEL key. We suggest that you go through this experiment at least one more time so you become familiar with the operation of this useful key. As with the cursor keys, you must use the SHIFT key to cause the INST operation to take place.

QUESTIONS

1. What basic math operations can the Commodore 64 do?
2. What math operations does the Commodore 64 do first, and which does it do second?
3. How many program steps can you put in a single program line?
4. How are individual program steps separated when they are used in a single program line?
5. What are parentheses used for in math program steps?
6. What is the answer to each of the following math operations:
 - (a) $? = 5 * 12 + 4$
 - (b) $? = 3 * 4 + 12 / 5 * 8$
 - (c) $? = (((4 * 6) / 3) + 18) - 7$

7. What does REM stand for and how is it used in a BASIC program?
8. What operation lets you put values into the computer from the keyboard?
9. How does the computer identify information?
10. What does the INST/DEL key do?

PROBLEMS

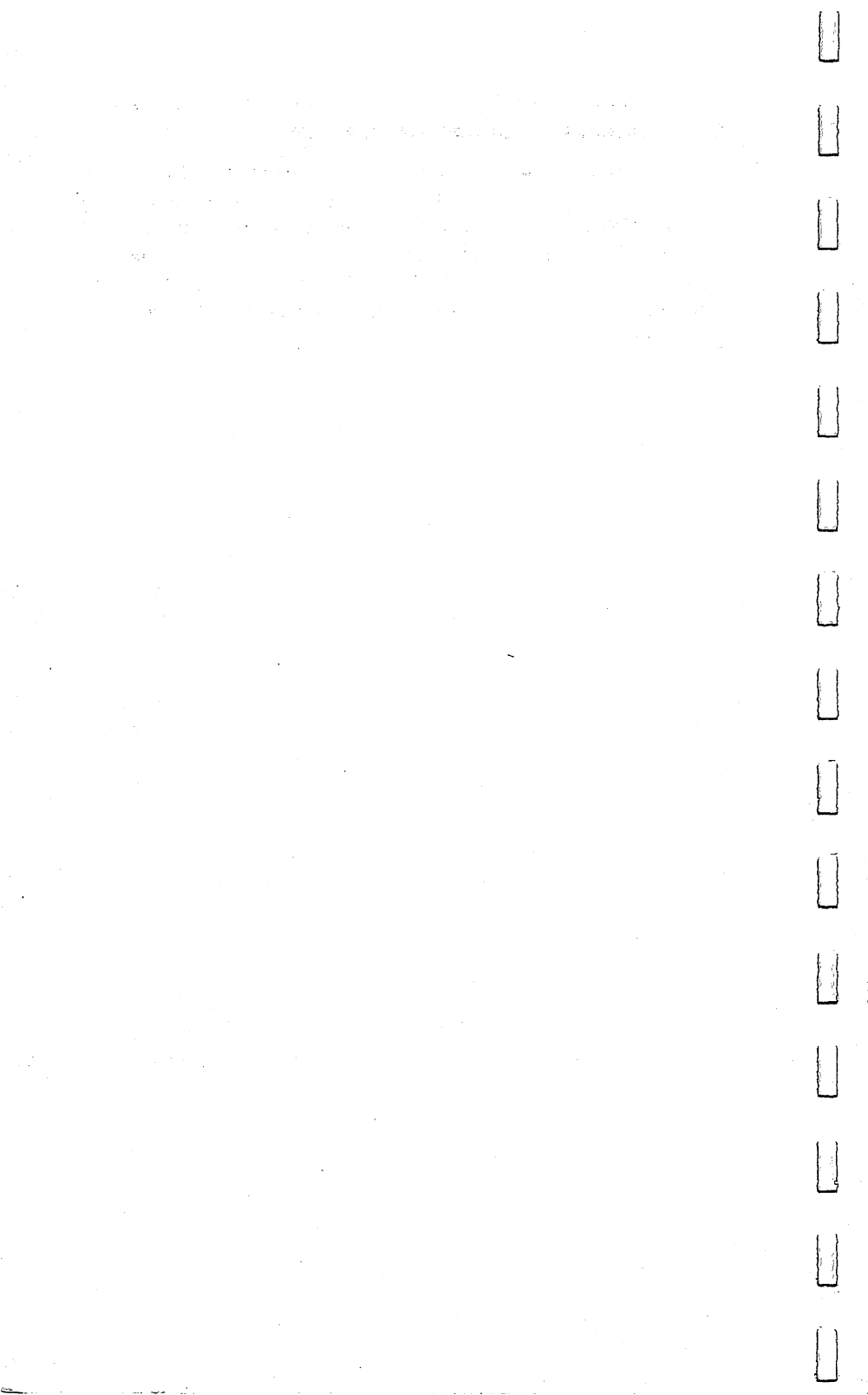
1. Write a program that lets you enter three numbers. The first two numbers are added together and the result is multiplied by the third number. The result is then displayed.
2. Using the formula $C = 5/9*(F - 32)$, write a program that lets you enter a temperature in degrees Fahrenheit (F) and displays the equivalent temperature in degrees Celsius (C). If you enter 68 (F), a 20 (C) should be displayed.
3. Write a program that lets you convert dollars into Swiss francs. Assume that there are 2.5 Swiss francs to the dollar (each franc is worth \$0.40 or 40 cents). You should be able to enter any amount in dollars (such as 5.00) and the equivalent number of Swiss francs (12.5) should be displayed.
4. If the speed of light is 186,000 miles per second, how many seconds are required for light to travel 1 mile? How many seconds are required for light to travel 1 foot (assume that there are 5280 feet in a mile)?
5. If a 3-pound sack of apples costs \$1.29, and a 5-pound bag of apples costs \$2.20, which costs less per pound, the sack or the bag of apples?
6. Write a general-purpose program that lets you enter two prices and two weights for something that you want to purchase, and

have the computer determine the cost per unit of measure, so that you can determine the less expensive item. For example, if a 24-ounce box of detergent costs \$2.29 and a 52-ounce box costs \$4.89, which is the better buy?

7. If a car travels for 2 hours and 20 minutes, and goes 120 miles, what is the average speed of the car in miles/hour? If 3.8 gallons of gasoline were used by the car, how many miles/gallon is the car getting?
8. If 14 aluminum drink cans weigh one pound, and you can sell them at the rate of 5 pounds for \$1.28, how many cans do you need to earn \$10.00?
9. Write a program that lets you enter the number of drink cans that you have, and calculates the amount of money that you will receive, based on the rate of 14 cans/pound, and \$1.28/5 pounds.
10. If a recipe calls for 2 eggs, one cup of milk, and $1\frac{2}{3}$ cups of flour, how much of each ingredient will be required if you have 5 eggs, and you want to use all of them in the recipe?
11. If an acre of land is a square, 208.71 feet on each side, how many square feet are there in an acre? How many acres are there in fields that are 425 feet \times 1023 feet, 500 feet \times 712 feet, and 3028 feet \times 1120 feet?
12. If a farmer has a field in the shape of a circle, and the diameter of the field is 345 feet, how many acres of land are in the field? To calculate the area of a circle, use the formula $0.7854 \cdot D \cdot D$, where D is the diameter of the circle. There are 43,560 square feet per acre.
13. If the shortest day of the year has 7 hours and 20 minutes of sunlight, and the longest day has 14 hours and 52 minutes of sunlight, on the average, how many additional minutes of sunlight do we get each day, as we go from the shortest day (December 21 in the northern hemisphere) to the longest day (June 21 in the northern hemisphere)? Assume that there are 182 days between the shortest and the longest days.
14. A bank pays you 8.5% interest per year on your savings account. Thus, if you had \$100.00 at the beginning of the year, you would have \$108.50 at the end of the year. If you have

\$524.30, how much will you have at the end of the year (assume that no money is withdrawn from the account)?

15. The bank mentioned in Problem 14 has changed its policy so that instead of paying you 8.5% interest each year, it will pay you 8.5/12% interest each month. Assuming that your \$524.30 is in the bank for a year, how much money will you have in your account after a year? If you had your choice of having your interest "compounded" monthly or yearly, which would you prefer?



CHAPTER 4

MAKING DECISIONS

A computer cannot make up its “mind” about anything; it must be programmed by someone to make specific decisions. A computer can, however, make these programmed decisions quickly and choose among many alternatives. When spacecraft landed on Mars, on-board computers made almost instantaneous decisions about firing the rocket engines, where to land, how fast to land, and so on (Fig. 4-1). Of course, the computer didn’t just decide to go to Mars one day; *people* built the lander and programmed the computer to do just what it did.

Your Commodore 64 can be told to do many things, but these must be preset in programs that are no more than lists of instructions. So far, all of the example and experimental programs have been simple. The computer has done some math and it has input and output information, but the programs have not altered the path that the computer took through the program. The computer went from one program line number to the next higher line number, one at a time. This is called a *straight-line* program, as opposed to a *branch* program, both of which are shown in Fig. 4-2.

THE GOTO COMMAND

An easy thing for you to do is to tell the computer to go back and do a task again and again. In a previous chapter, you saw a pro-

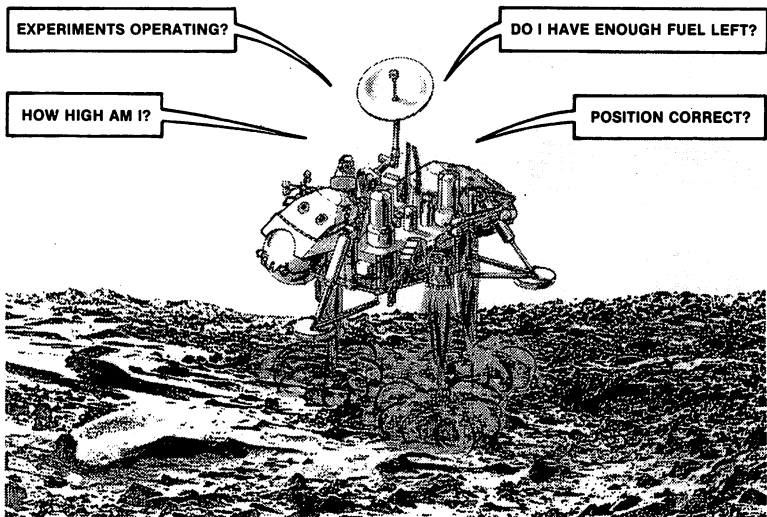


Fig. 4-1. Mars lander makes decisions quickly as it lands.

gram in which two values were multiplied to calculate a person's wage:

```

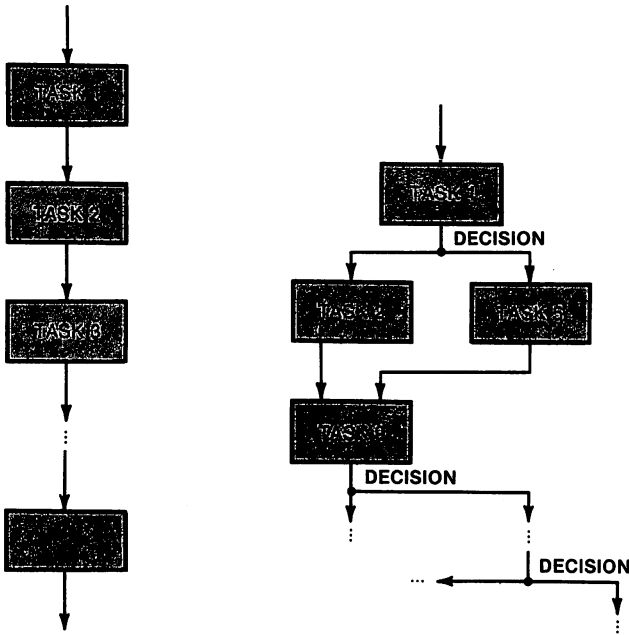
30 INPUT "HOURS WORKED"; HOURS
40 INPUT "HOURLY WAGE"; WAGE
50 PAY = HOURS*WAGE
60 PRINT "YOUR PAY THIS WEEK IS " PAY

```

The program is started by typing RUN. (We'll assume you remember to press the RETURN key, so we won't show it.) When the computer completes the calculation, it displays READY on the TV screen. To get it to run the same program again, for another employee, you would have to type RUN. This can be a bother, particularly if you have people waiting in line to get paid. It would be nice to simply tell the computer, "When you're finished, go back and do it again."

The GOTO command is used to tell the computer to go to a specific place in a program. The example in Fig. 4-3 shows how the GOTO command can be used to direct the computer to a specific line in a program. There are other program lines between the GOTO command at line 350 and the PRINT command at line 1200, but to make the example clearer, they have been left out.

When the computer reaches line 350 and reads the GOTO 1200



(A) Straight-line program.

(B) Branching program.

Fig. 4-2. Comparison of straight-line and branching programs.

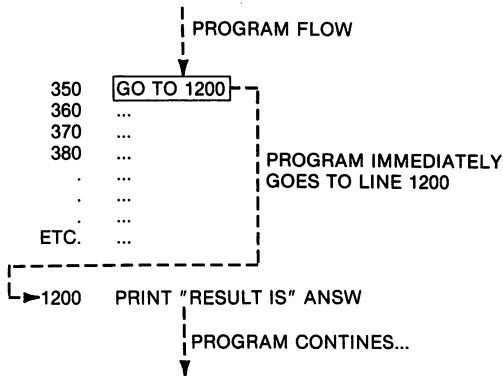


Fig. 4-3. Using the GOTO command to get to a specific line in a program.

command, it immediately goes to program line 1200 and starts work there, skipping over the program lines in between. In this example, the computer “jumps” from line 350 to line 1200 where it

prints the message, RESULT IS, followed by the value labeled ANSW. The Commodore 64 computer doesn't care what is done at line 1200, the GOTO command just tells it where to go. After completing the PRINT operation, the computer goes on to the next line that follows 1200.

Of course, if a GOTO 456 command is used in a program, the computer program *must contain line 456*, if the computer is to operate properly. For example, if you have only the following three-line program in the computer, what do you think the computer will do when it reaches the GOTO command at line 30?

```
10 INPUT V
20 PRINT V
30 GOTO 100
```

Since the program tells the computer to go to line 100, it will try to find line 100 in the program. Since there isn't a line numbered 100 in the program, an error message will be displayed on the TV screen:

```
RUN
? 45
45
```

```
?UNDEF'D STATEMENT ERROR IN 30
READY.
```

The *undefined statement error* message tells you that something was undefined in line 30. In this case, the computer couldn't find line 100 in the program. There are other conditions that can cause errors, and the error messages for the Commodore 64 computer are listed for you in Appendix A. Errors don't harm the computer, but they must be corrected if a program is to run properly.

By using the GOTO command and a line number, you can force the computer to go to any place in a program where there is a line number. This is a powerful addition to your list of BASIC instructions, since you can now cause the computer to do things again and again.

Here is a simple program that uses a GOTO command so you can see how it is used. Can you figure out what the computer will do?

```
10 INPUT "VALUE 1"; V1
20 INPUT "VALUE 2"; V2
30 SUM = V1 + V2
```

```
40 PRINT SUM
50 GOTO 10
```

Once the computer has printed the sum of the two values, V1 and V2, the GOTO command at line 50 points it back to line 10, and it continues working there. The computer does not “know” that it has been pointed back to the *start* of the program. It simply goes to the line number used in the GOTO command.

Here is what the TV screen would look like if this program were run:

```
VALUE 1? 5
VALUE 2? 6
11
VALUE 1? 234
VALUE 2? 521
755
```

and so on.

Here is an interesting variation on the VALUE program just shown. Can you see what is different?

```
10 INPUT "VALUE 1"; V1
20 INPUT "VALUE 2"; V2
30 PRINT V1 + V2
40 GOTO 10
```

The intermediate step of labeling the sum of V1 and V2 has been removed. In this program, the computer is told to print the result of V1 + V2 without labeling and saving the result. This type of operation can be used to speed up a program if a result is not going to be used somewhere else in the program. Since you only want to see the result, why have the computer take the time to label it and set it aside?

Here is another interesting program for you to think about:

```
100 Z = 0
110 PRINT Z
120 Z = Z + 1
130 GOTO 110
```

If you run it, this program will display numbers on the TV screen, starting with 0 and increasing by one: 0, 1, 2, 3, and so on. It does it quickly, too. In this program, the GOTO command points the computer to program line 110 rather than to the start of the program.

Look at program line 120. This shows you another interesting way in which labels are used. The program line $Z = Z + 1$ simply says to get the value labeled with Z, add one to it, and then label the result Z. The program line $Z = Z + 1$ is NOT saying that Z equals Z plus 1. The label has been used to identify the starting value and it is then switched over to identify the result. The overall effect is to simply add one to the value labeled Z. This is done frequently in computer programs.

These computer programs are called *loops*, since the computer is forced to loop back and go through some of the same program steps again and again. Loops are important in computer programs, since they give you more control over what the computer is doing.

BREAKING OUT

Are there any problems with these “loop” programs? The big problem is that once the looping program is started, there is no way to get the computer out of it. The computer will complete its operations, go back and do them again, complete its operations, go back . . . , on and on and on. Is there a way to get the computer out of the loop? Actually, there are several ways, but only one is useful. Of course, you can always pull the plug, but that doesn't count.

The Commodore 64 has a RUN/STOP key on the left side of the keyboard, shown in Fig. 4-4. When the computer is running a program, you can use this key to stop it. When the key is pressed, it will tell you where the computer was operating in the program by displaying a message such as:

```
BREAK IN 450  
READY.
```

This tells you that you have caused the computer to break out of a program, and it gives you the line number where the computer was working. In this case, the computer was doing something at line 450 in the program when the RUN/STOP key was pressed.

Now that the computer has been stopped, the program can be listed, changed, corrected, and so on. You can also tell the computer to continue its operation by typing CONT [RETURN]. This tells the computer to continue on, even though you stopped it temporarily. You cannot use the RUN/STOP key to stop the computer if it is waiting for information from the keyboard; that is, if it is working on an INPUT command. Since the computer is waiting for

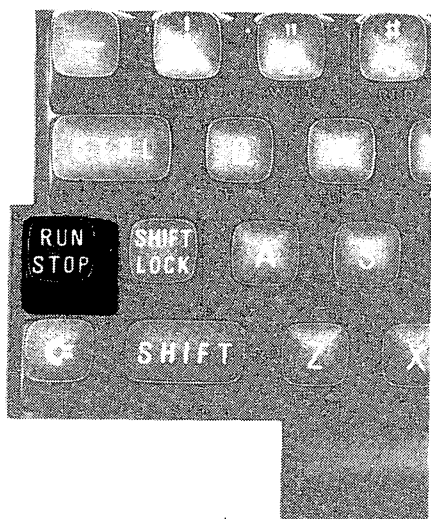


Fig. 4-4. Location of the RUN/STOP key on the left side of the keyboard.

information to be typed in, you must “reset” it. You can do this by pressing and holding the RUN/STOP key and then pressing the RESTORE key located on the right side of the keyboard, as shown in Fig. 4-5. When this is done, the READY message is displayed on



Fig. 4-5. Location of the RESTORE key on the right side of the keyboard.

the TV screen. If you stop a program by using the RUN/STOP and RESTORE keys together, you must type RUN to start it again.

When the RUN/STOP and RESTORE keys are pressed this

way, the computer is reset, just as if you were restarting the program. Of course, the program is still in the computer ready to be used again. Remember that the RUN/STOP key must be pressed and held while the RESTORE key is pressed.

Experiment No. 4-1. Loops and Breaks

In this experiment you will see how you can use the RUN/STOP and RESTORE keys to break out of loops in computer programs.

Type NEW to clear out any programs in the computer. Type the following program into the computer and list it to be sure it is correct. Make any changes needed and then run it.

```
100 X = 0
110 PRINT X
120 X = X + 1
130 GOTO 110
```

What is displayed on the TV screen? A column of numbers is displayed on the left side of the TV screen. The numbers seem to move up the side quickly, with new numbers being displayed in the bottom left corner of the display area.

While the program is running, press the RUN/STOP key. What happens? What is displayed on the screen? The numbers stop increasing and a message is displayed on the TV screen. The message should look like one of these:

```
BREAK IN 110
READY.
```

or

```
BREAK IN 120
READY.
```

or

```
BREAK IN 130
READY.
```

Why could three different messages be displayed? When you press the RUN/STOP key, it's impossible to know where the computer is in this program; it could be at line 110, 120, or 130. Run the program again and stop it again. Just press the RUN/STOP key to stop it. Now what line number is shown in the BREAK message? Is it the same one?

Restart the program by typing RUN. Press the RUN/STOP key.

Did the computer stop at the same line number? You can try this several times to see if you can stop the computer at different places in the program. It took us seven tries before we got the computer to stop at least once at each program line: 110, 120, and 130.

Can you stop the computer at line 100? Probably not, since this program step is done only once, right at the start of the program. It isn't included in the loop, so you'd have to be pretty fast in going from typing RUN to pressing the RUN/STOP key to catch it doing this at the start of the program.

Run the program again and wait until the numbers being displayed are into the hundreds. Press the RUN/STOP key. The number display will stop. Now, type CONT. What happens? Remember to press the RETURN key. The display continues. It does not start over again from zero. Press the RUN/STOP key again to stop the program. Now type X=10000 [RETURN]. Type CONT. What is displayed now? The display continues, but the numbers are in the ten thousands. When you used the RUN/STOP key to stop the program, you were able to change the value given the label X. You then restarted the program and the count continued, starting with the new value.

If your program is running, stop it. Just press the RUN/STOP key. Now, press/hold the RUN/STOP key and press the RESTORE key. What happens? The TV screen is cleared and the READY message appears in the upper left-hand corner.

Type NEW to clear out the program and type in the following program:

```
50 INPUT X
60 PRINT X
70 GOTO 50
```

Check it and make any corrections that are needed. Run the program and type a value when the computer displays the question mark on the screen. Is the value "printed" on the TV screen properly? Is the computer waiting for another value? The number should be displayed and another question mark should appear below it.

When the question mark appears again, press the RUN/STOP key. Does it have any effect on the program or the display? No, there is no effect. The RUN/STOP key cannot be used to break the computer out of an INPUT command, where it is waiting for information from the keyboard.

Press/hold the RUN/STOP key and press the RESTORE key.

What happens now? The screen is cleared and the READY message appears. When the RUN/STOP key seems to have no effect on the program, you can use the RUN/STOP and the RESTORE keys together to reset the computer.

REAL DECISIONS

Although the GOTO command can be used to force the computer to go to a specific program line, no decision is made. So, how can computers make complex decisions in medicine, finance, and science? Most complex "questions" can be broken down into smaller ones that are easier to understand and answer. Your doctor doesn't take one look at you and decide that you have an ear infection. He asks questions such as:

"What hurts?"

"Do you have a fever?"

"Are you taking any medicine?"

"Have you had any trouble hearing?"

and so on.

Computers make decisions in the same way, and it's the computer programmer who breaks down the complex questions into simpler, smaller ones that are easier to answer. Computers really use statements, instead of questions, and they *evaluate the statements*, telling whether they are true or false. Here are a few examples of statements that can be *evaluated* by a computer such as your Commodore 64:

5 is greater than 78. (True or False)

INCOME is less than EXPENSES. (True or False)

WEIGHT is equal to 1000. (True or False)

These statements are either true or false, and we'll assume we know the values for INCOME, EXPENSES, and WEIGHT. The computer can test similar statements and then use the true-or-false answer to make decisions. The computer can't give you a true-or-false answer for questions such as, "Margaret is prettier than Joan," or "Fred is nicer than Sam."

Here's an example of a statement that is either true or false, and two "actions" that are based on the answer:

It is raining today. (True or False)

If the answer is TRUE, take your umbrella.

If the answer is FALSE, don't take your umbrella.

You can see how the statement is evaluated and the proper action taken by looking at the *flowchart* in Fig. 4-6. Once the state-

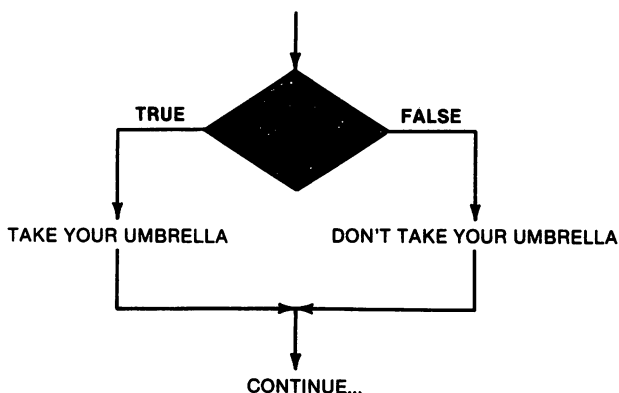


Fig. 4-6. The “umbrella” flowchart with true and false actions.

ment has been evaluated, the “program” branches in either of two directions, based on the answer.

You can simplify this type of operation by putting the statement and the “true” answer in a slightly different form: IF “It’s raining” is true, THEN take your umbrella.

The “false” answer isn’t included here, since if it isn’t raining, you usually don’t think about an umbrella at all. You can “test” the statement, “It’s raining,” by looking out the window or opening the door. If the statement is true, THEN you do something special. If the statement is false, no special action is needed. This type of operation is shown in Fig. 4-7.

Computers using BASIC language programs can evaluate statements in a similar way to see whether they are true or false. Of course, your Commodore 64 computer can’t look out a window and tell you that it’s raining, so what can it do to make decisions? Since you’ve used four simple math operations, you’ll now see how the computer can compare values to see whether they are equal or unequal. You’ll also see how the computer can test two values to see if one is greater-than or less-than the other. These operations give the computer a great deal of decision-making power.

THE IF-THEN OPERATION

Just as we used simple if-then sentences in the previous examples, the computer can use IF-THEN operations in programs. As

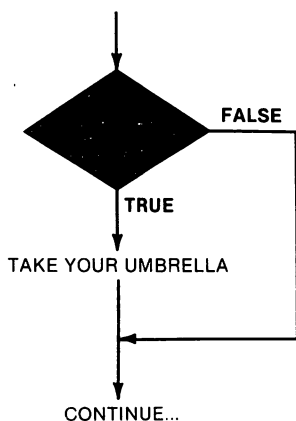


Fig. 4-7. The "umbrella" flowchart with only the true action.

part of an IF-THEN operation, the computer is given a "statement" to evaluate and a "command" to do if the statement is true. Here's the general form for the IF-THEN operation used with your Commodore 64:

IF (this statement is true) THEN (do this command)

and it can be condensed to:

IF (statement) THEN (command)

Let's look at the types of statements that can be evaluated as either true or false by the Commodore 64:

SCORE = 100 (Is "SCORE equal to 100" True or False?)

SCORE < 75 (Is "SCORE less than 75" True or False?)

SCORE > AVERAGE (Is "SCORE greater than AVERAGE" True or False?)

The symbol < is used for "less-than" and the symbol > is used for "greater-than." You'll see these symbols used often in computer programs. Here's how one of these statements might be used in a BASIC-language program for your Commodore 64:

140 IF SCORE = 100 THEN PRINT "PERFECT"

In this example, SCORE is a label for a value, and the computer evaluates the statement, "SCORE = 100," to see if it is true or false. If it is false, the computer goes on to the next program line. If it is true, the command following THEN is done and PERFECT is "printed." After PERFECT is displayed on the TV screen, the computer goes on to the next program line. This can be shown with the help of the *flowchart* in Fig. 4-8.

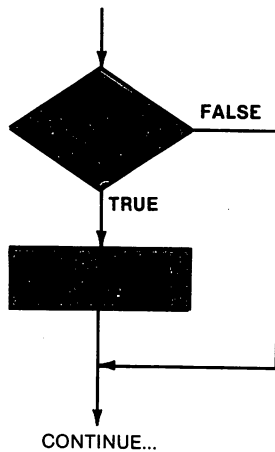


Fig. 4-8. A typical IF-THEN flowchart.

All types of commands can be used in IF-THEN operations. For example, if you want the computer to go to line 1575 when SCORE is greater than AVERAGE, the IF-THEN operation would look like this:

```
IF SCORE > AVERAGE THEN GOTO 1575
```

A flowchart for this is shown in Fig. 4-9. Keep in mind that the computer only goes to line 1575 if the statement "SCORE > AVERAGE" is true. *Labels* have been used in this statement to keep it general. Perhaps test scores have been typed in from the keyboard and the computer has figured out the average before it gets to this part of the program.

The command that follows the THEN is just like a separate program line in a BASIC program, and several commands can be used together as long as they are separated by colons. In this example, a PRINT and a GOTO command are used after the THEN:

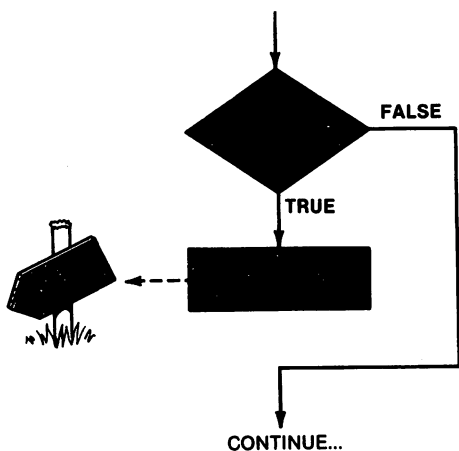


Fig. 4-9. An IF-THEN flowchart with a GOTO command.

IF SCORE < 75 THEN PRINT "NOT TOO GOOD" : GOTO 450

A flowchart for this is shown in Fig. 4-10.

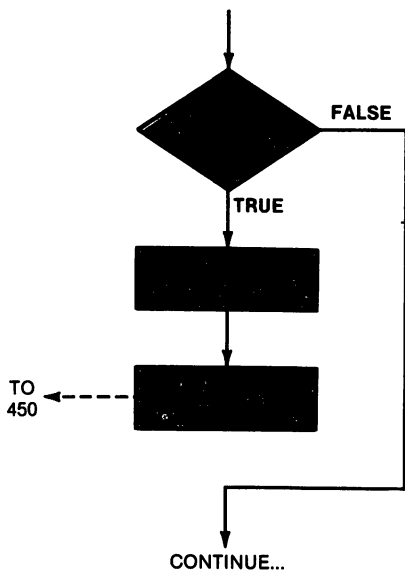


Fig. 4-10. An IF-THEN flowchart with multiple commands.

Experiment No. 4-2. The IF-THEN Operation

This experiment will show you how an IF-THEN operation can be used in a BASIC language program to make a decision. You will be able to type in numbers between 0 and 100 and the computer will tell you whether they are greater-than or less-than 50. Clear out any old programs that are in your computer and type in the following program. *Watch those line numbers!*

```
20 INPUT "NUMBER "; N
60 IF N > 50 THEN PRINT "GREATER THAN 50"
70 IF N < 50 THEN PRINT "LESS THAN 50"
90 GOTO 20
```

List your program to be sure that it has been typed in correctly. Make any changes that are needed.

Run the program. Type in several values between 0 and 100, some greater-than and some less-than 50. Does the computer give you the right response for each? Is the computer really "smart"? The computer should give you the right answers as it determines whether the value is greater-than or less-than 50. If the program does not work correctly, stop the computer, list the program, and check it again. The computer isn't really very smart, since your program tells it exactly what to do. A computer just follows directions.

Your computer will continue to wait for numbers to "test." What happens when you type the number 50? Is anything printed? Is this what you expected? The computer program checks for values greater-than or less-than 50, but it does not check for the value 50, itself. Can you suggest a way to have the computer check the value typed in to see if it is 50? Line 80 has not been used, so you can try and put in a program line of your own, if you wish to.

80 _____

You can check for the condition, $N = 50$, and the following program line can be used:

```
80 IF N = 50 THEN PRINT "EQUAL TO 50"
```

Type in program line 80 shown above, so your complete program looks like this:

```
20 INPUT "NUMBER "; N
60 IF N > 50 THEN PRINT "GREATER THAN 50"
70 IF N < 50 THEN PRINT "LESS THAN 50"
80 IF N = 50 THEN PRINT "EQUAL TO 50"
```

```
80 IF N = 50 THEN PRINT "EQUAL TO 50"  
90 GOTO 20
```

Now run the program. When the computer "asks" for a value, type in 50 from the keyboard. Does the computer program display the correct message? If line 80 has been typed in correctly, the computer should print the message, EQUAL TO 50, when you type in the value, 50.

At the start of this experiment, it was noted that values between 0 and 100 could be typed in. When the program is running, type in 567. What happens? This value is accepted, and the "GREATER THAN 50" message is displayed. We would like to limit the numbers that can be input to between 0 and 100. Can the computer be used to detect numbers greater than 100? What about numbers less than 0? Yes, an IF-THEN operation can be used to check the keyboard entries and to reject any that are outside of the 0 to 100 range. You won't have to write these program steps, but think about what you'd like the computer to do. Here are several additional lines (marked with an asterisk (*)) that will solve the problem:

```
* 10 PRINT "NUMBERS BETWEEN 0 AND 100 ONLY"  
20 INPUT "NUMBER "; N  
* 30 IF N > 100 THEN GOTO 10  
* 40 IF N < 0 THEN GOTO 10  
60 IF N > 50 THEN PRINT "GREATER THAN 50"  
70 IF N < 50 THEN PRINT "LESS THAN 50"  
80 IF N = 50 THEN PRINT "EQUAL TO 50"  
90 GOTO 20
```

What effect do these program lines have? Line 10 just prints a message on the screen that tells the user what range of numbers is allowed. Once the value has been input by the computer at line 20, it is checked to be sure that it is in the range of 0 to 100. How is this done? At line 30, the computer tests the value to see if it is greater than 100. If it is, the computer goes back to line 10 and then asks for another value. At line 40, the computer tests the value to see if it is less than zero. If it is, the computer goes back to line 10 and then asks for another value. Only if the value is between 0 and 100 does the computer go on to line 60, where the value is tested to see if it is greater-than, less-than, or equal-to 50. If you would like to, you can type in the new lines marked with an asterisk (don't type in the asterisks!), and see how the program works. You can also try to sketch the flowchart for the complete program.

In Experiment 4-2, you saw how the IF-THEN operation can be used to make decisions. Although these decisions weren't critical, this type of decision-making is what makes computers so powerful. It can make these types of decisions quickly, without coffee breaks, and it will not make mistakes. Yes, mistakes are made, but because a *program doesn't work properly* or a circuit doesn't work the way it should. Computers have survived millions of miles of space travel and have worked perfectly in the far reaches of our solar system. They are making true-false decisions all the time.

MORE LOOPS

You have seen how a GOTO command can be used to force the computer to go to a specific line in a program. When used in a loop such as:

```
10 PRINT "TEST"  
20 GOTO 10
```

there is no easy way to get out of the loop. If you wanted to go through the loop only 10 times, there is no way to tell the computer to stop after "printing" TEST on the TV screen 10 times. Although it is not often used this way, the IF-THEN operation can be used to count loops. (You'll see a better way to control loops in another chapter.)

Let's take a further look at how IF-THEN operations can be used to count loops and to provide a way out. Earlier in this chapter, a program was used to show how the GOTO instruction could be used:

```
10 X = 0  
20 PRINT X  
30 X = X + 1  
40 GOTO 20
```

Remember that the $X = X + 1$ operation simply increased the value labeled X by one. If you run this program you'll see a column of numbers on the left side of the TV screen. The numbers are "pushed up" as new ones are "printed" at the bottom of the TV screen. The value of X is increased by one each time the computer goes through the loop. An IF-THEN statement could be used to break out of the loop after the computer goes through it a set number of times. Here is an example of that type of program:

```
10 X = 0
20 PRINT X
30 X = X + 1
40 IF X = 10 THEN END
50 GOTO 20
```

The IF-THEN operation tests the statement, $X = 10$, to see if it is true. If it is true, the command following THEN is done. The END command may be a new one to you, but it is easy to figure out what it does. It simply stops the computer. What happens if X is not equal to 10? Well, the statement, $X = 10$, is then false, and the computer goes on to program line 50. It does not reach the END command unless the condition in the IF statement is true.

Can you figure out what numbers will be printed on the TV screen when this program is run?

Experiment No. 4-3. Counting Loops

This experiment will show you how to use an IF-THEN command to get the computer to “break out” of a loop after doing it a number of times. You will not have to put together any program lines of your own.

Clear the computer for a new program. Type in the following program and check it. Correct any errors.

```
10 X = 0
20 PRINT X
30 X = X + 1
40 GOTO 20
```

Run the program. What do you see on the TV screen? Is this what you expected? You should see a column of numbers on the left side of the screen. The numbers seem to “move up” as new ones are displayed at the bottom of the column. Can you stop the computer? Yes, press the RUN/STOP key. Now, *change* program line 40 and *add* program line 50, as shown below:

```
40 IF X = 10 THEN END
50 GOTO 20
```

Check your program to be sure these lines have been typed in correctly. Before you run the program, try and figure out what numbers will be displayed on the TV screen. Run the program and see if you are right. You should see the numbers 0 through 9 displayed in a column on the left side of the TV screen. Is this what you expected? Maybe you thought you would see 0 through 10.

Remember that after the one is added to the value labeled X (line 30), it is tested by the IF-THEN operation (line 40). If X is not equal to 10, the computer goes on to line 50 where it is pointed back to line 20. If X is equal to 10, "X = 10" is true and the computer is stopped by the END command. The value 10 is never printed. However, the computer did go through the loop 10 times, printing 10 values on the TV screen. A flowchart for this program is shown in Fig. 4-11.

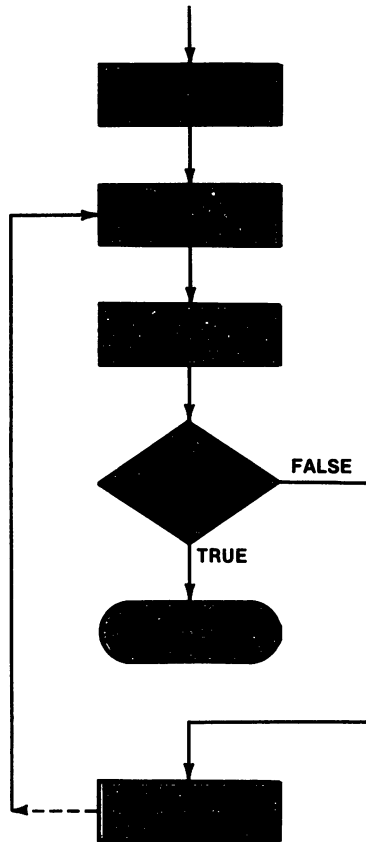


Fig. 4-11. A flowchart for the loop-counting program.

In the IF-THEN commands, GOTO commands are often used to point the computer to a line in the program:

```
IF XF = FR + FQ THEN GOTO 1265
```

However, you may find IF-THEN commands in which the word GOTO has been left out. The following program line has the same

effect as the preceding one. The computer “knows” that you want it to go to line 1265 if XF is equal to (FR + FQ):

IF XF = (FR + FQ) THEN 1265

TO BE AND/OR NOT TO BE

Sometimes it is helpful to make several true or false decisions at the same time. These statements can be combined in one IF-THEN operation. Look at the following:

IF *we are out of eggs* AND IF *you want eggs for breakfast*,
THEN *buy some on the way home*.

IF *it is raining* OR IF *rain is forecast*,
THEN *take your umbrella*.

These can be simplified so they are easier to understand:

IF (we are out of eggs) AND (you want eggs for breakfast),
THEN . . .

IF (it is raining) OR (rain is forecast), THEN . . .

By using AND and OR operations, the computer can test several different statements at the same time. This saves “computer time,” and by combining statements this way, programs may be simplified, too. It is easy to put statements together in IF-THEN operations as long as you know the rules for using the AND and OR operations. Here they are:

1. When an AND is used, both of the statements must be true for the THEN command to be done. If either of the statements is false, the THEN command is not done. This is shown in Table 4-1. The results of testing or evaluating each statement are shown in parentheses.

Table 4-1. Table of Results for an AND Operation

Statement	Statement	THEN Command Done?
(False)	(False)	No
(False)	(True)	No
(True)	(False)	No
(True)	(True)	Yes

2. When an OR is used, either or both of the statements must be true for the THEN command to be done. If both of the state-

ments are false, the THEN command is not done. This is shown in Table 4-2.

Table 4-2. Table of Results for an OR Operation

Statement	Statement	THEN Command Done?
(False)	(False)	No
(False)	(True)	Yes
(True)	(False)	Yes
(True)	(True)	Yes

In a previous experiment, two IF-THEN operations were used to test a number to see if it was between 0 and 100. If it was below 0 OR above 100, it was rejected. Here is how the operations were used:

```
10 PRINT "NUMBERS BETWEEN 0 AND 100 ONLY"  
20 INPUT "NUMBER "; N  
30 IF N > 100 THEN GOTO 10  
40 IF N < 0 THEN GOTO 10
```

and so on.

If the number typed in is greater than 100, the IF statement at line 30 detects this and the computer is forced to line 10. If the number is less than 100, the computer goes on to see if the number is less than 0. If it is, the GOTO operation at line 40 forces the computer to line 10. Only when the number is between 0 and 100 will the computer go on to the program line following line 40.

The two IF statements can be combined into one by using an OR operation, and parentheses have been used to separate the statements:

```
10 PRINT "NUMBERS BETWEEN 0 AND 100 ONLY"  
20 INPUT "NUMBER"; N  
30 IF (N > 100) OR (N < 0) THEN GOTO 10
```

In this example, the IF-THEN operation checks two statements to see if the number is greater than 100 OR less than 0. It is possible to have the computer check and see if the number is *within* the range, instead. This would use an AND operation, and it would be more complicated than the OR operation, at least in this case.

MIXED OPERATIONS

There are times when you will want to check the same two values for two different conditions. For example, it might be useful to

check today's RAINFALL to see if it is *greater-than or equal-to* the RECORD rainfall that is on file in the computer. You could use the OR operation to do this:

```
IF (RAINFALL > RECORD) OR (RAINFALL = RECORD)
THEN . . .
```

By looking at Table 4-2, you can see that the THEN command would be done if *either of the statements is true*. Since the same two values, RAINFALL and RECORD, are being compared in each operation, you can have the computer do the greater-than and equal-to operations at the same time. Other combinations of greater-than, less-than, and equal-to operations can be used, too, as shown here:

```
GRADE <= SCORE (GRADE less-than or equal-to
SCORE)
RAINFALL >= RECORD (RAINFALL greater-than or
equal-to RECORD)
TRY <> TARGET (TRY less-than or greater-than
TARGET)
```

This combination of operations is only useful when the same two values are being compared in different ways. In the TRY <> TARGET example, the computer is really checking for the not-equal condition; that is, TRY is *not equal* to TARGET.

These conditions can be checked by using simple IF-THEN operations, and several examples are shown here. Different types of commands are shown following "THEN" so you can see examples of how they are used.

```
IF RAINFALL >= RECORD THEN PRINT "NEW RECORD IS "
RAINFALL
```

In this example, if the RAINFALL is greater-than or equal-to the RECORD, the computer prints the message, "NEW RECORD IS," followed by the value assigned the label RAINFALL.

```
IF TRY <> TARGET THEN PRINT "YOU MISSED, TRY
AGAIN":GOTO 595
```

In this example, the program tests to see if the values labeled TRY and TARGET are not equal. If they are not equal, the computer prints the message, "YOU MISSED, TRY AGAIN," and it goes to program line 595.

```
IF GRADE <= SCORE THEN GOTO 250
```


Here, the computer checks the value labeled GRADE to see if it is less-than or equal-to the value labeled SCORE. If this is true, the computer goes to program line 250.

THE NOT OPERATION

You have seen how the AND and OR operations can be used in IF-THEN operations so that several different statements can be tested at the same time. There is one other operation that isn't used very often, so we've left it for last. This is the NOT operation, and it allows you to reverse the meaning of a statement. For example, "You say white, I say black. You say black, I say white," or "If it's true, make it false. If it's false, make it true."

Here are two examples in which the NOT operation has been used to "reverse" the meaning of each statement:

NOT (COST = VALUE) (COST is *not* equal to VALUE)
NOT (COST < VALUE) (COST is *not* less-than VALUE)

It takes a bit of programming experience and trial and error to get used to the NOT operation. It isn't used very often, but we just wanted to show you that it is part of programming in BASIC.

A LITTLE HISTORY

The AND, OR, and NOT operations are called *logical operations*, and although you may find it difficult to believe, these operations have been in use for over *100 years*. In the nineteenth century, the English mathematician, George Boole, devised a way of solving logic problems with a special form of mathematics. This type of math is now known as *Boolean algebra*, but it was relatively unused until scientists and engineers applied it to solving problems with the first electronic computers in the 1940s.

These three logical operations are the foundation of all desk-top computers, just like the one you are using. These logical operations are done by tiny electronic circuits, of which there are thousands and thousands in your computer. These circuits make hundreds of thousands of decisions each second, and it is this high-speed decision making that makes small computers so powerful and useful. Even the biggest computers used by banks, universities, and research centers use electronic circuits that do AND, OR, and NOT operations. In the same way that all math operations depend on addition and subtraction, all modern computer operations depend

on AND, OR, and NOT operations. Even small pocket calculators and digital clocks depend on these simple operations.

PICK A NUMBER, ANY NUMBER

In many games, you don't know how many spaces you'll move until you spin the spinner or toss the dice. Since computers are used in many games, they need some way to "spin a spinner," too. We don't know of any computers that have spinners or dice in them, but most computers do have a way of "picking a number," or coming up with a *random* value. This means you can get the computer to "pick a number" for you. Of course, you won't know ahead of time what number the computer will come up with.

The Commodore 64 can "pick" a random number, or value between 0 and 1, by using the RND(1) operation which is part of its BASIC language. This means that the computer can come up with values between 0 and 1, such as 0.345, 0.914, and 0.310. The RND(1) operation NEVER gives you the value 0 or 1 — that's just the way it works. You can use a BASIC operation like this in a program to get a random value:

```
SAMPLE = RND(1)
```

The computer labels the random number "SAMPLE."

Experiment No. 4-4. Random Value Program 1

You will type in and run a program that will print random values on the TV screen. The purpose of this experiment is to show you that the random number operation really works.

Use the NEW command to clear out the computer for a new program. Type in the following program and check it:

```
10 SAMPLE = RND(1)
20 PRINT SAMPLE
30 GOTO 10
```

Run the program. You will see values displayed on the TV screen, but they will move up the screen too quickly to be read. Press the RUN/STOP key to stop the program, and you should see 24 or so random values displayed on the TV screen. The chances are very good that no two values will be the same. You may see a value such as 8.93456278E-03. Although it looks odd, it's just the computer's way of displaying a very small value and you don't need to know what it means right now.

Did you see the value 0 or 1 displayed? The display may have moved too quickly for you to see all the values clearly, so you might have missed the value 0 or 1 if either was displayed. Can you think of a way to check for the values 0 or 1? An IF-THEN operation can compare the value labeled SAMPLE with the values 1 and 0. Here's how it could be done:

```
30 IF (SAMPLE = 1) OR (SAMPLE = 0) THEN END
40 GOTO 10
```

The program would now be:

```
10 SAMPLE = RND(1)
20 PRINT SAMPLE
30 IF (SAMPLE = 1) OR (SAMPLE = 0) THEN END
40 GOTO 10
```

The IF-THEN operation at line 30 tests for either the SAMPLE = 1 or the SAMPLE = 0 condition. If either of these conditions is true, the THEN command is done. In this case, the END command will stop the computer.

Put the new line 30 in your program and add line 40 to complete the new program. Run your program. Does the computer stop? No, the computer continues to display random values on the TV screen. You can let it run all night if you want to, but it will continue to display new values without stopping. What is your conclusion? The RND(1) operation generates random values *between 0 and 1*, but it does not generate the value 0 or 1.

Since it's difficult to move your game marker by 0.984812986 spaces, the random values picked so far don't seem to be particularly useful. However, by simply multiplying the random values by another value, you can have the computer pick more useful numbers. For example, if you want to have the computer pick a random number between 0 and 10, you can do this by multiplying the value found in the RND(1) operation by 10. Here is what that part of the program would look like:

```
SAMPLE = RND(1)*10
```

Now the results will be between 0 and 10 instead of between 0 and 1. If you want a random value between 0 and 50, you can get the computer to pick one in this range by using the following program line:

```
SAMPLE = RND(1)*50
```

In both cases, the RND(1) operation “picks” a random value between 0 and 1, but the multiplication operation spreads the numbers over a larger range. In almost every case, the value used in the multiplication is a whole number, or integer.

Experiment No. 4-5. Random Value Program 2

In this experiment, you will find out how the computer can be made to “Pick a number between 0 and 10.” Clear your computer then type in and check the following program:

```
10 SAMPLE = RND(1)*10
20 PRINT SAMPLE
30 GOTO 10
```

Run the program. You will see the random values “move up” the screen as new values are displayed on the bottom row on the TV screen. After the program has run for a few seconds, press the RUN/STOP key to stop the program. Are the values displayed between 0 and 10? Are any values displayed more than once? The values are between 0 and 10, and we didn’t find any values that were equal when we ran the program. Although the chances are small, you may find two equal values displayed on your TV screen. The values 0 and 10 aren’t found.

Change program line 10 in your program to the following:

```
10 SAMPLE = RND(1)*90
```

Now run the new program. After a few seconds, stop the program and look at the values displayed on the TV screen. Are they between the values 0 and 90? The values should be between 0 and 90.

In this experiment, you saw that you could change the “range” of random values that the computer can “pick” for you.

INTEGERS

Although the range of the random values can be changed, it is still difficult to move a game marker by 8.73481053 spaces. So, what can be done to have the computer pick values such as 9, 4, and 6, instead of 9.45271052, 4.8562321, and 6.46241739. The *integer operation*, INT, is used to remove or “strip-off” any decimal fractions; digits to the right of the decimal point. In this way, it “changes” a number that has a decimal fraction into an integer or whole number. Here is how it is used:

```
PRINT INT(9.45271052)
```

When this is done by the computer, only the 9 is displayed on the TV screen. The INT and RND operations can be used together to make the computer "pick" random whole numbers.

Once a random value between 0 and 1 has been "chosen" by the RND operation, a multiplication operation increases its "range." The INT operation is used last to "strip-off" the decimal fraction and "change" the value into an integer. This may seem a bit confusing, so look at the following example. This program line causes the computer to "pick" a number between, *and including*, 0 and 9:

```
SAMPLE = INT(RND(1)*10)
```

The largest random values will always be one less than the value used in the multiplication. Here are some sample program lines that you can use in your programs. The label, X, has been used as the label for the value:

(a) Coin Flip: 1 = heads, 0 = tails

```
10 X = INT(RND(1)*2)
```

(b) Dice Toss: Values 1 through 6

```
10 X = INT(RND(1)*6) + 1
```

We're not trying to make you an expert programmer, but here are some general-purpose random-value program lines in which you can substitute your own ranges for games, teaching programs, magic tricks, puzzles, and other programs where a random integer is needed.

(a) To pick a number between 0 and T:

```
10 X = INT(RND(1)*(T + 1))
```

(b) To pick a number between 1 and T:

```
10 X = INT(RND(1)*T) + 1
```

(c) To pick a number between Q and R, where $R > Q$:

```
10 X = INT(RND(1)*(R - Q + 1)) + Q
```

A WORD OF CAUTION

Although you're not going to be a programmer, we want you to know that you cannot use what are called "reserved words" as labels in your computer programs. It is unlikely that you will run

into any problems with prepackaged computer programs or cartridges that have been developed by a commercial group or competent programmer. However, if you decide to try your hand at even simple programs, you may run into problems without realizing it.

Reserved words are nothing more than the words in the BASIC language that represent operations. For example, IF, THEN, AND, and RND are all reserved words. So, what's the big deal? Well, if you're writing programs, be sure to check your labels so that you don't use any of the reserved words in them. There is a complete list of the reserved words in Appendix B, so these words can be found in one place.

Suppose that you wrote a short program to count something you've decided to call "Information Files." As a label, you've decided to use IF. Well, the computer "sees" the IF you've used as a label in one of your calculations:

```
145 IF = A5 + (TQ / 17)
```

The computer thinks that it is "looking at" the start of an IF-THEN operation. That really confuses the computer and it will give you an error message:

```
?SYNTAX ERROR IN 145  
READY.
```

If you see this type of error message when you try to run a program, check to be sure that a reserved word hasn't been used.

QUESTIONS

1. What does a GOTO command do in a BASIC-language program?
2. What information must you provide in a GOTO command?
3. Can a GOTO command cause a computer error? If so, what kind of an error?

4. Does a GOTO command have to point the computer to the start of a program, or can it point it somewhere else?
5. How can you get out of an "endless" loop?
6. How can you stop the computer when it's waiting for you to type in information for an INPUT command?
7. What kinds of "statements" can the Commodore 64 test, or evaluate?
8. How are statements used so the Commodore 64 can make decisions?
9. What conditions can be checked in IF-THEN commands?
10. What kinds of commands can be used after the THEN in an IF-THEN command?
11. What do the AND, OR, and NOT operations do?
12. What operation gets a random number from the computer?

13. How can you get the integer 15 from the value 15.962?

FOOD FOR THOUGHT

1. In one of the experiments in this chapter, the following program was used to show you how an IF-THEN command could be used to get the computer out of a loop:

```
10 X = 0
20 PRINT X
30 X = X + 1
40 IF X = 10 THEN END
50 GOTO 20
```

Rewrite the program so that it does the same thing, but use some other condition in an IF-THEN command. There's always more than one way to solve a problem.

2. In an example of the logic OR operation, an IF-THEN command was used to check a number to see if it was greater-than 100 OR less-than 0. Suggest a way in which the AND operation could be used instead. The operation must still check to be sure that values are between 0 and 100. Remember, the values 0 and 100 are allowed, too.

PROBLEMS

1. Write a program where three numbers are entered from the keyboard into the computer. The two largest numbers are multiplied, and the result is then divided by the smallest number. The division result is then displayed. Assume that the numbers can be entered in any order. Thus, if your program is properly written, the same result will be produced regardless of the sequence in which the numbers are entered. Assume that none of the numbers are the same.
2. Write a program that asks you if the washing machine is running. You answer with either a 1 for yes or a 0 for no. The computer then asks you if the water drain is plugged up, and again you answer with a 1 for yes or a 0 for no. If the washing

machine is running and the water drain is plugged, the computer should display the words, "STOP THE WASHING MACHINE."

3. Write a program that lets you enter an amount of money, such as 2.43, which represents \$2.43. The computer then tells you how many quarters, dimes, nickels, and pennies would be required for this amount of money. You want to use as few coins as possible, so calculate how many quarters are required first, followed by dimes, nickels, and pennies.
4. Write a program where the computer generates an integer random number between 0 and 100. The number is then displayed on the TV screen.
5. Write a program that generates a random number between 35.46 and 48.7. The program should generate random numbers continuously and display them on the TV screen.
6. Have the computer generate two random numbers between 0 and 50. These numbers should be displayed on a single line, separated by a plus (+) sign. You then have to enter the *sum* of these two numbers. If you enter an incorrect sum, the computer displays the same "problem" again. If you enter the correct answer, the computer generates a new problem for you.
7. Modify the program from Problem 6 so that the computer asks you 10 problems and gives you a grade between 0 and 100 after all 10 problems have been answered. If an incorrect answer is entered, 10 points should be subtracted from the grade and the computer should generate a new problem. Any "missed" problems should not be repeated.
8. Write a program where the computer generates a random number between 0 and 100, and you have to guess the number by entering guesses on the keyboard. After you enter each guess, the computer should tell you if your guess is too high, too low, or correct. If your guess is too high or too low, you continue to enter guesses until the correct number is entered on the keyboard.
9. Write a program that converts degrees Celsius to degrees Fahrenheit. The equation for this is $F=1.8*C+32$, where C is the temperature in degrees Celsius, and F is the resulting temperature in degrees Fahrenheit. When this program is run-

ning, enter the value 21. The computer should display the result (F) of 69.8.

10. Modify the program in Problem 9 so that the temperatures displayed (F) are rounded up or down. Thus, if a temperature of 21 is entered, the temperature displayed should be 70 rather than 69.8. Likewise, if the calculated temperature is 34.4, 34 should be displayed. If the fractional part of the temperature is .5 or greater, round up.
11. Write a program that lets you enter a day between 1 and 365. The computer then displays the month and the day of the month. For example, if you enter a 1 the computer displays January 1. If you enter a 45 the computer displays February 14. (NOTE: This is a long and tedious program to write.)
12. Write a program that generates a multiplication table for all possible combinations of numbers between 1 and 3. Thus, you should see:

```
1*1 = 1
1*2 = 2
1*3 = 3
2*1 = 2
2*2 = 4
2*3 = 6
3*1 = 3
3*2 = 6
3*3 = 9
```

on the TV screen.

13. Write a "checkbook" program. In this program, you should first enter the number of checks written the previous month, followed by the amount of each check. The computer should then display the total amount of money spent. You should next be able to enter the number of deposits that you made, followed by the amount of each deposit. You now enter the balance of your checkbook from last month, the total of all deposits is added to this, the total of all checks is subtracted from the result, and this new balance is displayed on the TV screen.
14. One problem with the solution for Problem 13 is that you have to know the number of checks and deposits. If you write a lot of checks, or have a number of deposits, this can take time to fig-

ure out. Modify the solution to Problem 13 so that when an amount of 0 for a check or deposit is entered, the computer assumes that you have finished entering either a check or deposit amount. For instance, you might see the following:

CHECK AMOUNT ? 34.56
CHECK AMOUNT ? 89.50
CHECK AMOUNT ? 3.75
CHECK AMOUNT ? 0
TOTAL CHECKS: 127.81
DEPOSIT ? 100.37
DEPOSIT ? 0
PREVIOUS BALANCE ? 389.37
CURRENT BALANCE: 361.93

The CURRENT BALANCE was determined by adding 100.37 to 389.37, and then subtracting 127.81 from the result of 489.74.



CHAPTER 5

MORE POWER TO YOU

Your Commodore 64 gives you a lot of computer power in a small package. If you want to use this power, there are new things to learn about. For example, there are new ways that the computer can make decisions, ways of making programs simpler, new ways to store information, and so on. We'll talk about these things in this chapter. We'll start by showing you a few "tricks" that can be used to print information on the TV screen.

SPECIALTY PRINTING

So far, you have been able to display numbers and letters on the TV screen by using a PRINT command. The PRINT command prints messages that are enclosed in quotation marks along with labeled values. Here is an example:

```
10 PRINT "THIS IS A MESSAGE"
```

When the computer finds this command in a program, it prints THIS IS A MESSAGE on the TV screen. It looks just the same as if you had typed it on the keyboard. Since you can put letters and numbers in a "message," to have them printed on the TV screen, you can put other types of keyboard operations in messages, too.

In one of the first experiments you did, you used the CLR/

HOME key to move the cursor to its home position in the upper left-hand corner of the screen. You also found that if you pressed the SHIFT key and then pressed the CLR/HOME key, the screen was completely cleared *and* the cursor moved to its home position. The CLR/HOME key only clears the TV screen. Programs aren't cleared out of the computer.

It is often helpful to start with a clear or "clean" TV screen. Some programs clear the TV screen to erase an old game display, or to show a new problem to be solved. Since the computer can't reach out and press the SHIFT and CLR/HOME keys, there must be another way to clear the TV screen.


The SHIFT and CLR/HOME key actions can be put in the message part of a PRINT command. When the computer reaches a PRINT command where the SHIFT and CLR/HOME operations are part of the "message," it automatically clears the TV screen. Here's an experiment that shows you how to do this.

Experiment No. 5-1. Clearing the Screen

In this experiment, you will see how *action keys* can be used in the message part of a PRINT command to clear the TV display.

Clear the computer for a new program, and use the CLR/HOME key to clear the TV screen. Now type the following program line into your computer and leave the cursor as shown:

```
10 PRINT '■
```

You now have the first part of a PRINT command typed into the computer. Press the SHIFT key and then press the CLR/HOME key as if you were clearing the TV screen. What happens on the TV screen? Did you expect the computer to clear the screen? The computer displays a "reversed heart" symbol, , right after the quote mark. Maybe you thought that the screen would be cleared instead. Your Commodore 64 computer is pretty smart. It can tell that you're typing the SHIFT and CLR/HOME keys as part of a PRINT command's message; that is, between the quote marks. The computer "knows" that you don't want it to take any action right away.

Since the CLR/HOME key is an *action key*, it doesn't actually print anything on the screen when you press it. Instead, it clears the screen. The "reversed heart" symbol is just the computer's way of telling you that it knows that this clear-the-screen operation is to be done later, when the program is actually running. As you'll

see later in this book, there are other symbols that stand for other special operations.

Type the final quote mark and press the RETURN key, so the line looks like this:

```
10 PRINT "☐"
```

When the computer reaches this line in a program, it will recognize the special symbol and will know that it is supposed to clear the screen. Add the following line to your program:

```
20 PRINT "CLEAR TEST"
```

List the program and check it to be sure it is correct. Remember, you can simply retype a line if you've made an error. List the program three more times just to put more characters on the TV screen. Now run the program. What happens? The screen is cleared and the CLEAR TEST message appears at the top of the screen. Remember, the program simply cleared the screen and printed this message. (The usual READY message appears, too.) When this short program is finished, the computer is ready to do something else.

The clear-the-screen operation is quite useful to programmers. It is often used to clear the screen at the start of a program, or to clear it when a program has been run. You can use it whenever you need a clear screen.

TYPING SPECIAL SYMBOLS

When computer programs are provided as part of an experiment or problem, it would be confusing to see special symbols, such as a "reversed heart," in the program listing. The special symbols are not on the keyboard, so you might get confused trying to print them on the TV screen. When we provide computer programs for you to type in, you'll see the *keys* that you are to press instead of the special symbols. For example:

```
10 PRINT "[SHIFT][CLR/HOME]"
```

However, if you list this, you'll see:

```
10 PRINT "☐"
```

If a program is complicated, we'll show you a complete *program listing*, so you can compare your program with the one provided in the experiment. Just remember that you'll have to *press and hold*

the SHIFT or CTRL key when either one is shown in a program line.

PLAYING FOR POSITION

In several of the experiments you did in previous chapters, you found that it was fairly easy to display numbers in a column on the left side of the TV screen. The Commodore 64 can also display numbers across the screen, in a row. When the Commodore 64 finishes a PRINT command it always places the cursor at the left side of the line below it. This automatically gives the computer a "clean" line on the TV screen for the next PRINT command. This is called a "line feed," and it is an automatic part of the PRINT command.

However, you can tell the computer that you don't want a "clean" line, so that printing will continue on the same line, instead. To keep the computer printing on the same line, you must put a semicolon at the end of the PRINT command. Here's an example:

```
670 PRINT "ONE LINE";  
680 PRINT " OF PRINT"
```

After the computer prints ONE LINE on the TV screen, instead of moving the cursor to the left side of the line below, it leaves the cursor right after the E in LINE. When it reaches the following PRINT command, it continues printing OF PRINT right after ONE LINE. The result is ONE LINE OF PRINT, printed on a single line on the TV screen. The semicolon at the end of line 670 "told" the computer to leave the cursor where it was and not to go to a clean line.

Here's another example that shows how semicolons may be used to keep the computer printing on one line:

```
240 RZ = 2500  
250 PRINT "SCORE =";  
260 PRINT RZ;  
270 PRINT "POINTS"
```

This causes the computer to print a single line on the TV screen:

```
SCORE = 2500 POINTS
```

Experiment No. 5-2. Printing in Columns and Rows

In this experiment you'll see how a semicolon can be used with a PRINT command to tell the computer to print in rows instead of

columns. Clear your computer for a new program and type in the following program:

```
10 PRINT X
20 X = X + 1
30 GOTO 10
```

Run the program. What do you see on the TV screen? Increasing numbers are displayed on the left side of the TV screen. Change line 10 in the program by typing in the following. Remember the semicolon at the end of the PRINT command:

```
10 PRINT X;
```

Your complete program should now look like this:

```
10 PRINT X;
20 X = X + 1
30 GOTO 10
```

Run the program. What do you see on the TV screen? The numbers are displayed across the screen, *line after line*. Stop the computer when the numbers reach 1000 or more. Are any of the numbers at the right "edge" of the TV screen "broken," or are only complete numbers displayed?

At first the numbers are in neat columns, but when the computer gets to 1000, some of the numbers are broken at the right edge of the TV display, and several lines look like this:

```
1 1012 1013 1014 1015 1016 1017 1
018 1019 1020 1021 1022 1023 1024
1025 1026 1027 1028 1029 1030 103
1 1032 1033 1034 1035 1036 1037 1
```

The numbers are not lined up in columns, and a whole screen of numbers looks very confusing. In the next section you will find out how to get the computer to print neat columns. In this experiment, we accomplished our goal of printing numbers across the screen rather than up and down one side.

THE TAB COMMAND

If you were running a program to help you balance a checkbook or put grocery prices on the TV screen, the "jumbled" display shown in the previous section would be very difficult to read and understand. Help is on the way. The TAB command can be used to

line up columns of numbers on the TV screen, and TAB is just short for "table." A printed "table" puts information in up-and-down columns that are easy to read, and the TAB command lets the computer display information in this easy-to-read form.

The TAB command uses a number that tells the cursor how far to move *from the left side of the TV screen*. For example, a TAB(9) command tells the cursor to move over nine spaces from the left side of the TV screen, while a TAB(15) command tells the cursor to move over 15 spaces from the left side of the TV screen. *The TAB command is used only as part of a PRINT command*. For example:

```
10 PRINT TAB(5) COST;
```

In this example, the computer moves the cursor over five spaces to the right and prints the *value* that has been labeled COST. Since a semicolon has been put at the end of the command, the cursor won't go on to a clean line below. Perhaps something else is going to be printed on the same line.

When using the TAB command, don't use any extra spaces between the word TAB and the parentheses, or the computer will not know what you mean. For example, this TAB command is incorrect:

```
TAB (9)
```

Experiment No. 5-3. Using the TAB Command

The purpose of this experiment is to show you how the TAB command can be used to control the display of information in neat columns that are easy to read.

Clear your computer for a new program and carefully type in the following program:

```
10 PRINT X;  
20 X = X + 1  
30 PRINT TAB(5) X;  
40 X = X + 1  
50 PRINT TAB(10) X  
60 X = X + 1  
70 GOTO 10
```

Be sure you have typed in the semicolons at the end of lines 10 and 30. Run the program. What do you find displayed on the TV screen? Three columns of numbers are displayed on the TV screen,

and the numbers should be easy to read in this form. Change line 50 in the program to the following:

```
50 PRINT TAB(15) X
```

What do you think will happen when you run the program? Run it and see. The right-hand column has been moved farther to the right. The TAB command is used when you want to have numbers, words, or other information displayed in neat columns that you can read without straining your eyes. If you decide to try the TAB command in a program, just remember that you can only use it with a PRINT command. The TV screen display for the Commodore 64 has 40 characters in each row.

MORE DECISIONS

In the previous chapter, you saw how the computer made decisions by using the IF-THEN command. This is a useful command, since it lets the computer test a statement to see if it is true or false. If the condition is true, the command following the THEN is done. Here's an example:

```
50 IF ALFA = 100 THEN PRINT "LIMIT REACHED": END
```

In this example, if the statement, ALFA = 100, is true, the computer prints LIMIT REACHED, and the program ends. If ALFA = 100 is found to be false (this means that ALFA is *not equal to 100*), then the computer continues to the next program line. Remember that ALFA is just a label that identifies a value saved by the computer.

The Commodore 64 has another type of decision-making instruction. While it's not as flexible as the IF-THEN command, it can be used in some cases to save time. This new command is the ON command, and it is only used to *test a value* to see if it is equal to 1, 2, 3, 4 and so on up to a maximum value of 255. What does the ON command do once it has done the test? Look at this example:

```
100 ON ALFA GOTO 155, 300, 950
```

ALFA is first tested to see if it is equal to 1. If it is, the computer goes to line 155 in the program. If ALFA is not equal to 1, the computer tests to see if it is equal to 2. If it is, the computer goes to line 300 in the program. If the value isn't 2, the computer tests to see if it is equal to 3. If it is, the computer goes to line 950.

If the value is not 1, 2, or 3, the computer just keeps going in the program. A flowchart for this ON command is shown in Fig. 5-1.

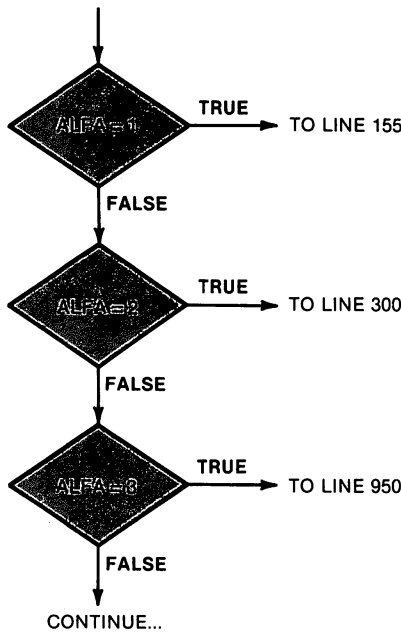


Fig. 5-1. Flowchart for an ON command.

In this example, the ON command only tested the *three values*, 1, 2, and 3, since there were only *three line numbers* after the GOTO part of the command. The ON command always starts testing with a value of 1, and it runs as many tests as there are line numbers in the ON command. How could the ON command be used in a program? Many programs ask you to type in a number; to answer a multiple-choice problem, to move a player in a game, or to select a special action from a list. In the following example, the computer user has been asked to type in a number to tell the computer which one of several programs to run. The choices are:

1. ROAD-RACE GAME
2. MATH PROBLEMS
3. BUSINESS PROBLEMS
4. PHONE NUMBER FILE

Here are several program lines that could be used to “select” the

program to be run. To make this simple, the program steps for each of the choices haven't been shown:

```
200 PRINT "TYPE YOUR CHOICE"  
220 INPUT CHOICE  
240 ON CHOICE GOTO 1250, 3570, 5790, 7100  
260 GOTO 200
```

```
1250 REM START OF ROAD-RACE GAME PROGRAM  
1255 Etc . . .
```

```
3570 REM START OF MATH PROBLEMS FOR KIDS  
3575 Etc . . .
```

```
5790 REM BUSINESS CALCULATIONS PROGRAMS  
5795 Etc . . .
```

```
7100 REM PHONE NUMBER AND ADDRESS FILES  
7120 Etc . . .
```

In this example, if the CHOICE typed in is not 1, 2, 3, or 4, the computer reaches the GOTO command at line 260 and it asks you to type in another choice. This is an important part of the program, since it prevents the computer from taking any unplanned action when some number other than 1, 2, 3, or 4 is typed in. This is called an "error trap," since it "traps" numbers that can't be used for choices. Some programs use very complicated "error traps" so that programs can't be "messed-up" by someone who types in something a bit unusual.

When a computer asks you to tell it what you want it to do by listing several choices, this list is called a *menu*. Many programs use menus so that you can select one action from a list. When you hear people talk about a program that uses a *menu*, this list of choices is what they are talking about.

You can probably see that the ON command is limited in what it can do, but it can be used to replace many IF-THEN commands:

```
IF CHOICE = 1 THEN GOTO 1250  
IF CHOICE = 2 THEN GOTO 3570  
IF CHOICE = 3 THEN GOTO 5790  
IF CHOICE = 4 THEN GOTO 7100
```

There is no reason why some of the line numbers in an ON command can't be the same. In the following example, if the value

labeled CANS is 3 or 5, the computer goes to the same line in the program:

```
100 ON CANS GOTO 155, 200, 890, 1550, 890
```

COUNTING LOOPS — THE FOR-NEXT COMMAND

When we were discussing the IF-THEN command, we showed you how it could be used to get the computer out of a loop after it had gone through it a set number of times. The following program shows how an IF-THEN command can control a loop program so that "YOUR NAME" is printed on the TV screen five times:

```
10 T = 1
20 PRINT "YOUR NAME"
30 IF T = 5 THEN END
40 T = T + 1
50 GOTO 20
```

Computer programmers would say that the computer made five "passes" through this loop. "Pass" is a word used when we are talking about loops, and it means that the computer has made a "trip" through the program loop.

Using an IF-THEN command to count passes through a loop is not very efficient, since you have to program the computer to count each pass and check to see if the limit has been reached. The FOR-NEXT command is used just to count passes through loops, and a *loop counter* is built right into it. The FOR-NEXT command has two parts: a FOR command at the start of the loop and a NEXT command at the end of the loop. Here is how a FOR command starts a loop:

```
50 FOR GAME = 1 TO 10
```

The FOR operation first sets up a *loop counter* that has been labeled GAME in this example, but almost any label can be used. The example shown sets the counter to 1, and sets the maximum loop count to 10. The loop count has 1 added to it after each pass through the loop, so you can see that the computer will make 10 passes through this loop, with loop counts of 1, 2, 3, and so on up to 10.

The NEXT command is put at the end of the loop:

```
100 NEXT GAME
```

This tells the computer that it has reached the end of the loop.

The computer then adds 1 to the loop counter (GAME) and checks to see if it has gone through the loop 10 times. When all 10 passes through the loop have been made, the computer continues with the program line that follows the NEXT command. Here is how a FOR-NEXT command can be used:

```
50 FOR LTR = 1 TO 12
70 PRINT "I LOVE YOU!"
100 NEXT LTR
120 PRINT " JACK"
```

When this program is run, it prints the message, I LOVE YOU!, on the screen 12 times, followed by JACK: a computerized Valentine. A flowchart for this program is provided in Fig. 5-2.

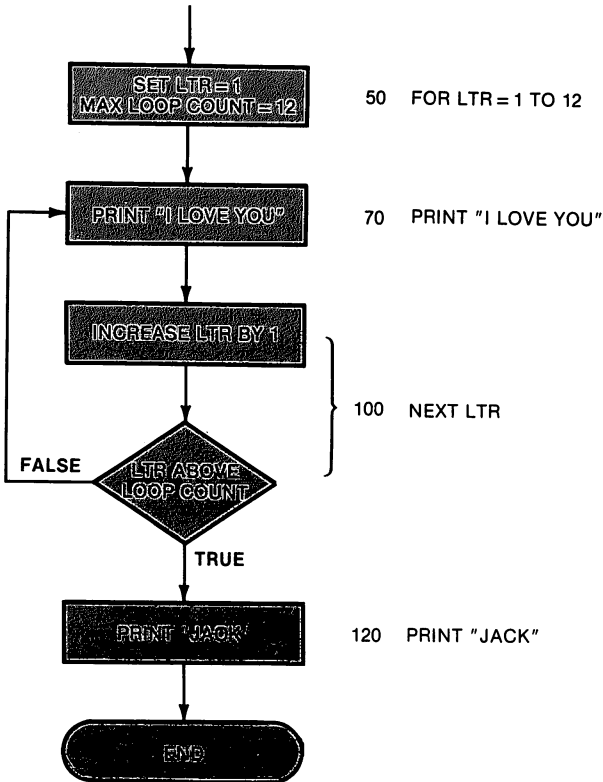


Fig. 5-2. Flowchart for a FOR-NEXT operation.

The PRINT command at line 70 has been indented several extra

spaces so you can quickly identify the steps in the loop. This is a simple thing to do, and it lets you immediately identify the loop operations. If you decide to write programs that use loops, use the indentations. It helps keep track of what's going on.

Experiment No. 5-4. The FOR-NEXT Loop

This experiment shows you how the FOR-NEXT command can be used in programs to count passes through loops. Clear your computer for a new program and type in the following program:

```
10 FOR TR = 1 TO 10
50 PRINT "NAME"
90 NEXT TR
```

Run the program. What happens? You should see the message, NAME, printed on the TV screen 10 times. Go back and change line 50 so the computer will print your first name. Run the program again to be sure it works correctly.

How can you change the program so the computer goes through the loop 100 times? Just set the upper limit of the loop count to 100. Change line 10 in your program so that it is now:

```
10 FOR TR = 1 TO 100
```

Run the program. Did the computer display your name 100 times? Did you really count all of them? It's probably difficult to tell, since the display moved so quickly. It would be difficult to try and count names as they flash by.

You can display the value of the loop count along with your name, since the count has been given a label. This will let you keep track of the number of passes the computer has made through the loop. Add the following line to your program so that the loop count is displayed on the TV screen:

```
60 PRINT TR
```

Here is a listing of the complete program for you:

```
10 FOR TR = 1 TO 100
50 PRINT "NAME"
60 PRINT TR
90 NEXT TR
```

Run the program. Can you see the numbers as they flash by on the TV screen? They are hard to see, but 100 should be the last number displayed.

To convince you that the computer made 100 passes through the loop, try this: run the program again, but right after you start it, press the CTRL key and hold it down. What happens to the TV display? The display slows down so you can see what is happening on the TV screen. You can press the CTRL key to slow down the rate at which information is displayed on the TV screen.

You can also slow the TV display by giving the computer something else to do. Add the following line to your program:

```
70 FOR P = 1 TO 120 : NEXT P
```

Now run the program. Don't press the CTRL key this time. What has happened? The display has been slowed so you can read the numbers on the screen. Do you know why the added program line slowed the display? The added program line is a loop, too, but the FOR and NEXT operations have been put on one line, separated by a colon. Here's what they look like when they are written one over the other:

```
70 FOR P = 1 TO 120  
80 NEXT P
```

This loop doesn't have anything to do between the FOR and NEXT commands, so it's often called a "do-nothing" loop. It just causes the computer to go through this simple loop 120 times. Although the computer can do things quickly, making it do "nothing" 120 times slows it down quite a bit. This type of do-nothing loop is also called a *time-delay* loop, and it is often used to slow the computer so you can keep up with it.

Let's do one last thing with this program. Add a command so you can type in the number of loops that the computer is supposed to do. Here is the line to put in your program:

```
5 INPUT "LOOPS"; LP
```

Now change line 10 to:

```
10 FOR TR = 1 TO LP
```

List your program. It should look like this:

```
5 INPUT "LOOPS"; LP  
10 FOR TR = 1 TO LP  
50 PRINT "NAME"  
60 PRINT TR  
70 FOR P = 1 TO 120 : NEXT P  
90 NEXT TR
```

The number of passes that you want the computer to make through the loop is now typed in from the keyboard. Run the program and type in a value for LOOPS. Since the time delay FOR-NEXT line (line 70) is still in your program, it will take quite a while for the computer to make a million passes through the loop, so keep your number below a thousand.

Can you take the time delay loop out of your program? You should be able to. How do you stop the program before all the passes have been done?

A REAL USE FOR A LOOP

There are many times when an *average* of several values is needed. Remember that the *average* of several values is simply the sum of the values divided by the *number of values added together*. This type of calculation is used to calculate the average balance in a checking account, the average cost of groceries over several months, the average cost of gasoline for a year, and so on. There are many uses for this type of program.

The following program can be used to figure or "compute" the average of values that are typed in from the keyboard. Let's say that we're averaging a family's grocery bills for a month. Since the number of bills will be different from month to month, it is helpful to be able to type in the number of bills that are to be averaged. This program is very flexible and you can use it to average many other things. If you want to, you can type it into your computer and try it. You don't have to type in the REM line, line 15:

```
10 PRINT " "
15 REM THIS CLEARS THE SCREEN
20 INPUT "NUMBER OF VALUES ="; NV
30 SUM = 0
40 FOR LP = 1 TO NV
50   INPUT "VALUE ="; V
60   SUM = SUM + V
70 NEXT LP
80 PRINT "AVERAGE IS" SUM / NV
90 GOTO 20
```

If you decide to try this program, try averaging the following three values to test the program: 85.90, 97.50, and 68.72. The average is 84.04.

Several important things happen in this program. It lets you

type in the number of values that are to be averaged. This number is labeled NV and it is used in the FOR command at line 40. This sets up the loop counter and also the maximum number of passes through the loop, or NV. The values to be averaged are input at line 50. Once a value has been input, it is added to the running total, or SUM, and to get the *average value*, the SUM is divided by the number of values, NV, at line 80. This line also prints the average on the TV screen.

NESTED LOOPS

You have probably used sets of measuring cups that could be placed one inside the other to make a neat stack that can be easily stored. Program loops can be placed one inside the other, too. Let's look at a program that uses two loops, one inside the other. In this program, one loop simply prints the numbers 1 through 10 on the TV screen, while the other loop prints five asterisks between each number. Here is the program:

```
10 FOR N = 1 TO 10
20 PRINT N
30 FOR T = 1 TO 5
40 PRINT "*";
50 NEXT T
60 PRINT
70 NEXT N
80 GOTO 10
```

Let's look at this program, starting with the inner loop that prints the five asterisks. Here it is:

```
30 FOR T = 1 TO 5
40 PRINT "*";
50 NEXT T
60 PRINT
```

A flowchart for this program is shown in Fig. 5-3. The FOR command sets up the loop for five passes, and the computer prints five asterisks on the same line. The semicolon keeps the printing on the same line. The PRINT command at line 60 is not part of the FOR-NEXT loop, and it doesn't "print" anything. It's just used to return the cursor to the left side of the line below so that the next number will be printed on a "clean" line.

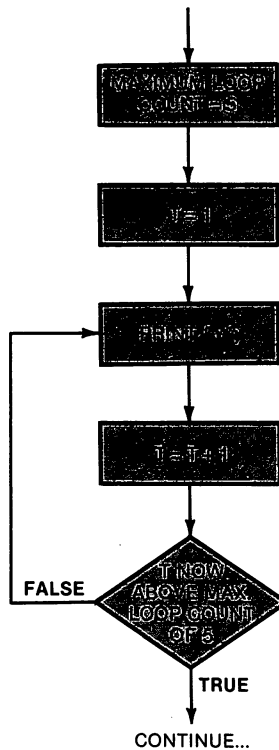


Fig. 5-3. Flowchart for the "five asterisk" loop.

Now take this loop out of the program and look at what's left:

```

10 FOR N = 1 TO 10
20 PRINT N

```

```

70 NEXT N
80 GOTO 10

```

This is a simple loop, too, and it is shown in the flowchart in Fig. 5-4. The loop has been set up for 10 passes, and since the label N has been used to identify the loop count, you can print the loop count, too. The GOTO command at the end of the loop simply tells the computer to go back and start the program over again. A complete flowchart for the program is shown in Fig. 5-5.

When loops are used this way, one inside another, they are said to be "nested," and programmers use nested loops often. The

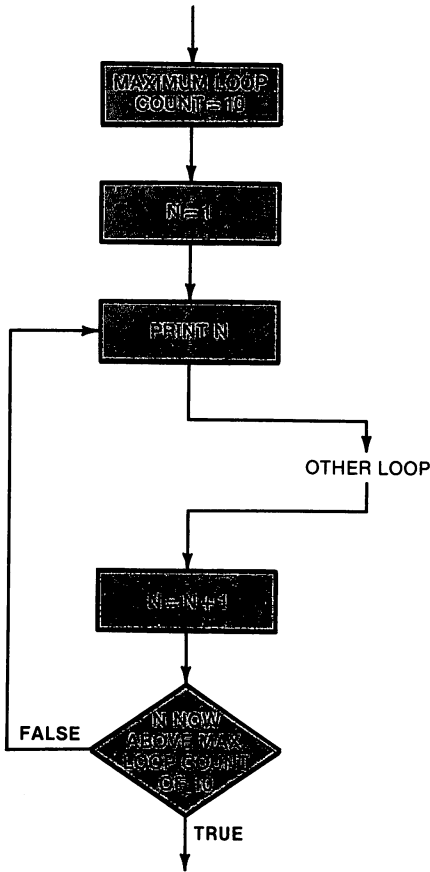


Fig. 5-4. Flowchart for the main printing loop.

“smallest” loop is called the “inside” loop and the “largest” loop is called the “outside” loop. Since an indented program listing was used in this example, it shouldn’t be hard to tell the loops apart.

Let’s look at another program that uses nested loops, but if you’ve had enough of them, you can go on to the next section.

Although the next program looks complicated, it just uses two nested loops like those shown in the previous example, but there are more things done in each loop. This program was written by a housewife who wanted to do more than just average her food costs each month. This program also tells her the total amount spent on groceries over several months and the average spent each month.

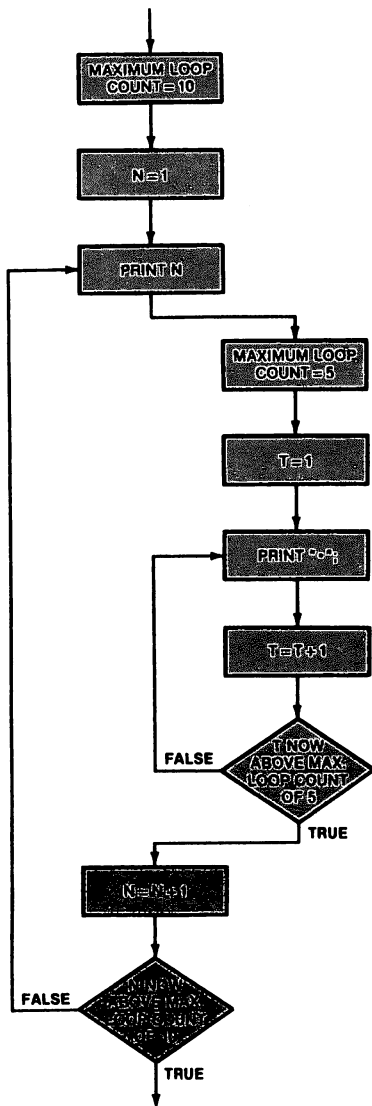


Fig. 5-5. Flowchart for the complete printing program.

The illustration in Fig. 5-6 shows what the program calculates for the three monthly grocery bills. You can break this program into smaller pieces if you want to look at it in detail. Here's the program:

```

RUN
GROCERY BILL PROGRAM
NUMBER OF MONTHS TO AVERAGE? 3
NUMBER OF BILLS THIS MONTH? 3
AMOUNT =? 100
AMOUNT =? 75
AMOUNT =? 50
MONTHLY AVERAGE IS 75
NUMBER OF BILLS THIS MONTH? 4
etc...

TOTAL OF ALL BILLS IS 486.95
AVERAGE COST PER MONTH IS 223.98

```

Fig. 5-6. Typical printed output from the grocery-bill program.

```

100 PRINT "GROCERY BILL PROGRAM"
120 INPUT "NUMBER OF MONTHS TO AVERAGE"; NM
140 TTL = 0
160 FOR M = 1 TO NM
180   INPUT "NUMBER OF BILLS THIS MONTH"; NB
200   SUM = 0
220   FOR B = 1 TO NB
240     INPUT "AMOUNT ="; AMT
260     SUM = SUM + AMT
280   NEXT B
300   PRINT "MONTHLY AVERAGE IS" SUM / NB
320   TTL = TTL + SUM
340 NEXT M

```

```
360 PRINT "TOTAL OF ALL BILLS IS" TTL
380 PRINT
400 PRINT "AVERAGE COST PER MONTH IS" TTL/NM
```

TAKE ONE GIANT STEP

Let's look at a slightly different use of FOR-NEXT loops. In the FOR-NEXT loops that you've seen so far, 1 is added to the loop count each time the computer passes through the loop so the computer can tell how many passes it has made. There may be times when you'd like to add some value to the loop count other than 1. You can do this simply by telling the computer what you want added to the count. Here's an example:

```
100 FOR TR = 1 TO 200 STEP 3
```

In this case, the computer adds 3 to the count after each pass through the loop. So, the loop count would be 1, 4, 7, and so on. If you don't tell the computer what size "step" is being used, it simply adds 1 to the count after each pass through the loop.

Since the maximum loop counter value in this example has been set to 200 in the FOR command, what happens as the loop count increases toward 200? When counting by 3s, the count looks like this:

```
. . . 187, 190, 193, 196, 199
```

In this case, the computer gets out of the loop after reaching a count of 199, since the next value, 202, is greater than 200. Remember that a *maximum* loop count of 200 was set up in the FOR command.

Do you want to count to 100,000 by 17s? Here's a program that does it for you:

```
100 FOR C = 1 TO 100000 STEP 17
110 PRINT C
120 NEXT C
```

The computer quits at 99995, since the next value (100012) puts it over the 100000 mark.

Loops don't have to start with a count of 1. Any other value can be used, as long as the maximum value is greater than the starting value. The following program goes through this loop *six* times:

```
250 FOR TX = 15 TO 20
```



```
260 PRINT "HAVE FUN"  
270 NEXT TX
```

Remember, the loop counts would be 15, 16, 17, 18, 19, and 20!
Loops can count down, too. Here's an example that we'll let you think about:

```
1020 FOR XZ = 100 TO 50 STEP -1  
1030 PRINT XZ  
1040 NEXT XZ
```

In this program, the loop count starts at 100. This is *higher* than the final loop count, which is set at 50. How can this be? Well, the step has been set at -1 , which simply means that the loop count will have *1 subtracted from it each time the computer goes through the loop*. So, the first count is 100, the next count is 99, and so on. The loop is finished when XZ gets to 50.

SUBROUTINES TO THE RESCUE

We all do routine jobs, again and again, but at different times and places; making a bed, fixing a sandwich, and mowing a lawn are things we do frequently. Many computer programs have operations that do the same thing, but at different times and places in a program. Let's look at an example.

An office-cleaning service uses a computer program to do these three things:

1. Print bills to be sent to customers.
2. Print letters typed by a secretary.
3. Print envelopes.

The computer prints the company's name and address on each bill, letter, and envelope. Do the three parts of the program each have instructions to do this printing? Probably not, since it is wasteful of both the computer's time and the programmer's time to duplicate the same program steps three separate times. It is better to put the part of the program that prints the name and address in one place and let the different parts of the program share it. This is shown in Fig. 5-7. You can see that when the printing subroutine is shared, the program is shorter and any errors or changes are limited to one part of the program.

Although our example may be a bit simple, this program-sharing technique is common. When programmers are writing long com-

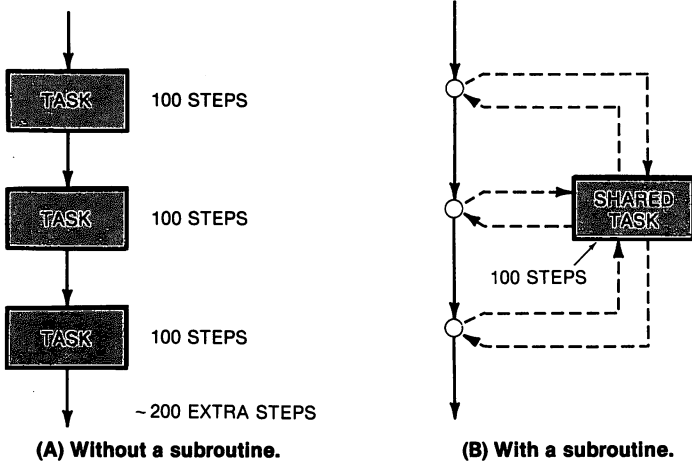


Fig. 5-7. Using a subroutine saves program space and limits errors.

plex programs, they like to save as much time and energy as possible, so they look for tasks that can be shared. These shared tasks are called *subroutines*, and they provide a way of simplifying and shortening programs.

Here is another example of how a subroutine could be used. A hardware store manager uses a computer to keep track of the products he sells. The products have been given part numbers between 1 and 10000, so that the computer can tell one from another. The product numbers are used by different parts of the hardware-store program, so a *subroutine* is used to get the product number from the computer keyboard whenever it is needed. Simple INPUT commands could have been used throughout the program, but the programmer decided to check the number to be sure it is in the range 1 to 10000. This takes more program steps, so why spend time duplicating these steps (and any errors) throughout the program, when the program can share one set of instructions that is easy to get to? Here's what the steps might look like:

```

2000 PRINT "TYPE THE PART NUMBER"
2020 INPUT PN : PN = INT(PN)
2040 IF (PN < 1) OR (PN > 10000) THEN PRINT
    "OUT OF RANGE": GOTO 2000

```

When a number is typed in, the computer uses the INT command to remove any decimal fractions that might have been typed

in by accident. The IF-THEN operation checks to be sure the number is between 1 and 10000. If it is outside this range, the message, "OUT OF RANGE," is printed and the user gets another chance to type it in. This "traps" any incorrect numbers. Other types of errors could be checked for, too.

Whenever the programmer needs a part number for a task, he can "tell" the computer to go to this number-input subroutine and get it. Programs use a GOTO command to point the computer to a specific program line, and there is a similar instruction for subroutines. This is the go-to-subroutine, or GOSUB instruction, and a line number is used with it to tell the computer where the subroutine is. Unlike a GOTO command that simply tells the computer, "Go to a specific place," the GOSUB command tells it, "Go, but remember to come back when you're done."

A RETURN instruction is used at the end of every subroutine to tell the computer that it's time to go back to the main program. Here's what the complete number-input subroutine would look like:

```
2000 PRINT "TYPE THE PART NUMBER"  
2020 INPUT PN : PN = INT(PN)  
2040 IF (PN < 1) OR (PN > 10000) THEN PRINT  
    "OUT OF RANGE": GOTO 2000  
2060 RETURN
```

And here is how the main program would point the computer to it:

```
250 GOSUB 2000  
260 etc . . .
```

Now, whenever the programmer needs to have a part number typed in from the keyboard, he can simply use the GOSUB 2000 command to get it. He doesn't have to retype all of the input and error-checking steps. Subroutines are very useful to programmers.

Let's do an experiment to see how a subroutine can be used in a program to save programming time.

Experiment No. 5-5. Using a Subroutine

In this experiment, you'll see how a subroutine can be used for a simple task, and how the subroutine can be used at several places in a program. Clear your computer for a new program, and type in the following subroutine:

```
2000 FOR P = 0 TO 39
```

```
2010 PRINT "*";
2020 NEXT P
2030 RETURN
```

Do you know what this subroutine will do? Let's just run the subroutine and see. Type GOSUB 2000 [RETURN] and see what happens. You should see a line of asterisks across the TV screen. If the asterisks go down the screen instead, you forgot the semicolon at the end of the PRINT command at line 2010.

Now let's use the subroutine in a program. Add the following lines to the ones already in the computer:

```
100 FOR L = 1 TO 10
110 PRINT L
120 NEXT L
130 GOSUB 2000
140 END
```

The complete program will look like this when you list it:

```
100 FOR L = 1 TO 10
110 PRINT L
120 NEXT L
130 GOSUB 2000
140 END
```

```
2000 FOR P = 0 TO 39
2010 PRINT "*";
2020 NEXT P
2030 RETURN
```

Run the program. You can type RUN or RUN 100. You can give the computer a specific line number in RUN, GOTO, or GOSUB commands that you type in from the keyboard if you want the computer to start at a particular place in a program, rather than at the lowest line number.

What is displayed on the TV screen when the program is run? You should see the numbers 1 through 10 displayed down the left side of the TV screen, with a row of asterisks across the screen below them. Now add the following lines to your program:

```
140 FOR Q = 1 TO 3
150 PRINT "C64"
160 NEXT Q
170 GOSUB 2000
180 END
```

The complete program, including the subroutine, should look like this:

```
100 FOR L = 1 TO 10
110 PRINT L
120 NEXT L
130 GOSUB 2000
140 FOR Q = 1 TO 3
150 PRINT "C64"
160 NEXT Q
170 GOSUB 2000
180 END

2000 FOR P = 0 TO 39
2010 PRINT "*";
2020 NEXT P
2030 RETURN
```

Run the program. You should see a display like this on the TV screen:

```
1
2
3
4
5
6
7
8
9
10
*****
C64
C64
C64
*****
```

In this experiment, the subroutine has been used to do a simple task; print 39 asterisks across the TV screen. However, it saved programming time and effort, since the same asterisk-printing instructions were used twice in the program. This meant that you didn't have to duplicate or copy the program lines that printed the asterisks across the TV screen when they were needed again. You simply used the GOSUB 2000 command.

Can you think of other tasks that might be done by using subroutines instead of writing the same program steps over and over again? Special math operations might be put in subroutines; for example, figuring sales tax.

Subroutines are very useful, even in short programs where it is necessary to have the computer do the same thing again and again. The task might be as simple as printing a line of asterisks across the screen, or it might be as complex as figuring how to point a telescope at a particular star in the night sky.

LOTS OF INFORMATION

There are many times when we need to have the computer store more than one or two pieces of information. In all of our previous examples, we have shown you how the computer uses labels to identify information and save it for use somewhere else in a program. This has worked out well so far, but there is a limit to the amount of information that can be stored this way.

Let's assume that we are running tests on flashlight batteries to see how long they last. We put the batteries in a flashlight and leave it on, and we keep a record of how long it takes for the light to go out. If we wrote the results on paper, they might look like this:

Battery type 1, 5½ hours
Battery type 2, 4¾ hours
Battery type 3, 6 hours

How can we use the computer to store the test results for eight kinds of batteries? A program could be written using eight different labels: B1, B2, B3, and so on. That seems to do the trick, but we still have to get the information into the computer. Since eight different labels have been used, one for each type of battery, we'll need *eight INPUT commands*:

```
160 INPUT "B1 VALUE"; B1
180 INPUT "B2 VALUE"; B2
200 INPUT "B3 VALUE"; B3
220 INPUT "B4 VALUE"; B4
240 INPUT "B5 VALUE"; B5
260 INPUT "B6 VALUE"; B6
280 INPUT "B7 VALUE"; B7
300 INPUT "B8 VALUE"; B8
```

Imagine testing 100 batteries and trying to save the test times this way! Computers would lose a lot of their power if we had to set up programs with many input commands such as those shown. There is a better way to store this kind of information.

The computer can easily store a lot of information, and you can think of it being stored in a chest of drawers, as shown in Fig. 5-8.

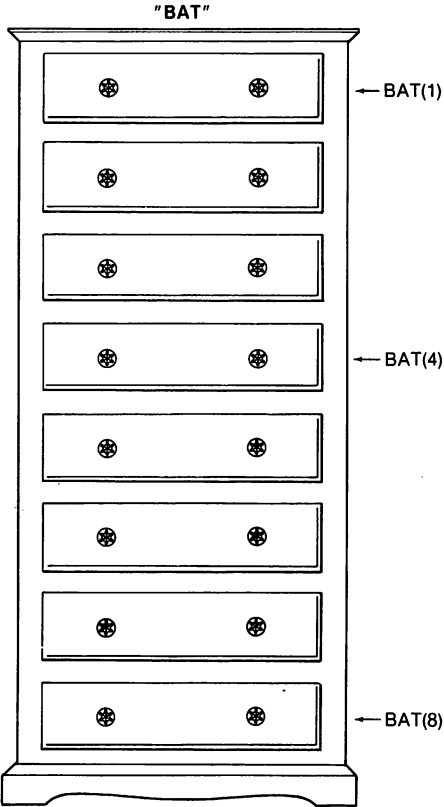


Fig. 5-8. An array of information is organized like a set of drawers.

Each drawer has been numbered and can hold a piece of information. The chest is given a "name" so you can identify *all* of the information stored in it.

In computers, this is called a *table* and it is given a name, too. Individual pieces of information in the table are given a number to identify them. So, each piece of information in a table can be identified using the name of the table and the number where it is located.

Here's what a table might look like:

TABLE "BAT" — BATTERY TEST TIMES

Battery Type	Test Time
1	5½ hours
2	4¾ hours
3	6 hours

This table has been named BAT, and the test information has been put in it as BAT(1), BAT(2), BAT(3), and so on for each type of battery tested. The number in parentheses identifies or "locates" each piece of information. When the computer "sees" a label followed by a number in parentheses, such as BAT(7), it knows this is the seventh value in the BAT table. A table like this is also called an *array of information*, or just an *array*, and it's nothing more than an orderly arrangement of information.

However, it might still look as though individual INPUT commands are needed to get this information into the computer:

```
160 INPUT "B1 VALUE"; BAT(1)
180 INPUT "B2 VALUE"; BAT(2)
```

and so on.

When an *array* or a *table* is used, you can get at the different pieces of information by using the name of the table and a *label* in place of the number in the parentheses. For example, the program line:

```
20 INPUT BAT(1)
```

does the same thing as these:

```
10 TEST = 1
20 INPUT BAT(TEST)
```

The only difference is that a label has been used in place of the number in the second set of instructions. You can use many different types of instructions to change a labeled value so the computer can quickly locate information in a table, or array. Here's an example of how an array can be used to store eight values typed in from the keyboard. The program has been kept simple:

```
10 FOR TEST = 1 TO 8
20 INPUT BAT(TEST)
30 NEXT TEST
```

You're familiar with the FOR-NEXT loop, and you can see that

the computer will go through this loop eight times. When the computer goes through the loop the first time, the value of the loop counter, TEST, is 1, so at line 20 the computer is really doing this:

```
20 INPUT BAT(1)
```

This means that the first value typed in becomes the first value in the BAT table. When the computer goes through the loop the next time, the loop counter is equal to 2, so the the second value input is labeled BAT(2). The computer goes through this loop eight times, storing eight values in the BAT table. They are stored as BAT(1), BAT(2), and so on up to BAT(8). You can get them out of the table just as easily. Let's do an experiment to see how the computer can store and get values using a table.

Experiment No. 5-6. Using an Array or Table

In this experiment, you will use a simple program to store an array in the computer. Clear your computer and type in the following program:

```
10 FOR TR = 1 TO 8
20 INPUT BAT(TR)
30 NEXT TR
```

Now run the program. When the computer displays a question mark on the screen, type in the value 1. Remember to press [RETURN]. Now type in values of 2, 4, 8, 16, 32, 64, and 128 for the other question marks. Your TV screen should look something like

```
RUN
? 1
? 2
? 4
? 8
? 16
? 32
? 64
? 124
```

```
READY.
```

The eight values are stored in the array labeled BAT. How can you display one of these values on the TV screen? You can simply

type PRINT BAT(4) to get the fourth value printed on the TV screen. Go ahead and do this. Is the correct value displayed on the TV screen? The number 8 should be displayed, since it is the fourth value you typed in. You can display the other values this way, too. Just use a PRINT command followed by the label for the array and the location of the value in parentheses. Try to display two or three of the other values; for example, type in PRINT BAT(7).

Add the following program lines to your program. Just type them in as shown:

```
40 SUM = 0
50 PRINT "VALUES ARE:"
60 FOR X = 1 TO 8
70   PRINT "VALUE" X" IS" BAT(X)
80   SUM = SUM + BAT(X)
90 NEXT X
100 PRINT "TOTAL IS" SUM
```

Here is the complete program:

```
10 FOR TR = 1 TO 8
20   INPUT BAT(TR)
30 NEXT TR
40 SUM = 0
50 PRINT "VALUES ARE:"
60 FOR X = 1 TO 8
70   PRINT "VALUE" X "IS" BAT(X)
80   SUM = SUM + BAT(X)
90 NEXT X
100 PRINT "TOTAL IS" SUM
```

Run this program. After you type in the eight values, the computer displays them for you. It also gives you the "location" of the value in the table, and the total is displayed.

Run the program again, but use some different numbers. You can check your results by using a calculator, if one is available. Can you change the program so that the array is set up to store only five values? You can try this if you want to.

This experiment shows you how the computer can be used to store information in a table, and you have seen how the computer can recall the information that it needs. You should be able to see that using an array is much easier than using individual labels and INPUT commands to type in many pieces of information.

THE SIZE OF YOUR ARRAYS

When arrays are used, they are given a name, and a number in parentheses is used to "locate" a stored value. When a number is used this way with the label or name of an array, it is called a *subscript*. In the Commodore 64, you can have arrays with *subscripts* from 0 through 10, so 11 pieces of information can be stored. In the previous examples, arrays started with the subscript 1, since it's easy to remember that the first value is XYZ(1).

You can have larger arrays, *but you must tell the Commodore 64 the maximum size of the array* before you try and use it. To set up a large array, you use the dimension command, DIM, and follow it with the name of your array and the *maximum* subscript that you plan to use. For example, an array named CHECKS with 100 pieces of information would be set up with this command:

```
10 DIM CHECKS(100)
```

Actually, 101 places in the array can be used, but let's assume that we start storing information at CHECKS(1), instead of at CHECKS(0). If you see a DIM command in a program, you'll understand that the programmer is simply telling the computer that an array is going to be used to store information. This doesn't mean that you must use all of the locations in an array for information. At some times, the array may contain only a few pieces of information, while at others it may be filled. The DIM command just tells the computer the array's *maximum* size.

You can set up several arrays at the same time, for example:

```
10 DIM CHECKS(50), AMOUNTS(50), DATES(50)
```

This statement sets up three arrays that can hold up to 50 pieces of information in each. Perhaps a checking account program is going to use arrays to store information. The arrays are always set up with a DIM command right at the start of the program. In fact, this is the first thing done in a program if an array is going to be used. Remember that you can set up and use an array with a subscript of up to 10 without using the DIM command. If you want to store more information, you'll have to use the DIM command.

A SPECIAL KIND OF ARRAY

Arrays or tables are very useful, since they let us store a lot of information in the computer. Let's assume that we want to store

the weights of the nine planets, Mercury through Pluto, in the computer so they can be used in an action game for kids. A loop could be set up so that the weights are typed in at the start of each game, but it would be a real bother to type them in each time the game is run. You could set up the weights in an array right at the start of the program; for example:

```
10 PLANET(1)=123456 : PLANET(2)=456789
```

and so on.

This can be a bother, too, and there's a better way to store this kind of information in a program. You can simply use a DATA statement in your program and put the weights of the planets in a single line:

```
100 DATA 123456, 456789, 1298098
```

and so on.

This simply tells the computer, "Store this information for later use, but don't give it a label, yet." By the way, most programmers put DATA statements at the end of their programs.

Now that the information has been stored in a DATA statement, you can get at it with a READ operation or command. The READ command simply reads each piece of information from the DATA statements as if it were reading it from a list of values. Once the information has been read, you can give it a label or use it in any way you want. When you use the READ command again in your program, *the second piece of information is read from the DATA statement*. In this way, you can put information right in your programs and use it one piece at a time. Let's do an experiment to see how this works.

Experiment No. 5-7. Using the DATA and READ Commands

The purpose of this experiment is to show you how the DATA and READ commands can be used. Clear your computer for a new program and type in the following program:

```
10 FOR T = 1 TO 4  
20   READ QX : PRINT QX  
30 NEXT T  
40 DATA 123, 456, 789, 88
```

Run the program. Are the data values displayed on the TV screen? They should be. You can change the four values in the data

statement if you want to and run the program again to see them printed on the TV screen.

The values in the DATA statement are really part of your program, and you cannot change them except by typing in a new program line. Change line 10 in the program to:

```
10 FOR T = 1 TO 5
```

Run the program. Are the values printed? What else is displayed on the TV screen? You should see an "error message" printed on the screen, since the FOR-NEXT loop tries to READ five values from the DATA statement, and there are only four values in it. The computer displays the following:

```
?OUT OF DATA ERROR IN 20  
READY.
```

You cannot read more information from a DATA statement than is really there.

DATA statements are very useful, since they let you store a great deal of information in the computer for later use. For example, if you are using the computer to play a space-war game, the weight of each planet and its size can be stored in a DATA statement. Two READ commands are used to read them. Instead of using values in this example, we'll just show you what would be stored in the DATA statement. Of course, the values would be used in a real program:

```
50 READ WEIGHT : READ SIZE  
60 DATA Weight of Mercury, Size of Mercury,  
Weight of Venus, Size of Venus, etc . . .
```

The first READ command reads the first value in the DATA statement, *Weight of Mercury*, and labels it WEIGHT. The next READ command reads the second value, *Size of Mercury*, and labels it SIZE. When the computer comes back to the READ commands, the READ WEIGHT command reads the third value in the DATA statement, *Weight of Venus*, and labels it WEIGHT. The READ SIZE command reads the fourth value, *Size of Venus*, and labels it SIZE. In this way, the weight and size of the planets are stored together, each being read in order by a different READ command.

Notice that you can assign any labels you want to the values the computer gets in the READ command or commands. *However, when DATA and READ commands are used, programmers must*

pay very careful attention to the order in which the information is stored and how it is read.

When a game or other program has finished, it may use a GOTO command to start over again. If this is done, the programmer must point the computer back to the start of the DATA statement, so it will "read" through the information again. The RESTORE command does this. For example:

```
10 READ RX : PRINT RX
20 RESTORE
30 READ RX : PRINT RX
40 READ RX : PRINT RX
50 READ FZ : PRINT FZ
60 etc . . .
```

```
100 DATA 12, 67, 99
```

In this example, the first READ RX : PRINT RX operation prints the value 12 on the TV screen. The computer gets ready to go on to the second value in the DATA statement, but the RESTORE command says, "No, go back to the first value." The READ RX : PRINT RX commands at line 30 print the value 12 again. The following READ command at line 40 gets the value 67 and it is printed. The READ command at line 50 gets the value 99 and it is printed, too. Note that this value is labeled FZ. You can use any labels you want to get information from a DATA statement.

The RESTORE command simply tells the computer to go back to the first value in the DATA statement. This is useful if you want to go through the information again. For long lists of information, you can use multiple DATA statements in your program. Here is an example:

```
200 DATA 200, 547, 6789, 2, 512, 43
220 DATA 400, 600, 53, 1, 0, 0, 45
```

The Commodore 64 sees this as a *continuous list* of 13 values.

QUESTIONS

1. You can use special "commands" in the message part of a PRINT command to get the computer to do keyboard-type operations. How would you get the cursor to its home position without clearing the screen?

2. How would you use two PRINT commands in a program to print something on a single line on the TV screen?
3. What is the TAB command, and how is it used?
4. What do you think would happen if you tried to do a PRINT TAB(15) "FUN"; and then a PRINT TAB(8) "TIME" on the same TV screen line?
5. What does the ON command do? What is tested by this decision-making command?
6. When would you use the ON command in a program?
7. What does the FOR-NEXT command do?
8. Can you use steps other than 1 with a FOR-NEXT command? What kinds of steps can be used?
9. What is a nested loop?
10. What is a subroutine? How might it be used?

11. What is an array? How is it used?
12. Why are arrays so flexible? How big can an array be?
13. What are the READ, DATA, and RESTORE operations used for?

PROBLEMS

1. Write a program that draws a diagonal line from the top left-hand side of the TV screen to about the middle of the bottom of the screen. (HINT: To draw the diagonal line, use the graphics character produced by a [SHIFT] M. This graphics character will be enclosed in quotes in a PRINT statement.)
2. Modify the solution to Problem 1 so that the line is drawn from the top right-hand side of the screen to the bottom left-hand side of the screen.
3. Write a program that flashes the message "THIS MESSAGE GETS YOUR ATTENTION" on the TV screen. The message should flash on and off between 1 and 3 times every second.
4. Write a program that causes the "heart" character ([SHIFT] S) to move from the center of the left-hand side of the TV screen, to the center of the right-hand side of the TV screen. Once the heart is on the right-hand side of the screen, the movement of the heart from left to right should be repeated.
5. Write a program that causes the following to be displayed on the TV screen:


```
ADD - 1
SUBTRACT - 2
MULTIPLY - 3
DIVIDE - 4
```

```
COMMAND ?
```

Once you enter a command number (between 1 and 4), the computer will ask you for two numbers, which will then be added, subtracted, multiplied, or divided, depending on the command (number) that you entered first. Once the result is displayed, the program should be repeated. For example,

```
ADD - 1
SUBTRACT - 2
MULTIPLY - 3
DIVIDE - 4
```

```
COMMAND ? 1
```

```
NUMBERS ? 3, 4
RESULT IS 7
```

```
ADD - 1
SUBTRACT - 2
MULTIPLY - 3
DIVIDE - 4
```

```
COMMAND ? 3
NUMBERS ? 3, 5
RESULT IS 15
```

6. Write a program that displays a multiplication table that contains all possible combinations of the numbers 1 through 3 times the numbers 10 through 13. Assume that multiplying 2 times 10 is the same as multiplying 10 times 2.
7. Write a program that calculates and displays all of the prime numbers between 1 and 100. A prime number is a number that can only be exactly divided by itself and by 1. Some examples of prime numbers are 2, 3, 5, 7, and 11. Nonprime numbers include 4 (which can be divided by 4, 1, and 2) and 12 (which can be divided by 1, 3, 4, 6, and 12).

8. Write a program that lets you enter between 2 and 20 numbers. These numbers are stored in the computer so that it can calculate and display the average of all the numbers (the sum of the numbers divided by the number of numbers entered), the lowest number entered, and the highest number entered. No calculations must be performed on the numbers as they are entered into the computer. All calculations must be performed after all numbers have been entered.
9. Write a program where a single "die" is thrown 100 times (there are two "die" in a pair of dice). Keep track of how many times a 1, 2, 3, 4, 5, and 6 is thrown, and at the end of 100 throws, display the total number of times each number was "thrown."
10. Write a program that is used to keep track of car sales for each of five salesmen. At the end of the month the computer should display the name of each salesman, along with the number of cars sold.
11. Write a subroutine that draws a playing card from a deck of cards. After the card has been drawn, the computer displays its suit (heart, club, diamond, or spade), along with its value of either 2 through 10, Jack, Queen, King, or Ace. (HINT: Assume that each card is given a value of from 1 to 13. Once a card is "drawn," somehow "mark it" so that it can't be drawn again.)
12. Write a program that lets you enter an amount of money in dollars and cents. The computer then displays the equivalent number of French francs, German marks, and English pounds. Assume that there are 7.49 francs, 2.48 marks, and .642 pounds per dollar. These values should be stored in a DATA statement, along with the name of the country and its unit of currency.

CHAPTER 6

STRINGS AND THINGS

In previous chapters, you saw how the computer used values in math and decision-making operations. Computers process values very quickly, doing thousands of math operations each second, and this is exactly what makes them so useful and powerful. Computers process strings quickly, too; sorting names on address lists, locating information in library records, and printing business reports. In this chapter, you'll see how your computer uses strings, combining them, taking them apart, and using them to make decisions.

Strings are simply groups of letters, numbers, punctuation marks, and other symbols, all of which we'll put under the heading of "characters." A string such as "TEST REPORT 12" cannot be given a numeric value, and this type of information cannot be processed by "multiplying" or "adding" it to some value. The Commodore 64 computer stores strings the same way it stores values. Both are given a label so that they can be identified for later use. Here are some examples of strings and the labels given them:

```
NAMES$ = "JIMMY SMITH"  
DATES$ = "MAY SIXTH"  
UNITS$ = "KILOGRAMS"
```

Each string label ends with a dollar sign, and the characters in the string are enclosed in quotes. As we said earlier, the last quote

mark isn't needed, but we like to use it to mark the end of a string. Since the Commodore 64 recognizes only the first two letters (or letter and number) of a label, the preceding labels and strings are the same as these:

```
NAS = "JIMMY SMITH"  
DAS = "MAY SIXTH"  
UN$ = "KILOGRAMS"
```

The Commodore 64 prints a value on the TV screen by using a PRINT command and a label, and it prints a string the same way. Here are two program lines that will display the word, KILOGRAMS, on the TV screen:

```
10 UNITSS$ = "KILOGRAMS"  
20 PRINT UN$
```

You can also use the computer to input a string of characters and store it for later use. The INPUT command does this, but you must remember to use a string label in the command. Here is how the INPUT and PRINT commands can be used in a program:

```
250 INPUT R$  
270 PRINT R$
```

When this program is run, individual characters are typed in and then the RETURN key is pressed. The RETURN key tells the computer that you have finished typing in your information, letting it go on to the next program step. The string of characters typed in is labeled R\$, and it can be used later in the program.

You can also put messages in the INPUT and PRINT commands that are used with strings to make them more useful. Here is another example:

```
250 INPUT "TYPE YOUR STRING"; R$  
270 PRINT "THE STRING IS . . ." R$
```

USING STRINGS

Your computer can do many useful things with strings, and we'll start by looking at how the computer puts strings together. You can think of the strings as characters printed on strips of paper. By using some adhesive tape, you can connect or put together these "strings" in many ways (Fig. 6-1). In the Commodore 64, strings are connected, or linked, by using the plus sign (+). The strings are



Fig. 6-1. Using strips of paper and tape to make up strings.

not "added" to one another, since this would be meaningless. When the plus sign is used with strings, it just means that the strings are *linked* to form a new string. Here is a program we wrote and ran to show you how this works:

```
10 FIRST$ = "KAREN"  
20 LAST$ = "SUMMERS"  
30 PRINT FIRST$ + LAST$  
RUN  
KARENSUMMERS
```

READY.

The two strings labeled FIRST\$ and LAST\$ are linked in the PRINT command so the computer prints KARENSUMMERS on

the TV screen. The computer does not insert any spaces between the strings. It prints exactly what is in the two strings.

There are no extra spaces in either string, so none are printed on the TV screen. If you want to have spaces printed in the strings, you must put them in each string. In this example, there is a space after KAREN, and one after SUMMERS:

```
10 FIRST$ = "KAREN "  
20 LAST$ = "SUMMERS "  
30 PRINT FIRST$ + LAST$  
RUN  
KAREN SUMMERS
```

READY.

If you don't include spaces or other special characters in your strings, they can be linked to the strings later. This example shows how an asterisk can be placed between the strings FIRST\$ and LAST\$:

```
10 FIRST$ = "KAREN"  
20 LAST$ = "SUMMERS"  
30 PRINT FIRST$ + "*" + LAST$
```

The result is KAREN*SUMMERS. The asterisk is a one-character string that has been put in between the FIRST\$ and LAST\$ strings. Other characters or strings can be linked this way, too.

When numbers or values are added, their order, or position, is not important. For example, $3 + 4$ gives the same result as $4 + 3$. When strings are linked, their order is *very* important. Here is a program example that shows what happens when strings are combined in different ways:

```
10 FIRST$ = "KAREN "  
20 LAST$ = "SUMMERS "  
30 PRINT FIRST$ + LAST$  
40 PRINT LAST$ + FIRST$
```

When this program is run, two different strings are printed on the TV screen:

```
KAREN SUMMERS  
SUMMERS KAREN
```

In these examples, the linked strings have been printed, but they

were not saved in the computer. If you want to link strings and store them for later use, you just use a label for the new string:

```
250 NAME$ = LAST$ + FIRST$
```

All sorts of strings can be put together this way, and the following experiment gives you a chance to try doing it.

Experiment No. 6-1. Building a String

In this experiment, you will run a program that uses a loop and an INPUT command to get characters from the keyboard. The program links the individual characters you type to form a complete string that is displayed on the TV screen.

Clear your computer for a new program and type in the following:

```
10 FOR T = 1 TO 12
20   INPUT X$
30   R$ = R$ + X$
40 NEXT T
50 PRINT R$
```

After checking your program to be sure that you have typed it in correctly, run it and type in a letter after each question mark. Remember to press the RETURN key after typing each letter. What happens? After the 12 letters have been typed in, the complete string is displayed on the TV screen. Your letters are probably different, but your TV screen should display something like this:

```
RUN
? A
? C
? Z
? F
? Q
? F
? K
? E
? S
? T
? B
? P
ACZFQFKESTBP
```

```
READY.
```

Now, type the command, PRINT R\$, and press the RETURN key. What happens? The 12-letter string is printed on the TV screen again. Since the letters form a string that was labeled R\$ and was saved by the computer, the string can be used again and again.

Look at the letters from left to right. Are they shown in the same order as you typed them in? Yes, the order is correct. As new characters were typed in, they were linked to the right end of the string by the R\$ = R\$ + X\$ command, as shown in Fig. 6-2.

OPERATION: R\$ = R\$ + X\$

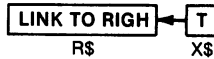


Fig. 6-2. Linking characters to the right-hand end of a string.

Run the program again, but now type in *two or three letters* after each question mark appears. Again, you must press the RETURN key to get the letters into the computer. Does the computer accept and store all of the letters? Yes, they are all saved. You are not limited to one character for each entry. Complete words or sentences could be typed into the computer this way.

Now, change your program so that line 30 looks like this:

30 R\$ = X\$ + R\$

How do you think this will change the operation of the program? Run the modified program, but type only one letter after each question mark. What does the display look like now? When the complete 12-letter string is displayed, it shows the letters in the *reverse* order, since the letters are linked to the left end of the string, as shown in Fig. 6-3. In the original program, each letter was linked to the right end of the string.

OPERATION: R\$ = X\$ + R\$



Fig. 6-3. Linking characters to the left-hand end of a string.

One final note about typing in strings: When a string of characters is typed in from the keyboard, it can only have 89 characters.

Experiment No. 6-2. Peculiar Characters

When you do this experiment, you'll find that not all of the characters on the keyboard can be typed in as part of a string. Some of

them do unusual things when you try and input them.

In the previous experiment, you typed letters into the computer. We avoided having you type other characters, since some of them are not accepted by an INPUT command. Clear your computer and type in the following program:

```
500 INPUT H$
510 PRINT "    *''+ H$ +''*"
520 GOTO 500
```

Be sure to leave four or five spaces between the first quote in the PRINT command and the asterisk. This will place the display away from the left margin so that it is easy to see. Run the program. When a question mark appears, type in a *letter* and press the RETURN key. You should see the letter printed on the TV screen between two asterisks: *F*, for example. You can safely assume that the INPUT command will accept all of the letters, numbers, and special graphic symbols. Try the punctuation marks and symbols such as %, (, etc. Are they all printed between the asterisks?

There are four "characters" that cause problems for the computer's INPUT command. These are the space, the quote mark, the comma, and the colon. The quote mark is simply ignored and nothing is printed on the TV screen for it. The comma and the colon are also ignored, but they cause the computer to display the message, EXTRA IGNORED. The space character is also ignored, but the previously typed character is printed again between the asterisks.

How can you type in these four peculiar characters and link them to a string if they are ignored? There is another keyboard input command that is often used for string-input operations, and we will show you how it works later in this chapter.

STRING DECISIONS

Your computer can make decisions based on the information in strings. For example, a computer program can be used to "look through" a series of names to see if Chris Hendrie's name is there. The computer compares each of the names it has with the string, CHRIS HENDRIE, to see if there is a matching name on the list. At another time, the computer might be asked to print the names of all the people on a magazine subscription list, *except for those people living in New Jersey*. Now, the computer would look at all the state names and print the information for those people whose state *did not match* the string, NEW JERSEY.

These string operations are similar to the *equal-to* and *not-equal-to* operations that were used with IF-THEN commands to compare values. In fact, these same operations can be used with strings. (The IF-THEN command tests a statement to see if it is true or false. If the condition is true, the command following the THEN is done and the computer continues on in the program. If the condition is false, the computer simply goes on with the program.)

Here's a simple example of a decision that's based on a string. When a program has finished its job, it might be programmed to ask you if you want to go through it again. You answer by typing YES or NO, and the computer makes a decision using simple string comparisons. Here are a few program lines that show you how it's done:

```
1040 PRINT "WANT TO DO IT AGAIN?"
1045 PRINT " TYPE YES OR NO"
1050 INPUT A$
1060 IF A$ = "YES" THEN GOTO 100
1070 END
```

The string you type in is compared with the string "YES" by the IF-THEN command at line 1060. If the strings are the same, the computer is pointed back to line 100 in the program (GOTO 100). If the strings are not the same, the program ends.

There is a problem in this program. The computer will go back and do the program again if you type YES, *but if you type anything else, the program will end.* The person who wrote this short program didn't bother to have the computer also check for the NO answer. Suppose you made a mistake and typed YEA instead of YES? The program would end.

A good programmer realizes that people make mistakes, so his program tests for a YES *or* a NO answer. If anything else is typed in, you get another chance to type YES or NO. Here is a better program:

```
1040 PRINT "DO YOU WANT TO TRY IT AGAIN?"
1045 PRINT "TYPE YES OR NO"
1050 INPUT A$
1060 IF A$ = "YES" THEN GOTO 100
1070 IF A$ = "NO" THEN END
1080 PRINT "JUST YES OR NO - PLEASE"
1090 GOTO 1040
```

The string typed in is checked with the string YES at line 1060, and if there is a match the computer goes to program line 100. If the string does not match YES, it is checked with NO at line 1070. If the string matches NO, the computer program stops. If the string doesn't match either YES or NO, the computer types out a short message and gives you another chance to type in either YES or NO.

Here is a simple game in which the computer tests two strings for a match:

```
100 R$ = "MAGIC"  
110 INPUT W$  
120 IF R$ = W$ THEN PRINT "YOU WIN": END  
130 PRINT "TRY AGAIN"  
140 GOTO 110
```

The "hidden" word, MAGIC, is labeled R\$, and the player is supposed to guess it by typing in one word at a time. The chances are small that you could guess the word without a clue or two, but this sample program shows how the computer can compare strings. Of course, the strings aren't really "equal" in the sense that $5 = 5$. However, the strings must have the exact same letters in exactly the same positions if they are to be seen as the same by the Commodore 64.

Computer programs can also check to see if two strings are "unequal," or *not the same*. This is shown in the following example:

```
220 INPUT R$  
230 IF R$ <> "BUGS" THEN END  
240 etc . . .
```

When the greater-than and less-than symbols are used together, this means "not-the-same-as." In this example, if the string typed in is not the same as BUGS, the computer is stopped by the END command. In order to continue the program, the computer user must type in the password BUGS. This program could have used the NOT command, instead:

```
220 INPUT R$  
230 IF NOT(R$ = "BUGS") THEN END  
240 etc . . .
```

String-comparison operations are used in games and learning programs such as "guess-a-word" or "hangman," in which the computer-user must correctly spell a word within a certain number

of tries. Most string-tests only check to see whether or not two strings are the same, they don't usually check to see if one string is "greater-than" or "less-than" another.

In the examples, upper-case, or "capital" letters have been used. However, the Commodore 64 can be set up to use lower-case letters, too. Since the Commodore 64 "sees" "y" and "Y" as *different characters*, programmers must pay careful attention to the types of the letters being used. If the following command is used in a program to test for the string APRIL:

```
100 IF PX$ = "APRIL" THEN . . .
```

The string, PX\$, must be APRIL and *not* April, april, or something else if the computer is to reach the THEN . . . command.

UNTANGLING STRINGS

There are three operations that let you "cut up" strings so you can get at pieces of them. You can take characters from the left, right, and middle of a string, once you have decided on the string to be used and the number of characters you want. There is also an operation that tells you the number of characters in a string, or its length.

The Length of a String

The length operation, LEN, is used with a string to "count" the characters in it. Letters, numbers, spaces, and all special characters (except for quote marks) are included in the count. Here is an example of how the characters in a string are counted. It doesn't matter whether you count from the left or the right:

```
THIS IS A 30 - CHARACTER STRING!  
123456789101112131415161718192021222324252627282930
```

The LEN command specifies a string and it gives you a value that can be printed, labeled, or used in a calculation. Here is how the LEN command might be used in a program:

```
100 PRINT LEN("BLUE RIDGE")
```

The computer would print the number 10 on the TV screen, since there are 10 characters in this string. The LEN command generally uses a label, and here is an example that shows this:

```
500 F$ = "THIS IS A TEST STRING"  
510 PRINT LEN(F$)
```

In this program, the computer counts the number of characters in the string, F\$, and prints this number (21) on the TV screen. The quote marks are not part of the string; they just show the computer where the string starts and ends.

The LEFT\$ and RIGHT\$ Operations

The computer uses the LEFT\$ and RIGHT\$ operations to get characters from each end of the string. In each case, the string's label and the number of characters wanted must be put in the instruction. Fig. 6-4 is an example of how these instructions work.

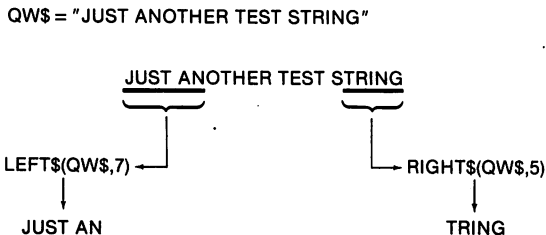


Fig. 6-4. Using the LEFT\$ and RIGHT\$ instructions.

The LEFT\$ and RIGHT\$ operations each put together a new string, so the results of these operations can be labeled, as shown in the following program listing and sample run:

```
350 H$ = "COMPUTER POWER"  
370 W$ = LEFT$(H$, 4)  
390 K$ = RIGHT$(H$, 3)  
410 PRINT W$  
430 PRINT K$  
450 PRINT H$  
RUN  
COMP  
WER  
COMPUTER POWER
```

READY.

The computer printed the left-hand four characters, COMP, and the right-hand three characters, WER, on the TV screen. The original string has not been changed by the LEFT\$ or RIGHT\$ operations, and it was displayed, too.

Here is another example of how the LEFT\$ and RIGHT\$ operations work. What do you think this program will display on the TV screen? You can type this program into your computer and try it, but before you do, try to come up with the answer.

```
560 P$ = "TERMITE KILLING ACTION"  
580 X$ = LEFT$(P$,7)  
600 G$ = RIGHT$(X$,4)  
620 PRINT G$
```

The program first sets up string X\$ as the seven left-hand characters, or TERMITE. Next, the four right-hand characters of *this new string* are made into string G\$ by the RIGHT\$ command. The result is MITE.

The RIGHT\$, LEFT\$, and LEN operations can be combined in a word-guessing game program, as shown in the next experiment.

Experiment No. 6-3. A Word-Guessing Program

This experiment gives you a simple word-guessing program that you and a friend can try just for fun. The LEFT\$, RIGHT\$, and LEN operations have been used to give "clues" about the word that is to be guessed. Clear your computer and type in the following program. Check it carefully:

```
10 INPUT T$  
20 Z = LEN(T$)  
30 PRINT " [SHIFT] [CLR/HOME] " : PRINT  
40 PRINT Z "LETTERS"  
50 PRINT LEFT$(T$,1) " " RIGHT$(T$,1)  
60 FOR G = 1 TO 5  
70 INPUT K$  
80 IF K$ = T$ THEN GOTO 500  
90 NEXT G  
100 PRINT "SORRY, WORD IS . . . "  
110 PRINT " " T$  
120 END  
500 PRINT "CORRECT"  
510 PRINT "MATCHED IN " G "TRIES"  
520 END
```

Before you run this program, let's see what it does. The first line lets you type in the word to be used in the game. The computer then determines its length, clears the screen, and prints the number of letters in the word. The PRINT command at line 50 prints the left-most and the right-most characters to give the player a clue about the word to be guessed. The steps that follow get the player's guesses and keep track of the number of tries used. Up to five tries are possible before the computer prints the correct answer.

Run the program and type in a simple word, such as FLAVOR. Your TV screen might look something like this:

```
6 LETTERS
F   R
? FLOWER
? FLAMER
? FLAVOR
CORRECT
MATCHED IN 3 TRIES
```

READY.

Or, maybe it will look like this:

```
6 LETTERS
F   R
? FLOWER
? FLAMER
? FRAMER
? FAVOUR
? FESTER
SORRY, WORD IS . . .
FLAVOR
```

READY.

It depends on whether or not the guesses lead to the correct answer. Although this may seem like a simple program, it can be developed into one that is more complicated, using colors, sounds, scores, and a large array, or table, of words to be matched or spelled correctly.

The LEN, RIGHT\$, and LEFT\$ operations can "extract" useful information from a string.

In the Middle of a String

You can get characters from the middle of a string by using the MID\$ command. Fig. 6-5 is an example of how this command

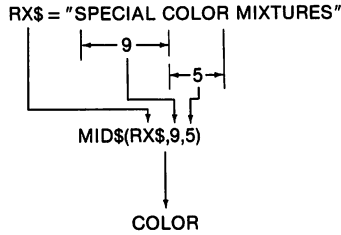


Fig. 6-5. Using the MID\$ instruction.

works. The MID\$ operation identifies the string, and the first number (9) tells the computer where to start getting the characters, counting from the left-hand side of the string.

The quote marks are not part of the string, so they aren't counted. The second number (5) tells the computer how many characters to get. Here is a short program that shows how the MID\$ command might be used. You can type it into your computer and run it if you want to:

```
10 T$ = "COMPUTER"  
20 FOR F = 1 TO 8  
30 PRINT MID$(T$,F,1)  
40 NEXT F  
50 END
```

THE GET COMMAND

In one of the experiments in this chapter, you found that there are four characters that the INPUT command "ignores." Programmers use the INPUT command mainly to input values and simple strings that do not use the space, colon, quote, or comma characters. However, if information containing these characters is to be typed in, the GET command is used.

The main difference between the INPUT and the GET commands is the way the keyboard is used. The INPUT command will input characters until you press the RETURN key, so you can use a single INPUT command to get a string with many characters, or a value with many digits.

When the computer reaches a GET command in a program, it

immediately goes to the keyboard and gets whatever key is pressed at that moment. It doesn't wait for you to press a key, nor does it wait for the RETURN key to be pressed. If no key is pressed, the computer gets "nothing." The GET command will only input a single character from the keyboard, but it won't "ignore" any key that is pressed.

It may sound as though you have to know exactly when the computer reaches a GET command in a program so you can have your finger ready to type a key. It's easier than that, since in most cases the GET command is used over and over again in a loop to get individual characters from the keyboard. The GET command is easy to use, as you'll see in the next experiment.

Experiment No. 6-4. Using the GET Command

The GET command is very useful for getting information from the keyboard, since no characters are ignored. You will see how the GET command can be used in this experiment. Clear your computer and type in the following program:

```
100 GET A$  
110 PRINT A$;  
120 GOTO 100
```

This program gets the character for whatever key is pressed on the keyboard and displays the character on the TV screen. The GOTO command points the computer back to the start of the program so it will do this again and again. Run the program. Watch the display and press several keys. What happens? The characters are displayed on the TV screen as they are typed in. The RETURN key has no effect except to cause the cursor to return to the left side of the line below. Do the space bar, quote, comma, or colon keys have any special effect on the display? No, they just print their characters on the TV screen. Of course, the space bar just moves the display over a space, as it would on a typewriter.

The computer is going through this three-line program very quickly. What do you think the GET command does when there are no keys pressed? Change the program by *removing the semicolon* in line 110. The complete program now looks like this:

```
100 GET A$  
110 PRINT A$  
120 GOTO 100
```

When you run this program, the display will be much different.

Go ahead and start the program. Press some of the keys. What is shown on the TV screen? The characters are displayed on the left side of the TV screen, but they move up the side quickly. In fact, it is difficult to see them. Even when no keys are pressed, the display still moves up. Remember that the computer goes through this loop many times each second. When no key is pressed, the computer receives a "null" or "nothing" character from the keyboard, and the PRINT command prints "nothing." *However, since the semicolon has been removed from the PRINT command, the computer still advances to a new line each time the PRINT command is executed.* This has the effect of "moving up" all the lines on the TV display.

By changing the program this way, you can see that the computer still goes through the GET, PRINT, and GOTO commands, even though none of the keys is pressed.

Experiment No. 6-5. Building Your Own String

In this experiment, you'll get a chance to see how the computer can "build" a string by using the GET command. Any of the keyboard characters may be used in the string. Clear your computer and type in the following program:

```
100 GET R$
140 T$ = T$ + R$
160 GOTO 100
```

Run the program and type in two or three words, using the space bar to separate them. Is anything displayed on the TV screen? How can you get your information back on the TV screen? Nothing is displayed, since there is no PRINT command in the program. Stop the program and type in PRINT T\$ [RETURN]. Are the words displayed on the TV screen now? They should be. The string was put together from the characters you typed and it was labeled T\$. Although the computer didn't know what you might do with it, it was still set aside for later use.

Change the program so that the information is printed on the TV screen. Add this line to your program:

```
120 PRINT R$;
```

Now, the complete program should look like this:

```
100 GET R$
120 PRINT R$;
```

```
140 T$ = T$ + R$
160 GOTO 100
```

Run this program and type in several words. You can use the space bar, colon, comma, and quote keys if you want to. Do they work the way the other keys do? Are the characters printed on the TV screen? The keys just print their characters on the TV screen. Stop the program and again type PRINT T\$ [RETURN]. Is your complete string printed again? It should be.

It is unfortunate that you have to stop the computer to get the entire string printed out. Let's see if we can have the computer type out the complete string when we type the "*" key. Now, the program will have to use an IF-THEN command to check for the asterisk. Here is the complete program for you to type in:

```
100 GET R$
110 IF R$ = "*" THEN GOTO 500
120 PRINT R$;
140 T$ = T$ + R$
160 GOTO 100
500 PRINT T$
510 GOTO 100
```

Run the program and type in a short, complete sentence. You can use the INST/DEL key to back space and correct any typing errors. When you're finished typing your sentence, press the * key and see what happens. You should see the computer display your complete sentence on the TV screen.

Experiment No. 6-6. Getting a Few Characters

This experiment lets you further explore the use of the GET command and how it might be used in a program to get only a few characters. This experiment is optional, and you can skip over it if you want to.

Suppose you want the computer to get only five characters from the keyboard. The GET command can be used in a loop that is done five times by the computer. Clear your computer and type in this program:

```
120 PRINT "TYPE 5 LETTERS"
140 FOR LC = 1 TO 5
160 GET L$
180 T$$ = T$$ + L$
200 NEXT LC
```

```
220 PRINT TS$
240 PRINT "THE END"
```

The computer will go through the loop between lines 140 and 200 five times, linking each letter to the string TS\$. When five characters have been obtained from the keyboard, the computer prints THE END. Run the program *but don't type any letters*. What do you see on the TV screen? The computer displays THE END, which means that it reached the end of your program! How can this happen, since you didn't type your five letters? The computer went through the loop five times, getting a "null" character from the keyboard each time. Your program can't tell the difference between a useful character and a "null" character. Remember that the string operations are not affected by a null.

The program can be modified to accept only printing, non-null characters. Add the following line to your program:

```
170 IF L$ = "" THEN GOTO 160
```

In line 170, the quote marks are right next to each other, there is no space between them. This represents a null character to the computer, and this statement tells the computer that if a null character is obtained from the keyboard, ignore it and go back and do the GET command again. The computer will only pass the IF-THEN command when a non-null character has been typed in.

Once you have added line 170 to your program, run it. Is the message, THE END, displayed on the TV screen? It shouldn't be. Type in five letters. What is displayed after all five have been typed? The five letters should be displayed as a complete string. This program shows how the GET command can be used with an IF-THEN command that checks for and ignores the null characters.

TELLING TIME

The Commodore 64 computer has a built-in 24-hour digital clock that is easy to use. The clock has been given the string label, TIMES\$, or simply TI\$, and you can use this label to "set" and "read" the time. The clock is accurate to one second and it will run for as long as the computer is powered. The clock is completely independent of your programs, so no matter what you do, the clock still keeps accurate time. This type of clock is called a *real-time clock*.

Setting the clock is easy. You put together a 6-character string of numbers that represents the hours, minutes, and seconds with two characters for each. So, to set the clock for exactly 5:30 A.M., you type in:

```
TI$ = "053000" [RETURN]
```

Since the clock has a 24-hour "cycle," times after noon must have 12 added to them. For example, 6:00 P.M. is 1800, 11:00 P.M. is 2300, and so on. You can set the seconds, too. For example, 9:00 A.M. and 45 seconds would be set by:

```
TI$ = "090045"[RETURN]
```

You don't have to do anything special with the string, TI\$. Simply by labeling the string of digits, you set the clock's time. Reading the clock is also easy. You simply use the label TI\$ in your program. For example, by asking the computer to PRINT TI\$, you will have the time printed on your TV screen. If your computer is on, you can type in:

```
PRINT TI$ [RETURN]
```

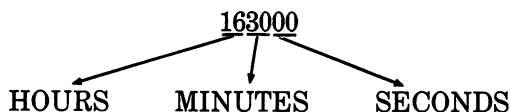
If the clock doesn't show the right time, it's probably because it wasn't set. Here's an experiment that shows you how to use the clock.

Experiment No. 6-7. Using the Computer's Clock

In this experiment we will show you how to use the Commodore 64's built-in clock. Clear your computer and type in the following program:

```
100 INPUT "TIME "; TI$
120 PRINT " [SHIFT] [CLR/HOME] "
130 PRINT TI$
150 PRINT " [CLR/HOME] "
160 GOTO 130
```

This program lets you type in the time to "set" the clock. After the clock has been set, the time is displayed on the TV screen. You can run the program and set the clock to any time you wish. Just remember that the format of the characters in the string is:



The characters must be typed in as a group of six, without any spaces or other characters used in the string. If you have a watch handy, you can synchronize the Commodore 64's clock with the time on your watch. You'll find that the computer's clock keeps good time.

Stop the program and start it again. Type in the following time:

235800

Do you know what time this is? It's 11:58 P.M., and no seconds. Watch the display. What happens when the seconds reach 59? What happens when the minutes reach 59? In about two minutes, the time changes to 000000, or midnight.

Since the time can be obtained from the computer by using a string label, can you suggest how you might change the program to include an "alarm"? You can set up an alarm by comparing the clock's time, TI\$, with your own string that represents the alarm's time. Here's how you might do it:

```
100 INPUT "TIME "; TI$
110 INPUT "ALARM "; ALS
120 PRINT " [SHIFT] [CLR/HOME] "
130 PRINT TI$
140 IF ALS = TI$ THEN PRINT "GET UP!!!"
150 PRINT " [CLR/HOME] "
160 GOTO 130
```

You can test this program by typing in a time that will start the clock and an alarm time that is only a minute or two later. For example:

```
RUN
TIME ? 040000
ALARM ? 040200
```

What happens when the clock reaches the alarm time? The alarm message, GET UP!!!, is printed on the TV screen. This is not a very effective alarm unless you happen to be using the computer. In a later chapter, you'll learn how the Commodore 64 can make sounds and generate a useful alarm signal.

At first, the clock may seem interesting but not very practical. However, many computer programs use a clock. For example, programs can "stamp" a time on a computer file so you know when it was last used. Games often use a clock so that if you don't make your move in a specific time, the computer just goes on. Some peo-

ple use "appointment book" programs to keep appointments in a computer file, so the clock can remind them when they are scheduled for important meetings.

STRINGS AND VALUES, VALUES AND STRINGS

It is important to remember that strings are not values and values are not strings. You can quickly tell one from the other by the labels used; if the label ends with a dollar sign, it's for a string, otherwise, the label is for a value.

Sometimes it is useful to change strings into values and values into strings. Of course, this is only useful for "numbers." It doesn't make sense to try and get a numeric value for the strings "BETH SCOTT," or "SARA JANE."

Let's look at a use for these operations. How can you set an alarm for an hour from now? In the experiment you just finished, you typed in a string of numbers to set the alarm. If you didn't want to have to figure out the new alarm time and type in a new setting, you'd have to do something such as this:

1. Get the present time string, TI\$.
2. Convert it to a value.
3. Add one hour to it.
4. Convert it back to a string.
5. Save it as the alarm string, AL\$.

The actual program to advance the alarm can be quite complex, and we won't discuss it any further. However, the *operations* that perform these conversions are the STR\$ for the value-to-string operation, and the VAL for the string-to-value operation. These operations are only used when you have strings of numbers, or values that are to be converted. Here is a simpler example that shows how the STR\$ operation can be used to get the first digit of a mailing code:

```
500 INPUT "MAIL CODE"; MC
510 M$ = STR$(MC)
520 X$ = MID$(M$,2,1)
530 PRINT X$
```

The first step is to INPUT the mail code, no matter how many digits it has. The STR\$(MC) operation converts the value into a string of characters, and the MID\$ operation gets the left-hand digit.

There is a special reason why the MID\$ operation is used instead of the LEFT\$ operation to get the left-most character in the mail code. The STR\$ operation automatically inserts the sign of the number at the start of the resulting string. A minus sign is put on the left side of a string for a negative number, but the computer leaves a blank space for positive numbers. If a number doesn't have a minus sign, it's assumed to be positive.

So, if you type in the *value* -11743, the *string* M\$ is "-11743" with the minus sign at the left end of the string. If you type in 41609, M\$ is just "41609" with a space at the left end. To get the first digit without the sign (or the space for it), the MID\$ operation is used. The MID\$ operation in the sample program says to the computer, "Go in two characters from the left and get one character."

The VAL operation does the reverse, converting a string into a value that can be used in math problems, for example. These operations are not found in too many programs. For more information about the STR\$ and VAL operations, check the *Commodore 64 Programmer's Reference Guide*.

QUESTIONS

1. How can you tell that a label is used to identify a string instead of a value?
2. Can a string of characters be input to the Commodore 64 with a standard INPUT command? If so, how?
3. How are strings combined?
4. Can strings be combined in any order?
5. What characters are "ignored" by an INPUT command? How can they be input for use in a string?

6. What types of decisions are made for strings?
7. What operation tells you the length of a string? Are all characters counted?
8. How can you get the left three characters and the right six characters of the string, CAT\$?
9. How can you get the middle five characters of the string, G\$ = "QUESTIONS"?
10. If a key is not pressed when a GET command is done by the Commodore 64, what is the result?
11. What kind of clock is built into the Commodore 64?
12. What is a "real-time clock"?
13. Can values and strings be interchanged? Could this be a useful operation?

PROBLEMS

1. Write a program so that you can enter a string and have the computer display the number of characters in the string.
2. Write a program that lets you enter a string. The computer then separates the string into two equal pieces and displays the two pieces of the string, each on a separate line. If the string contains an odd number of characters, then one piece will be one character shorter than the other.
3. Write a program that uses arrays, where you enter the names of five people, along with their ages. Once this is done, enter a name and the person's age should be displayed. If you enter an age, the person's name should be displayed. A typical display would be:

```
NAME OR AGE ? WENDY  
AGE IS: 19
```

```
NAME OR AGE ? 23  
NAME IS: HENRY
```

```
NAME OR AGE ? DAN  
NO SUCH PERSON!
```

4. Write a program so that once a string has been entered into the computer, the characters in the string are displayed on the TV screen, one character per line. For example:

```
STRING? COMPUTER
```

```
CHARACTERS ARE:
```

```
C  
O  
M  
P  
U  
T  
E  
R
```

5. Write a game program that lets you enter a word (a string). The computer then "scrambles" the string and displays the result. To scramble the string, just randomly change the position of the characters in the word. The program should operate on strings of any length. You then have to enter a guess as to what you thought the string (word) originally was. If your guess is wrong, the computer lets you enter another guess. If you guess correctly, you can enter another word to be scrambled.
6. Write a subroutine that causes a string to be displayed in the center of a line on the TV screen. You can assume that the string to be centered is called A\$, and that it is less than 40 characters long.
7. Write a program so that once a string has been entered from the keyboard, the first character of the string is displayed on one line, the first two characters are displayed on the next line, the first three on the next, until finally the entire string is displayed on the last line. As an example:

STRING TO USE ? ORANGE

O
OR
ORA
ORAN
ORANG
ORANGE

8. Write a program that lets you enter two strings, and then the computer displays them in alphabetical order. Assume that the strings only contain letters, no numbers or special symbols.
9. If you have solved Problem 8, write a program that lets you enter five strings into an array. The computer then displays the strings in alphabetical order, one string per line.

NOTE: In this problem, the strings do not have to be "sorted," that is, they do not have to be moved about inside the array. Instead, the program simply finds the first string and displays it, and then the next string, etc. The strings are

not moved around in the array. If you want, you can eliminate the strings from the array (set them to null "" strings) once they have been displayed.

10. In Problem 11, Chapter 4, you had to write a program that converted a day between 1 and 365 to the month and day of the month. Now, solve the same programming problem using the additional statements and commands that you have learned about in the last two chapters. (HINT: Use DATA statements in your program.)
11. Write a program that lets you enter a number such as 1208976. This number is converted to a string and then the computer displays the string, with commas in it, such as 1,208,976. Don't worry about detecting a number that has been entered using scientific notation, that is, numbers such as 6.5E+30 or 4.203E-5.
12. Write a program that causes the Commodore 64 to simulate a tickertape or electronic billboard. After entering a string (containing 40 or more characters), the first 39 characters of the string are displayed on the top line of the display. After a short period of time, for example, $\frac{1}{2}$ second, 39 characters are displayed again on the top line of the display, starting at the second character. This continues until the last character is displayed again, starting at the beginning.
13. If you have solved Problem 12, modify the program so that instead of displaying the last character in the message and 39 spaces, the message "wraps around." This means that as you get toward the end of the message, the beginning of the message starts to appear on the right-hand side of the screen.
14. Using the clock built into the Commodore 64 (TI\$), write a program that lets you enter four or five times, such as 2 minutes, 30 seconds (enter as 230), 4 minutes (enter as 400), and 10 minutes (enter as 1000). After these times have been entered, the computer starts to keep track of the time. After 2 minutes and 30 seconds have elapsed, the computer displays the message "TIME 1 HAS ELAPSED." After the second time period has elapsed, the computer displays the message, "TIME 2 HAS ELAPSED." This process should continue until all of the times that were entered on the keyboard have been "timed." This type of program would be useful in photography, where a num-

ber of the film development steps have to be timed, one right after the other.

15. Write a program that asks you the time, and then asks how many hours and minutes to wait before displaying the message, "ALARM," on the TV screen. Thus, if you tell the computer that it is 103015, and that you want the alarm to go off in 2 hours (020000), the computer will display the ALARM message at 123015.



CHAPTER 7

SPECIAL MATH FUNCTIONS

There are some special math functions that you will come across less frequently than addition, subtraction, multiplication, and division. Since these new functions are not found often in computer programs, we have put them in their own chapter. We will also tell you about the types of “codes” that computers use to transfer information. There are no experiments in this chapter, so you won’t need to use the computer as you read it.

Most computer programming books that discuss BASIC-language programs simply list the special math functions without telling you much about them. They leave it to you to decide whether or not you need to use them, providing a few simple examples of how these instructions work and what they do. There is a great deal of interesting history behind these math operations, and we thought you would be more interested in this than in learning 20 ways of using the cosine function.

THE SQUARE ROOT

Most people who have attended high school have heard of a “square root” even if they haven’t actually used this interesting function. Let’s go back to the sixth and fifth centuries, B.C., and look at the work of Pythagoras and his colleagues, the

Pythagoreans, who lived in what is now southern Italy. The Pythagoreans were interested in the abstract side of mathematics and did not use their mathematical skills in any commercial ventures. One of their beliefs was that there was a common measure between any two lengths. Thus, no matter what their lengths, there was a common measure between two pieces of rope, as shown in Fig. 7-1. In this example, one piece of rope has two “units”

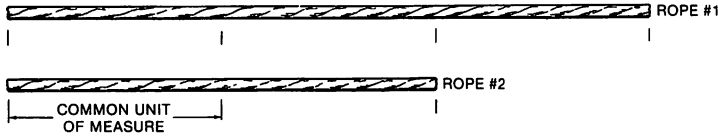


Fig. 7-1. There is a common unit of measure between the two pieces of rope.

while the other has three “units.” Of course, other lengths of rope would probably require different common “units.”

Ancient Egyptian land surveyors used a rope triangle with sides of 3, 4, and 5 units during their surveying. Such a triangle always contained a “right angle,” or an angle of 90° , which made it an ideal tool for laying out square or rectangular plots of land. No matter what size triangle was chosen, if the ratio of the sides was 3 to 4 to 5, a right angle was always formed. You can measure a piece of string and prove this for yourself.

Using this type of special triangle as an example, the Pythagoreans discovered an interesting thing about right triangles — those in which one angle is 90° . If a square was constructed for each side of the triangle, as shown in Fig. 7-2, the area of the large square (25) on the long side was found to be equal to the sum of the areas of the two smaller squares ($9 + 16$). It is thought that the Pythagoreans also knew this was the case for a right triangle in which the two short sides were of equal length, as shown in Fig. 7-3. This “sum-of-the-squares” relationship can be proven for other right triangles, too, but in their time the Pythagoreans probably weren’t able to do so. Today, this relationship between the “squares” on the sides of a right triangle is called the *Pythagorean Theorem*.

The Pythagoreans looked at the type of triangle shown in Fig. 7-3 and found that there was no common measure between the two short equal sides and the longer side. No matter how small a “measure” was used to divide the sides, they could not find one that was common to the short sides and the long side. Since the common-

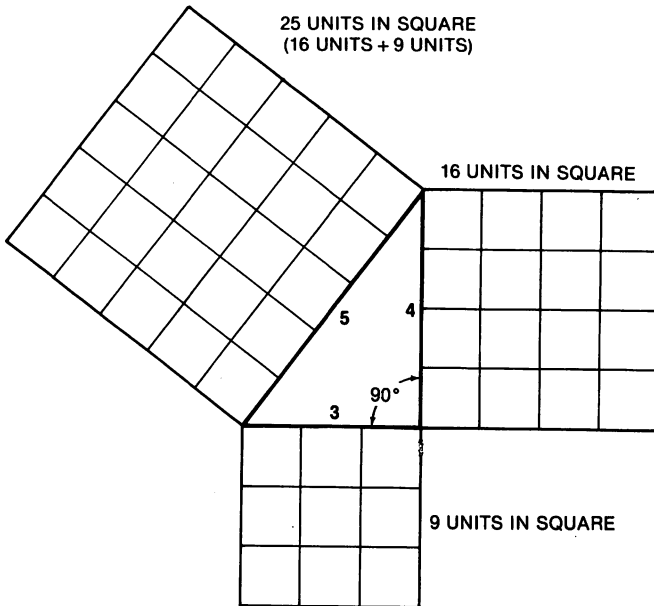


Fig. 7-2. A 3-4-5 right triangle shows the sum-of-the-squares rule.

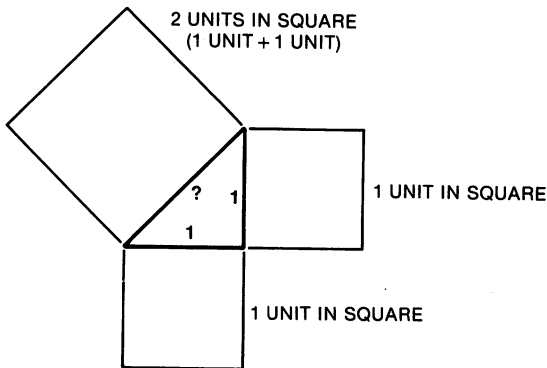


Fig. 7-3. Another right triangle that shows the sum-of-the-squares rule, but without a common measure between the short and long sides.

measure principle was central to their mathematical thinking, this posed a perplexing problem.

Obviously, the area of the large square is 2 square units, so the length of the long side must be a number that when multiplied by

itself yields 2. We know that this number is approximately 1.41, but the Pythagoreans did not have decimal numbers and could not find a number that would exactly represent this length. Since there was no common "measure" or *ratio* between the lengths of the short and long sides, the length of the long side was said to be "not a rational" number, or *irrational*.

As mathematics evolved, the side of a square was called the "root" of the square, or the number from which the square "grew." Now we simply say "square root," and calculators and computers can easily find the square root of a number. In the case of the value 2, the square root is close to 1.414. We say close, because the square root cannot be calculated to a final value. A pocket calculator gives the value as 1.4142136 . . . , and more decimal places may be calculated.

The Commodore 64 calculates square roots very easily using the SQR operation, and here is what it looks like:

```
ROOT = SQR(number) or DX = SQR(2.00)
```

The SQR function expects the number you want the root of to be greater-than or equal-to zero.

Here is how you can use the square root operation to find the long side of a right triangle if you are given the lengths of the two short sides:

```
500 REM COURTESY OF PYTHAGORAS
520 PRINT "ENTER TWO SHORT SIDES"
540 INPUT S1 : INPUT S2
560 LG = SQR(S1*S1 + S2*S2)
580 PRINT "LONG SIDE IS . . ." LG
```

There are many uses for the square root function in engineering, science, mathematics, statistics, surveying, astronomy, and other fields that evaluate numeric information. It is one of the more useful functions that we'll describe in this chapter.

THE VALUE OF PI

One of the problems facing ancient mathematicians was the exact measurement of the circumference, or the "length" around the outside of a circle. While the radius (*r*) and diameter (*d*) for the circle shown in Fig. 7-4 can be easily measured, there is no accurate way to measure the length of the circumference (*c*). You can use a compass to mark out a circle and you can try to measure the circumfer-

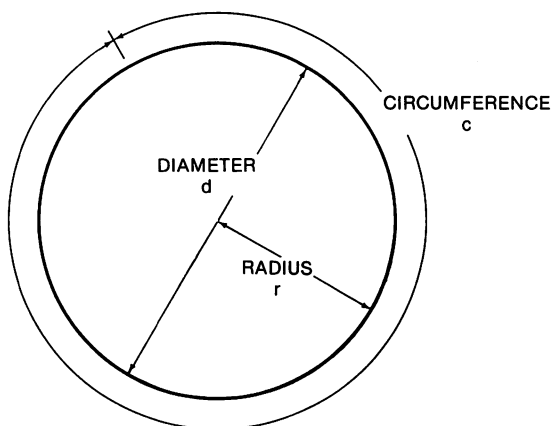


Fig. 7-4. The radius and diameter of a circle are easy to measure; the circumference isn't.

ence with a ruler. You'll find that it's difficult to measure a curved line with a straight-edged ruler, and the early mathematicians had the same problem. In their attempts to measure the circumference, they found that it was approximately three times the length of the diameter. Ancient Hebrew and Babylonian mathematicians fixed the ratio of the diameter to the circumference at exactly 1 to 3, or just 3.

The ancient Egyptians knew better, however, using the ratio of 1 to 3.1605 as early as 2200 B.C. Of course, they didn't have decimal numbers, so the ratio was written in a different form. The main point is that the Egyptians were able to come up with a more accurate ratio, realizing that the circumference was not simply three times the length of the diameter of a circle.

The Greek mathematician, Archimedes, who lived between 287 and 212 B.C., improved upon this ratio by using a process of approximations that is shown in Fig. 7-5. Using this method, a circle has a square placed inside it so that each *corner* touches the circle. Another square is placed outside the circle so that each *side* touches the circle. It is easy to measure the perimeter of both squares, and the circumference lies somewhere between these two values. Archimedes increased the number of sides on each square, making them into octagons, and he added more and more sides as he went on. In each case, the inside polygon had all its sides equal, and each corner touched the circle. The outside polygon had its sides of equal length, too, and each side touched the circle. As the

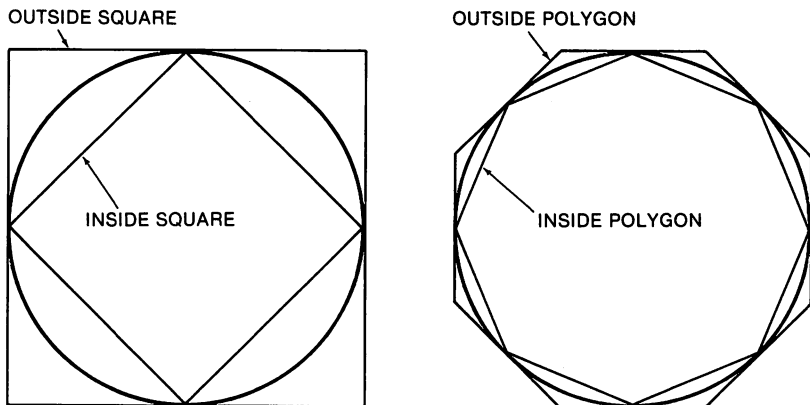


Fig. 7-5. Using approximations to measure the circumference of a circle.

number of sides of each of the polygons was increased, their perimeters more closely matched the circumference of the circle. When Archimedes had gotten the polygons so they had as many sides as possible, he was able to put the diameter-to-circumference ratio between 71 to 223 and 70 to 220. More simply, the circumference was between 3.14085 and 3.14286 times the length of the diameter.

A Hindu mathematician, Aryabhata, who lived in the sixth century A.D., was able to further refine the value to 3.1416, which is extremely close to the present value of 3.14159. This is a constant, and it is used by engineers, scientists, mathematicians, students, and almost anyone who has taken even an introductory course in geometry. The constant is called *pi*, for the Greek letter, π , which is used to stand for the value 3.14159. You can simply think of it as a special label for this value.

Most people can tell you the simple relationships:

$$\text{circumference} = \pi * \text{diameter of the circle}$$

And, since the diameter is twice the length of the radius:

$$\text{circumference} = \pi * 2 * \text{radius of the circle}$$

The value of pi has been preset in your Commodore 64 computer, and you will see the Greek pi symbol, π , on the up-arrow key on the right side of the keyboard. This is a special label used just for this value in the Commodore 64 computer. You can type:

PRINT π

and you will see the value 3.14159265 displayed on the TV screen. You can use this value in a program by using the label, π , in your math formulas. Here is a sample program that calculates the circumference of a circle when you type in its radius:

```
250 INPUT "RADIUS = "; RD
260 PRINT "CIRCUMFERENCE IS = " 2* $\pi$ *RD
270 GOTO 250
```

Now, with an accurate value for the ratio between a circle's diameter and circumference, it was possible for mathematicians to look more closely at circles and some of their other measurements. We now move on to trigonometry.

TRIGONOMETRY

Although this subject often seems to strike fear into the hearts of students, trigonometry is nothing more than "tri-angle measurement," or the measurement of triangles. Aristarchus, another Greek mathematician, first used what we would consider to be "tri-angle measurements" when he attempted to measure the distance between the earth and the sun, as shown in the distorted diagram in Fig. 7-6. His methods used complex geometric reasoning, but his result was incorrect due to the inaccuracy of his measurements. However, his *line of reasoning*, using triangles and the lengths of their sides, was correct and it pointed the way to more accurate measurements and further investigations of triangles.

The next mathematician we encounter is Hipparchus, who is thought of as the "inventor of trigonometry." Modern trigonometry arises from his measurement of chords in circles. As shown in Fig. 7-7, a chord is nothing more than a straight line that cuts a circle into two pieces. The resulting curved line is called an arc, and Hipparchus realized that there was a definite relationship between the length of the chord and the length of the arc. He wrote several "volumes" about measuring the "arc in a circle."

If lines are drawn between each of the two points where the chord line cuts through the circle and the center of the circle (Fig. 7-8), you'll see that an angle is formed. Each circle was considered to have 360° , so these angles could be measured in degrees. However, chords were measured by their length, and this was based not on a standard of inches or centimeters, but on the length of the radius of the circle. This type of measurement could lead to prob-

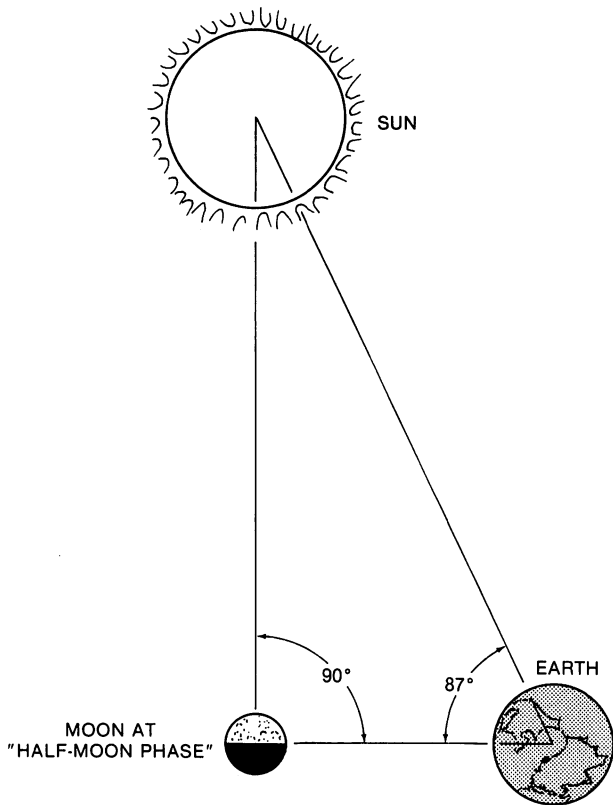


Fig. 7-6. Using angles to measure the distance from the earth to the sun.

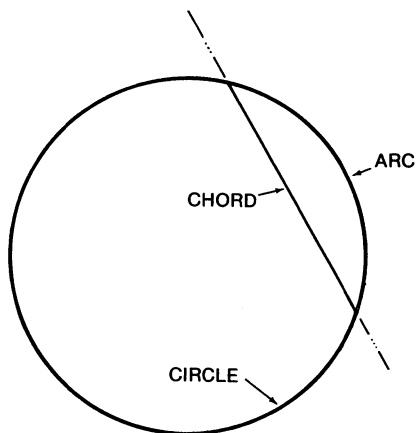


Fig. 7-7. An arc and a chord in a typical circle.

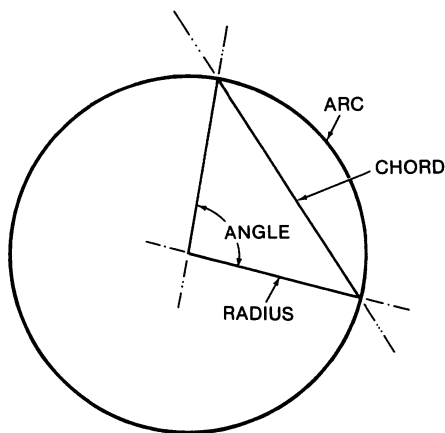


Fig. 7-8. An angle is formed between the center of a circle and the points where the chord crosses it.

lems, since the measurement of a chord depended on the units used to measure the radius of the circle.

This brings us back to the Hindu mathematician, Aryabhata. His contribution to trigonometry was to divide each chord in half, as shown in Fig. 7-9, and he also introduced a *right angle*, or 90° angle, into the measurement. As trigonometry developed, it was realized that the *ratio* between the length of the radius and the length of the half-chord was more useful than the lengths by themselves. For example, consider the two triangles (or half-chords) shown in Fig. 7-10. The circles have been left out for clarity. The angles are exactly the same, but the lengths of the "radius" and the "half-chord" are different. However, when the lengths are measured and the *ratios* are calculated, they turn out to be exactly the same. With an inexpensive ruler, we found that each "half-chord" was just about 0.46 times the length of the "radius." This is an important relationship, since no matter what size the triangle is, if the angles are the same, the ratios are the same.

The word to describe this relationship was translated and mistranslated several times, so we finally have the Latin word, *sinus*, which means "curve" or "bosom." This has been abbreviated to *sine* (which is pronounced "sign"), and is usually found in mathematics books as simply *sin*. The words "radius" and "half-chord" are no longer used in this relationship. Instead, we refer to the long, angular line as the *hypotenuse*, and the other lines are said to

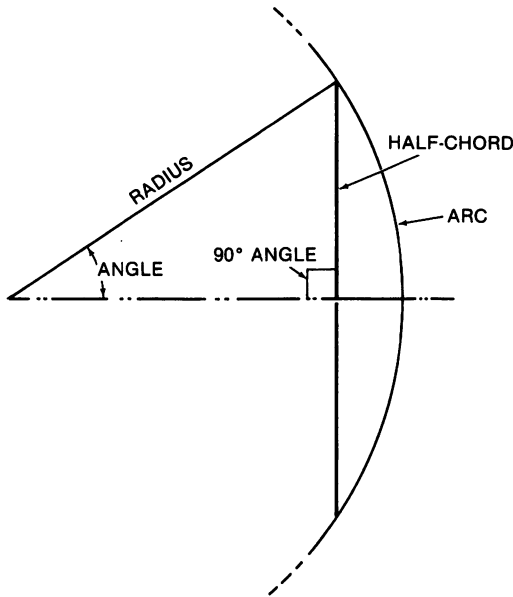
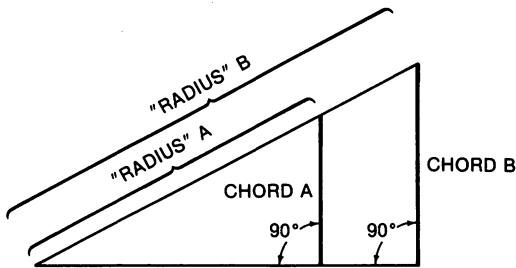


Fig. 7-9. The angle in a circle-chord can be simplified by looking at only half of it.



$$\frac{\text{CHORD A}}{\text{RADIUS A}} \cong \frac{\text{CHORD B}}{\text{RADIUS B}}$$

$$\frac{40}{86} = 0.465 \quad \frac{54}{115} = 0.469$$

$$0.465 \cong 0.469$$

Fig. 7-10. Two triangles that have the same angles have equal ratios between the sides.

be *adjacent-to*, or *opposite-from*, the angle we're interested in. The *sine* of angle A is just the ratio of the length of the *opposite* side to the *hypotenuse*. Of course, this is only true for a right-triangle.

Without going into the history behind them, we'll simply tell you that there are two other ratios of interest. One is called the *cosine*, or *cos*, and the other is called the *tangent*, or *tan*, of the angle. These are also ratios of the lengths of the sides of the triangle. The three relationships are illustrated in Fig. 7-11.

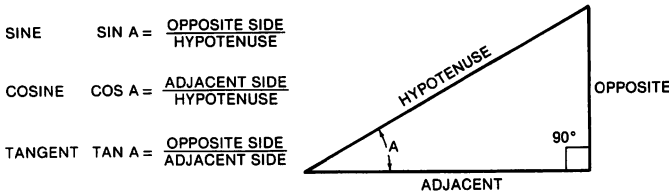


Fig. 7-11. The sine, cosine, and tangent ratios between the sides of a right triangle.

COMMODORE 64 TRIGONOMETRY

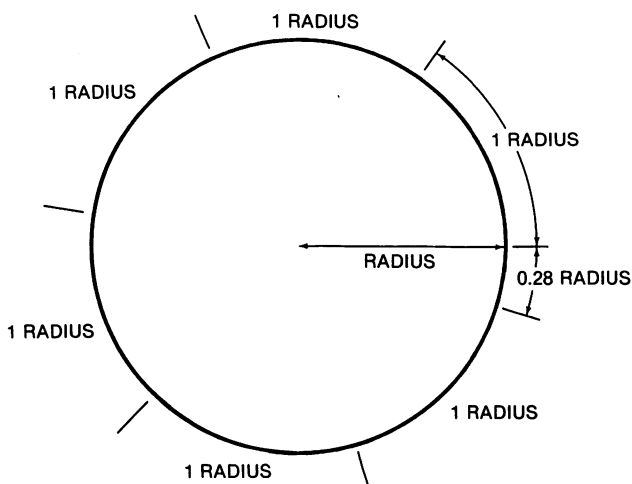
Your Commodore 64 computer can give you the *sin*, *cos*, and *tan* for any angle you give it, so it is possible to use these ratios in many interesting ways. They are particularly useful in science, engineering, and mathematics. We'll look at an example in just a moment. The formats for these BASIC-language operations are fairly simple:

$$A = \text{SIN}(QX) \quad D = \text{COS}(FK) \quad R = \text{TAN}(YW)$$

However, there is one problem: the Commodore 64 does not accept angles measured in degrees. A circle contains 360° , and this is convenient for many measurements. However, the Commodore 64 trigonometric, or *trig* functions require that the angle be measured in a unit called the *radian*. A radian is nothing more complicated than a "radius." Since the circumference of a circle is equal to:

$$\text{circumference} = 2 * \pi * \text{radius}$$

there are 2π radiuses, or radians, around the circle as shown in Fig. 7-12. No matter what the actual radius is, this will always be true. Since there are also 360° in a circle, it is not difficult to convert from radians to degrees, or *vice versa*. It may take you a while to get used to the term *radian*. Just remember that there are about 57° per radian. You can convert from degrees to radians with this formula:



CIRCLE = 2π RADIUSSES = 6.28 RADIUSSES = 6.28 RADIANSES

Fig. 7-12. The relationship between the radius of a circle and the number of "radians" around its circumference.

$$\text{radians} = \frac{(\text{angle in degrees}) * 2 * \pi}{360}$$

or from radians to degrees with this formula:

$$\text{degrees} = \frac{(\text{radians}) * 360}{2 * \pi}$$

In BASIC, these are:

$$\text{RAD} = \text{DEG} * 2 * \pi / 360$$

and:

$$\text{DEG} = \text{RAD} * 360 / (2 * \pi)$$

USING TRIG FUNCTIONS

Here are two examples that show you how trigonometry can be used. Not all of the mathematics or algebra is shown, since that is really secondary. We want you to have an appreciation for the types of problems that can be solved with the trig functions. The BASIC programs are provided for you.

In the first example, several young people are testing model

rockets and they want to know how high the rockets are going. The rockets are fired straight up and there is no wind to blow them off course. Two people use a home-built device at an observing point to measure the angle between the rocket and the level ground. This is shown in Fig. 7-13. Once the rocket has been fired, the students

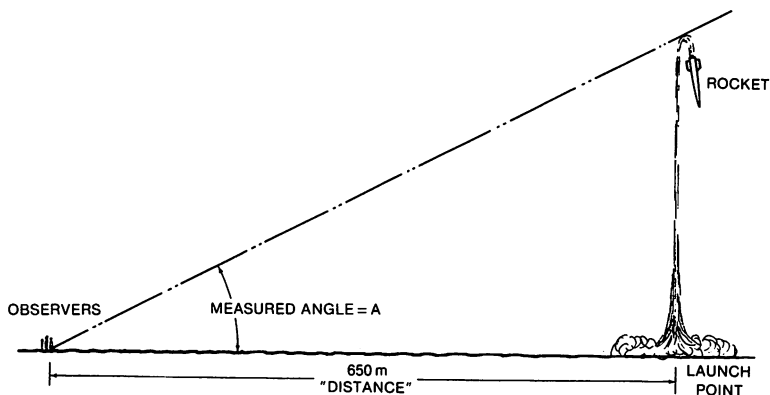


Fig. 7-13. Measuring the angle between the ground and the rocket to get its height.

track it until it reaches its maximum height. At this point, they note the angle between the earth and the rocket. Since the distance from the launch site and the students doing the measurements is 650 meters, can we calculate the altitude of the rockets?

The diagram of the launch site can be simplified to a right triangle. The angle, A, has been measured and the side of the triangle marked "distance" is 650 meters. The tangent function can help us out, since:

$$\tan(\text{angle } A) = \frac{\text{opposite side}}{\text{adjacent side}} = \frac{\text{rocket height}}{\text{distance from launcher}}$$

And, by rearranging the equation, you get:

$$\text{rocket height} = \text{distance from launcher} * \tan(\text{angle } A)$$

The angle must be converted into radians, too. Here is a computer program that will solve the problem:

```

200 PRINT "***ROCKET ALTITUDE CALCULATOR***"
220 INPUT "DISTANCE TO LAUNCHER"; DTL
240 INPUT "MAXIMUM ANGLE"; MA
260 RAD = MA*2*PI/ 360
280 ALT = DTL*TAN(RAD)
300 PRINT "ALTITUDE" ALT

```

In the second example, we'll extend this application a bit by supposing that a light wind is changing the rocket's flight path so that it doesn't always go straight up. Is it possible to measure its maximum altitude? Since the rocket is no longer going straight up, it cannot be done with only one observation. Two observers are needed, as shown in Fig. 7-14. The only measurements needed are:

1. The base-line distance between observers (BL).
2. The angle between the ground and the rocket for each observer (GA and GB).
3. The angle between the base line and each observation (HA and HB).

Since it is important that the observers record their angles at exactly the same time, a set of walkie-talkie radios is used to coordinate the measurements.

There are two ways to solve this problem: (1) make a scale drawing using the angles and the base-line distance and "measure" the rocket's altitude, and (2) calculate the altitude using trigonometry. We'll take the latter course. Here's the BASIC program that will solve the problem:

```
100 PRINT "***ROCKET ALTITUDE CALCULATIONS***"
120 PRINT " FOR TWO OBSERVERS"
140 PRINT
160 INPUT "BASE LINE LENGTH"; BL
180 PRINT
200 INPUT "OBSERVER A GROUND ANGLE"; GA
220 INPUT "HEIGHT ANGLE"; HA
240 PRINT
260 INPUT "OBSERVER B GROUND ANGLE"; GB
280 INPUT "HEIGHT ANGLE"; HB
300 PRINT
320 REM CONVERT TO RADIANS
340 C = 2*π/ 360
360 GA = GA*C : HA = HA*C
380 GB = GB*C : HB = HB*C
400 BX = BL/((TAN(GB)/TAN(GA)) + 1)
420 AX = BL - BX
440 PA = AX/COS(GA)
460 PB = BX/COS(GB)
480 REM ALTITUDE CALCULATIONS
500 A1 = PA*TAN(HA)
```

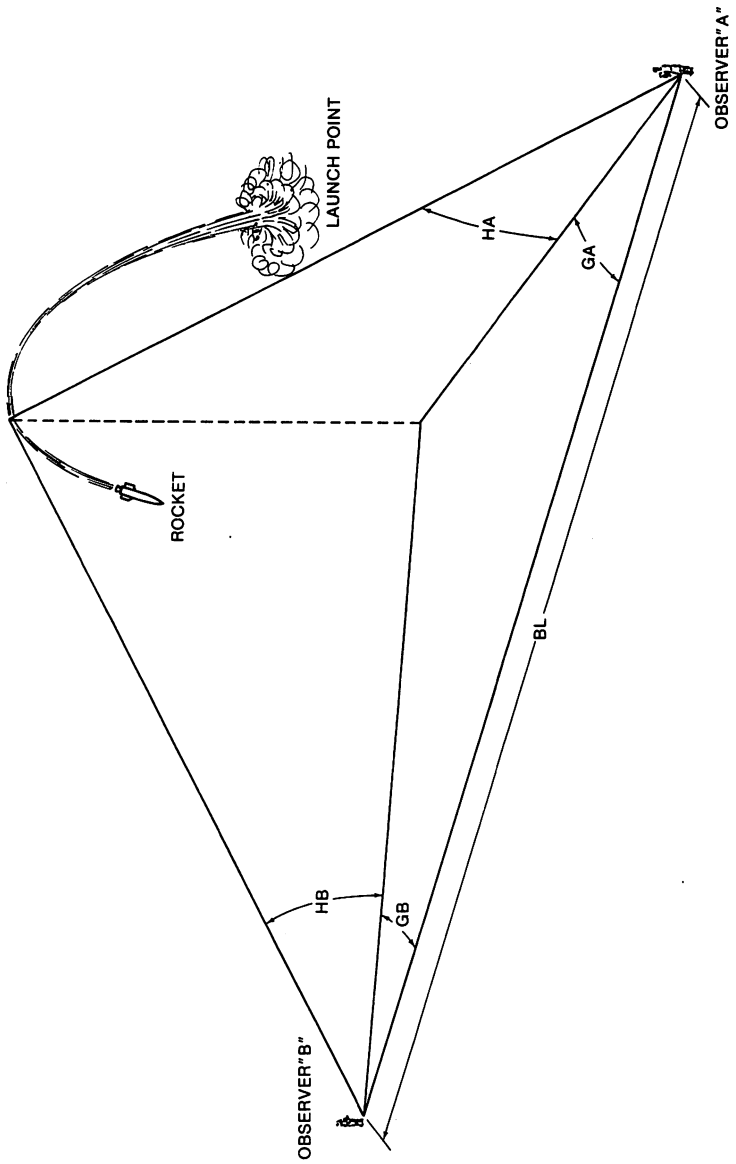


Fig. 7-14. Using two observers to measure the height of a curved flight for a rocket.

$$520 \quad A2 = PB \cdot \tan(HB)$$

$$540 \quad AVG = (A1 + A2) / 2$$

```
560 PRINT "OBSERVER A ALT = " A1
580 PRINT "OBSERVER B ALT = " A2
600 PRINT "AVERAGE ALTITUDE = " AVG
```

If you decide to run this program, here are some values you can use:

Base line between observers:	3000 meters
Observer A ground angle:	45°
Observer A height angle:	37°
Observer B ground angle:	26.5°
Observer B height angle:	26°

You'll find that the altitudes calculated for observers A and B are 1066 and 1090, respectively. The average is 1078. Remember, these values are based on experimental measurements, and there are always errors in them.

The important point of these examples is to give you an appreciation for the use of trigonometry and for the tremendous work done by early mathematicians as they developed these relationships and came up with the ratios used in the sine, cosine, and tangent operations.

There is one last trigonometry operation in the Commodore 64, and it is called the arc-tangent, or arctangent. If you have the tangent of an angle, the arctangent operation will give you the angle, in radians. The form for this operation is:

$$\text{ANGLE} = \text{ATN}(\text{tangent of the angle})$$

There are many other trig operations that can be done, based on the SIN, COS, TAN, and ATN functions of the Commodore 64, and they are listed in the *Commodore 64 Programmer's Reference Guide*.

LOGARITHMS

Early mathematicians spent years computing and compiling the values of the sine, cosine, and tangent for angles. Since these values were still thought of as "lengths of a chord," very small units were used to measure the radius of the circle so that fractional lengths were avoided as often as possible. The calculations of these "lengths" required tedious multiplications and divisions in the interest of greater accuracy, and they were not always error-free.

A better method was needed for manipulating large numbers,

and the Scottish mathematician, John Napier, contributed two solutions. His first was the development of decimal fractions as we know them, something we take for granted. Earlier mathematicians often multiplied small numbers by a million so they wouldn't have to work with fractions. At least one table of square roots was published in which this was done. The square root of 3000000 is 1732, which doesn't require any fractions, while the square root of 3 is 1.732. The value 1.732 would have been 1 and 183/250ths to the mathematicians in the sixteenth century. Although the roots in the table were 1000 times too great, this was easy to remember and fractions were dispensed with.

It did not occur to many mathematicians to extend their digits to the right as we do today, using a decimal point and decimal fractions. Napier developed the idea of using a "period" or decimal point and extending the fractions as their decimal equivalents in tenths, hundredths, thousandths, and so on. This meant that fractions could be easily represented and worked with using a single line of decimal numbers.

Napier's second development was the *logarithm*, which he described in a book published in 1614. It had taken him 20 years to develop and refine this idea and to provide useful tables of *logarithms* that others could use to simplify calculations. This had a profound influence on the mathematics of Napier's time, and logarithms are widely used today.

Without going into more of the history of logarithms, or "logs" as they are commonly called, we'll just say that Napier developed a special way of treating numbers. Basically, all numbers can be represented as a *common*, or *base value* with an appropriate exponent. *Exponents* or superscripts are mathematical shorthand notes that are placed above and to the right of numbers or labels to indicate how many times they are multiplied by themselves. Since modern logarithms use a *base* of 10, here is an example:

$$10*10*10 = 10^3 = 1000$$

Thus, the base-10 logarithm of 1000 is 3. There are tables of logarithms that provide the exponent, or "log," for any value, and most scientific calculators and small computers can give you the log of a number.

Let's see how logs can be used. In the following example, a value, X, is multiplied by itself five times:

$$X*X*X*X*X = \text{answer}$$

Exponents can be used to simplify the way the problem is written:

$$X \cdot X \cdot X \cdot X \cdot X \text{ or } X^2 \cdot X^3 \text{ or } X^5$$

There is something very interesting about the way the problem has been rewritten. Instead of doing the actual multiplications, the exponents have been *added*. Napier used this approach in his system of logarithms. By using logarithms, multiplication of numbers became the addition of their exponents, and division of numbers became the subtraction of their exponents. Other complex functions can be simplified by using logarithms, too.

Using logarithms, you can easily multiply 3.98712 by 2.12678 without doing any multiplication at all. You can find the log for each of these values in a table of logarithms and, since each log represents an exponent, simply add them. The result would be an exponent which is the *log of the answer*. Here is what the problem looks like:

3.98712	$\log(3.98712) = 0.6006584$
$\times 2.12678$	$\log(2.12678) = 0.3277226$
???	

$$\log(3.98712) + \log(2.12678) = \log(\text{answer}) = 0.928381$$

Now, you would look in the table in the logs column until you found 0.928381. On the same line would be the value 8.47971, which is the result of the original multiplication. Although this has been simplified a bit, it still shows you how powerful logs were in easing the job of complex calculations.

Napier's original table of logarithms is no longer used. It was quickly improved upon by other mathematicians, and the base-10, or common, logarithms are the ones in general use today. However, 10 is not the only base possible for logarithms.

There is another type of logarithm called the *Napierian* or *natural* system of logarithms, and it is based on the value 2.7182818. This "natural" base is simply called "e" by people who use this form of logarithm. Although called Napierian logarithms, these are not the original logarithms Napier developed.

As long as you are just using the logarithms to simplify multiplication, division, and other complex math operations, the base is unimportant. However, in some calculations it is important to distinguish between the two systems of logs. In the common log system, logs are noted as $\log(x)$, while in the natural log system, they are noted as $\ln(x)$.

COMMODORE 64 LOGS

The Commodore 64 uses natural logs, so it is unfortunate that the LOG notation has been chosen for the logarithm command in BASIC. To have the computer give you the natural log of a value, you use the command:

`QX = LOG(value)` (The value must be greater than zero.)

You are asking the computer, "What exponent do you use with 'e' to get 'value'?"

Once you have obtained the logarithm of a number from the computer, how can you get back to the original number? The Commodore 64 uses the EXP operation to do this. Here is an example:

`DZ = EXP(value)`

You are asking the computer, "What is the result of raising 'e' to the 'value' power?" In this case, the value must be less than 88. The 88th power of *e* is a very big number!

If there is a need to, you can convert between the natural and common logs. Here are these important relationships:

$$\ln(x) = 2.3026 * \log(x) \quad \text{or} \quad 0.4343 * \ln(x) = \log(x)$$

and

$$e^x = 10^{(0.4343 * x)} \quad \text{or} \quad e^{(2.3026 * x)} = 10^x$$

Logs are often used when people are comparing power levels, and the following relationship is used:

$$\text{power ratio} = 20 * \log(\text{power out} / \text{power in})$$

For example, if a hi-fi amplifier can produce 150 watts of power from a tape recorder that gives it only 0.1 watt, the relationship is:

$$\begin{aligned} \text{power ratio} &= 20 * \log(150 / 0.1) \\ &= 20 * \log(1500) \\ &= 63.52 \end{aligned}$$

The power ratio is called the "decibel," or dB, named after Alexander Graham Bell, the inventor of the telephone. Bell worked with deaf people, and the telephone was an attempt to develop a device to increase their ability to hear. Decibel simply means tenth-of-a-bel, since the larger unit of bel is not frequently used. If you buy a hi-fi amplifier and the salesman tells you that the amplifier can

deliver a 50-decibel power gain, you'll have a good idea of what he is talking about.

Since the Commodore 64 uses natural logs, the power relationship would be:

$$\text{power ratio} = \text{dB} = 20 * 0.4343 * \ln(\text{power out} / \text{power in})$$

or, in a BASIC computer program:

$$\text{DB} = 20 * 0.4343 * \text{LOG}(P0 / PI)$$

There are many other uses for logarithms in science, mathematics, and engineering.

SPECIAL CODES

Hundreds of years ago, if "information" was to be sent quickly over long distances, flags, fires, or other signaling devices had to be used. When the electric telegraph was developed by Samuel F. B. Morse, the "Morse" code of dots and dashes was used. In this code, dots and dashes were used to represent each letter, number, or other special symbol to be communicated from one telegraph station to the next. Morse code is still used today for radio communications.

As communication techniques advanced, the teletypewriter was developed. This is an electromechanical device that automatically transmits information from a keyboard to a device that prints actual letters and numbers on a strip of paper. Instead of using dots and dashes, a special code was developed by Emile Baudot, and the "Baudot" code was used to transfer information from one teletypewriter to another over telegraph wires.

As more and more computers came into existence in the 1950s and 1960s, it was obvious that a more efficient and "universal" code had to be adopted so that information could be transferred from one computer to another. One such code is called the American Standard Code for Information Interchange. This is abbreviated ASCII, and most people who are familiar with it call it the "as-key" code.

All of the letters, numbers, punctuation marks, and special symbols such as \$, have a unique ASCII "code." By using this code, computer designers and programmers can be sure that the code for the letter "A" will be the same from one computer to another. Without this standard, it would be difficult to transfer information from one computer to another.

Your Commodore 64 computer can use the ASCII representation for information. There are two special operations that may be used in BASIC programs to convert from string characters to their equivalent code and back again. Although these operations are not frequently used, you may find them in a program or two, particularly if communications between several computers are involved.

These operations are the ASC and CHR\$ operations. The ASC operation lets you "convert" a string character into its equivalent coded representation. For example, PRINT ASC("H") would print the value 72 on the TV screen, since 72 is the ASCII equivalent for the letter "H." The CHR\$ operation "converts" from ASCII to a string character. For example, the PRINT CHR\$(87) would print the letter "W" on the TV screen, since W is the character with the ASCII value of 87.

Here is an example of how the ASC operations can be used:

```
50 INPUT A$
60 PRINT ASC(A$)
70 GOTO 50
```

When this program is run, the value of the code for each character will be displayed on the TV screen as its decimal value. For example, the code for the letter "X" is 88. This type of character-to-ASCII conversion process is used when the Commodore 64 is used as a terminal to "talk" with another computer over a telephone line.

The CHR\$ command does just the opposite, taking a code and converting it to its equivalent character. Here is an example:

```
100 INPUT CODE
120 PRINT CHR$(CODE)
140 GOTO 100
```

If the value 50 is typed in, the string character "2" is printed on the TV screen. The values for the CHR\$ instruction can be between 0 and 255. However, in the Commodore 64, *only the values of 13, and those between 32 and 95 correspond to the standard ASCII codes.* The other codes have special functions within the Commodore 64. Some display the special graphic symbols on the TV screen and do other things. However, the values for the letters, numbers, punctuation marks, and special symbols are the same.

THE TAN "f" KEYS

The four tan keys marked f1 through f4, and located on the right side of the keyboard, have been ignored so far. These keys are not

used when you are programming the computer, since they don't print a special symbol or have any special meaning to the Commodore 64. However, these keys are useful, and you may see a game or other program that tells you to press one of them to cause something special to happen.

Each of the keys has its own special ASCII value, as listed in Table 7-1. You can get at the even-numbered "f" keys by pressing [SHIFT] and one of these keys. The keys can be used in a program by using a sequence of instructions such as this:

Table 7-1. ASCII Values for the Tan "f" Keys

Key	Value
f1	133
f2	137
f3	134
f4	138
f5	135
f6	139
f7	136
f8	140

```
200 INPUT FK$
220 F = ASC$(FK$)
240 IF F = 133 THEN GOTO . . .
260 IF F = 137 THEN PRINT . . .
```

This simple sequence checks for the f1 and f2 key operations, and takes whatever action the programmer has put in the program. The program would probably trap errors, but we haven't shown that. The ON command could be used, too, by subtracting 132 from the code for the "f" keys. This gives you a 1 for the f1 key, a 2 for the f2 key, and so on. Now the following program lines could be used:

```
500 GET F$
520 IF F$ = "" THEN 500
540 F = ASC$(F$) - 132
560 ON F GOTO 3500, 4590, etc . . .
```

This can simplify things a bit if sequential "f" keys are being used. The main purpose of the "f" keys is to give you some extra keys that can serve special purposes in a complex program.

For additional information about the ASCII characters and their codes, we suggest that you look at the appendixes in your Commo-

dore 64 computer guide, supplied with the computer, or in the *Commodore 64 Programmer's Reference Guide*, where this information is listed for you.

REFERENCES

1. Hooper, Alfred, *Makers of Mathematics*. New York: Random House, Inc., 1948.
2. *Commodore 64 Programmer's Reference Guide*. Indianapolis: Howard W. Sams & Co., Inc., 1982.

PROBLEMS

1. You are standing on top of a building that is 650 feet high (Fig. 7-15). You look down at the roof of another building, 230 feet away, at a 20° angle. How tall is this building?

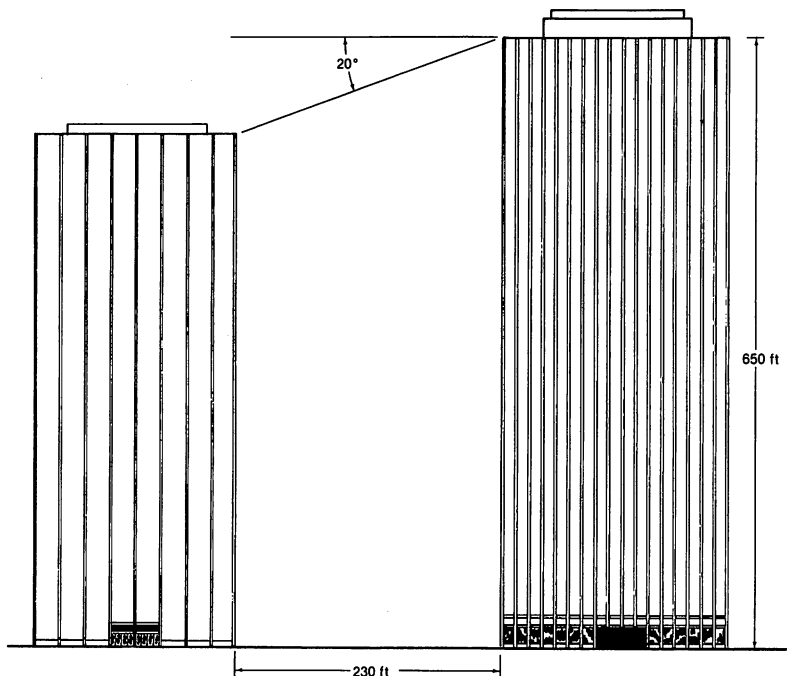


Fig. 7-15. Determining the height of a building.

2. When measuring the acidity of a liquid, the acidity is usually

expressed in units of pH. Water, a neutral liquid, has a pH of 7. A mildly acidic substance, such as vinegar, might have a pH of 5 or 6. A strong base, such as some bathroom cleaners, might have a pH of 13 or 14. The pH of a substance is defined as:

$$\text{pH} = -\log(\text{H}^+)$$

Thus, if the hydrogen ion (H^+) concentration is 0.0000001 molar, or 1.0×10^{-7} , the pH will be 7. Write a general-purpose program that lets you enter a hydrogen ion concentration, such as 2.89E -6, and displays the pH (5.55 for 2.89E -6). (Hint: Remember, the computer LOG function is really the natural log (ln) function, so you will have to convert from LOG to ln!)

3. Write a program that displays the sine of the angles, 10, 20, 30, . . . , 350° on the TV screen. The program should display both the angle and the sine of the angle.
4. Modify the program from Problem 3 so that the sine function is “plotted” on the TV screen. The sine for 0° should be at the top of the screen, and the sine for 360° should be at the bottom of the screen. The TV screen should appear as shown in Fig. 7-16. (Hint: Use the TAB function.)

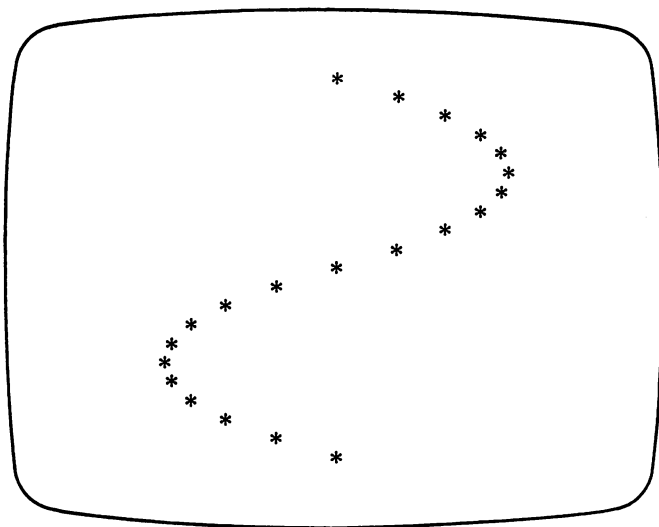


Fig. 7-16. Displaying the sine function on the TV screen.

5. Suppose the computer does not have a tangent (TAN) function. Write a program that compares the tangent of an angle to the sine divided by the cosine of the angle. Does this give us basically the same result? Can you guess how your computer determines the tangent of an angle?

U

U

U

U

U

U

U

U

U

U

U

U

U

U

U

CHAPTER 8

LIGHTS, ACTION

In this chapter, you will take a closer look at controlling the TV screen display. You will see how to use a computer program to position the cursor and how to control the color of what is displayed on the TV screen. You'll also see how you can control the screen without using PRINT commands, so that special displays can be put together.

THE SPACE COMMAND

In a previous chapter, you saw how the TAB command is used to position columns of information so they are easy to read. There is another command that is used to position information on the TV screen and it is called the space command, SPC. This is used within a PRINT command and it tells the computer to move the cursor a specific number of spaces to the right.

At first it may seem as though the SPC and TAB commands do the same thing; both commands move the cursor to the right, but they differ in how they do it. A TAB(10) command moves the cursor 10 spaces to the right *from the left edge of the display area*, but an SPC(10) command moves the cursor to the right 10 spaces *from its present position*. These operations are shown in Fig. 8-1. Neither the SPC nor the TAB command will erase or "destroy" any of

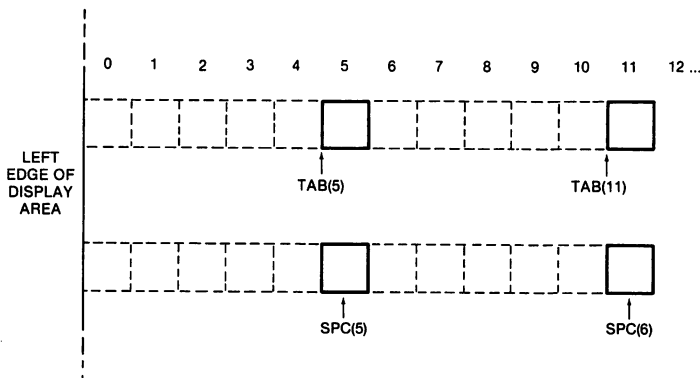


Fig. 8-1. How the TAB and SPC commands move the cursor.

the characters on the screen as they move the cursor from place to place.

Here is a sample program that uses the SPC command. You can type it into your computer and run it:

```

20 FOR S = 1 TO 38
30 PRINT SPC(S)"*"
40 NEXT S
50 FOR S = 37 TO 2 STEP -1
60 PRINT SPC(S)"*"
70 NEXT S
80 GOTO 20

```

MOVING FROM PLACE TO PLACE

The SPC and TAB operations move the cursor along a line on the TV screen to display information in an orderly way. Sometimes, it is useful to have complete control of the cursor, using the two cursor keys and the SHIFT key to move the cursor wherever you want. These same keyboard operations can be put in the "message" part of a PRINT command. You've already seen how this was done with the CLR/HOME key. If you are typing a "message" in a PRINT command and you press the cursor control keys, you'll find that the cursor doesn't move at all. Instead, each time one of the cursor control keys is pressed, a special symbol is printed in the "message." Here is an example in which the DOWN cursor control key was pressed while the "message" was being typed:

```

350 PRINT " █

```

The reversed "Q" displayed after the quote mark is the computer's notation to do a down-cursor movement when the "message" is used by the program.

When the cursor keys are pressed as a message is being typed, the Commodore 64 realizes that you don't want the cursor moved right now. However, when the computer gets to this "message" in the program, it recognizes the special symbols and then moves the cursor. Each of the four cursor movements prints a special symbol in a "message," and these are listed in Table 8-1. For example, when the computer gets to the following PRINT command, it will move the cursor down two lines and to the right two spaces before printing BIKES:

```
550 PRINT "█ █ █ █ █ BIKES"
```

Table 8-1. Cursor Control Symbols Used in Commodore 64 Messages

Key	Symbol
DOWN	█
UP	◻
RIGHT	▣
LEFT	▢

(NOTE: The UP and LEFT operations use the SHIFT key.)

Since the cursor commands move the cursor from its *present position* to a *new position*, it's a good idea to know exactly where the cursor is before you start to move it. Maps in shopping centers and large buildings have a brightly colored arrow saying "YOU ARE HERE." Without this guide, it might be difficult to figure out where you are and where you want to go. Since the cursor can be easily sent to its home position in the upper left-hand corner of the TV screen, that's a convenient place to start the cursor.

Experiment No. 8-1. Moving the Cursor

This experiment will show you how to use a program to position the cursor on the TV screen. Clear your computer and type in the following program. You must press the cursor keys as shown in the PRINT messages. Check your program for any mistakes. Be sure to type the semicolon (;) at the end of lines 10-30:

```
10 PRINT "[SHIFT] [CLR/HOME]";  
20 PRINT "[DOWN] [DOWN] [DOWN] [DOWN] [DOWN]";  
30 PRINT "[RIGHT] [RIGHT] [RIGHT] [RIGHT]  
[RIGHT]";
```

```
40 PRINT "HERE"
```

When this program is listed it will appear on the TV screen with the special symbols as follows:

```
10 PRINT "☐ ";  
20 PRINT "██████████";  
30 PRINT "██████████";  
40 PRINT "HERE"
```

After you have checked your program and corrected any errors, run the program. What do you see? The "message," HERE, is displayed near the upper left-hand corner of the TV screen. The READY message is also displayed.

Here's something a bit more complicated. Let's try a counting program that displays increasing numbers but only at one place on the screen. *DO NOT CLEAR THE COMPUTER*, since the program you just typed in will still be used. Here's the new program for you to type in: (Remember to press the [SHIFT] and [UP/DOWN] keys for the [UP] operation.)

```
100 PRINT "[SHIFT] [CLR/HOME]";  
110 PRINT "[DOWN] [DOWN] [DOWN] [DOWN] [DOWN]  
[DOWN]";  
120 PRINT "[RIGHT] [RIGHT] RIGHT] [RIGHT] [RIGHT]  
[RIGHT]";  
130 PRINT X  
140 X = X+1  
150 PRINT "[UP]";  
160 GOTO 120
```

What happens when you list this program on the TV screen? You'll see the program lines from the first part of the experiment, followed by the program lines you just typed in. Both programs are present in the computer. The program lines 100 to 160 should look like this:

```
100 PRINT "☐ ";  
110 PRINT "██████████ ";  
120 PRINT "██████████ ";  
130 PRINT X  
140 X = X + 1  
150 PRINT "☐ ";  
160 GOTO 120
```

If you are confused by seeing all of the program lines on the TV

screen at the same time, you can tell the computer to list only the lines that you want to look at. In this case, type LIST 100-200 [RETURN] and the computer will list only the program lines with numbers between 100 and 200.

Are you ready to run the program? Clear the TV screen and type RUN, but DON'T press the RETURN key yet. Carefully watch the upper left-hand corner of the TV screen as you press the RETURN key. Did you see the "HERE" message flash quickly on the TV screen when you started the program? What else happens on the TV screen? The "HERE" message was displayed quickly, just above the number. You can stop the program, clear the TV screen, and start the program again if you missed seeing it. You should be able to see "HERE" flash quickly on the TV screen right above the display of the numbers.

Let's continue with the counting program. Each higher number in the count "writes over" the one displayed before it, so the display counts quickly, much like a digital clock when it is being set to a new time.

The illustration in Fig. 8-2 shows how the cursor is moved by this

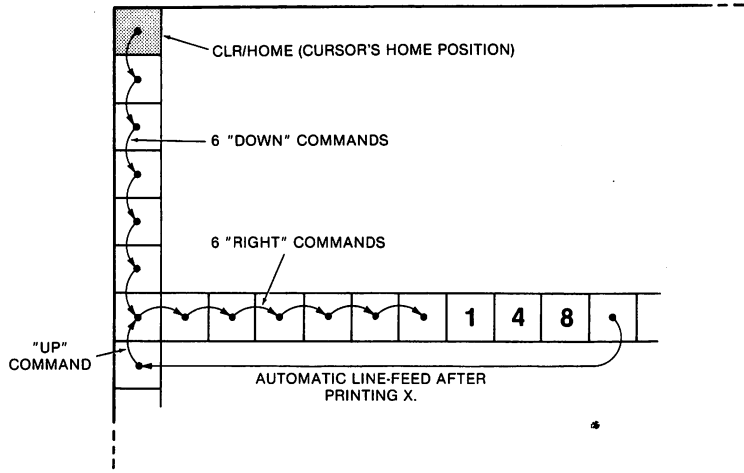


Fig. 8-2. The cursor movements for the number display program in Experiment 8-1.

program. The cursor is first moved down and to the right to place it near the center of the TV screen. After a number has been printed, the computer moves the cursor to the left side of the line below. This is the normal line-feed operation that automatically takes

place after each PRINT operation unless a semicolon is used to prevent it. The cursor operation in the PRINT command at line 150 moves the cursor back up to the line above so that the next number will be printed "over" the previous one.

This is one way in which values can be displayed in the same place in games, educational programs, and business programs. Do you know why the "HERE" message was displayed quickly on the TV screen when you started the program with the RUN command?

The first program you typed in at the start of the experiment doesn't have an END command to tell the computer that it has reached the end of that program. So, after the computer displays the "HERE" message, it keeps going right into the second program. An END command is used to stop the computer at the end of each program so that this sort of thing doesn't happen.

Type in the following program line to add it to your program:

```
50 END
```

Now type LIST 10-50 [RETURN] to list the first program. The program should look like this:

```
10 PRINT " ";  
20 PRINT " ";  
30 PRINT " ";  
40 PRINT "HERE"  
50 END
```

Now type RUN [RETURN]. What happens on the TV screen? The computer simply types HERE on the screen. It never gets to the counting program. Stop the computer and type RUN 100 [RETURN]. What happens now? The HERE message is cleared and the computer starts the counting program. The HERE message is not flashed on the screen, not even for an instant, as it was earlier in this experiment.

In this experiment you have seen how the cursor control keys can be used in the "message" part of a PRINT command to control the movement of the cursor from one position to the next.

THE MAGIC COLOR SCREEN

You can also use a BASIC program to change the color of the characters displayed on the TV screen. This is done using special keyboard operations in a "message" in the same way that the cursor was moved. There are many times when it is useful to change

to a different color to call attention to a word, number, or sentence on the TV screen.

The color of the cursor is changed by using the CTRL key (or the GRAPHICS key) and the eight color keys that share their functions with keys 1 through 8 in the top row of the keyboard, as shown in Fig. 8-3. If you press and hold the CTRL key and then



Fig. 8-3. The color control keys.

press one of the color keys, the cursor will change to the color shown on the key. Now when you type, the characters are displayed in the color you have selected. If you have a black-and-white TV set, you will see changes in the shades of grey as you change from color to color.

When the GRAPHICS key (C=) is used with the color keys, you get five other colors and three shades of grey. These "extra" colors are not shown on the keys, but they are listed in Table 8-2 for you. As you found earlier in this book, or by experimenting on your own, some of the screen/character color combinations don't look good. All the combinations are listed in Table 8-3, and are rated as excellent, fair, and poor.

Table 8-2. GRAPHICS Key Color-Control Operations

Keys Used	Printing Color
GRAPHICS and "1"	Orange
GRAPHICS and "2"	Brown
GRAPHICS and "3"	Light Red
GRAPHICS and "4"	Dark Grey
GRAPHICS and "5"	Medium Grey
GRAPHICS and "6"	Light Green
GRAPHICS and "7"	Light Blue
GRAPHICS and "8"	Light Grey

When the color of the cursor is changed, the characters already on the TV screen stay the same. *Only the characters printed after the color has been changed are displayed in the new color.*

You can also "reverse" the characters being displayed by using the CTRL key and the RVS ON and RVS OFF keys that share

Table 8-3. Recommended Screen/Character Color Combinations
 Printing Color

	Black	White	Red	Cyan	Purple	Green	Blue	Yellow	Orange	Brown	Light Red	Dark Grey	Medium Grey	Light Green	Light Blue	Light Grey	
Black		E		E	E	M		E	E		E	E	E	E	E	E	
White	E		E		E	E	E		M	E	M	E	E		E	E	
Red		E			M			E	E		E					M	
Cyan	E					M	E					M				M	
Purple	E	M														M	
Green	E	M		M								M		E		M	
Blue	M	E		E											M	E	E
Yellow	E		E				M		M	E	M	E	E				
Orange	M	E	E						E		E					M	
Brown		E							E	E		E				E	
Light Red	M	M	E					M		E						M	
Dark Grey	E	E		M				E						E	E	M	E
Medium Grey	E	E	M				M			M		E					E
Light Green	E					E	M					E					
Light Blue	E	E		E			E					M				M	
Light Grey	E	E	E		M	M	E			M	M	E	E		M		

E = Excellent Combination
 M = Marginal Combination

Blank = Not Recommended

their functions with the 9 and 0 keys. When the display is "reversed" by using the CTRL and RVS ON keys, the cursor color becomes the background color, and the background color is used to print the characters. This change won't be obvious from looking at the cursor, since its color and position stay the same. The "reverse" printing may be turned off by using the CTRL and RVS OFF keys. Reversed printing adds emphasis to a display, and creates a special visual effect. *Only the characters printed after the display has been "reversed" will be displayed in the reverse form.*

The color-change and reverse-printing operations can be included in the "message" part of a PRINT command, and they use special symbols to represent their actions. The symbols are shown in Table 8-4. The computer changes the color or displays characters in reverse only when it finds these special symbols in a program. For example, when the computer gets to the following print command:

```
100 PRINT "  THIS IS WHITE"
```

























it recognizes the  symbol and switches the printing color to

Table 8-4. Color Control Symbols Used in Commodore 64 Messages

Keys	Symbol
CTRL and BLK (Black)	
CTRL and WHT (White)	
CTRL and RED (Red)	
CTRL and CYN (Cyan)	
CTRL and PUR (Purple)	
CTRL and GRN (Green)	
CTRL and BLU (Blue)	
CTRL and YEL (Yellow)	
CTRL and RVS ON	
CTRL and RVS OFF	
GRAPHICS and BLK (Orange)	
GRAPHICS and WHT (Brown)	
GRAPHICS and RED (Light Red)	
GRAPHICS and CYN (Dark Grey)	
GRAPHICS and PUR (Medium Grey)	
GRAPHICS and GRN (Light Green)	
GRAPHICS and BLUE (Light Blue)	
GRAPHICS and YEL (Light Grey)	

white. The message, THIS IS WHITE, is then printed on the TV screen as white letters on the background color. Once the color has been changed, the computer uses the selected color until it is changed by another color-change operation in the program, or by a keyboard operation. Several special operations can be put in a "message." For example, clear, home, cursor, color, and reverse operations have been combined in this command:

```
100 PRINT "  COMBO"
```



This PRINT operation clears the screen and moves the cursor to its home position . It then moves the cursor down three lines  and over three spaces . The color is changed to green  and the color is reversed . The word COMBO is printed as background-colored letters surrounded by a green area.

Experiment No. 8-2. Color Control

This experiment shows you how to control the color of the TV display from within a program. If you have a black-and-white TV set, you'll see changes in the shades of grey. Clear your computer and type in the following program:

```
10 PRINT "[SHIFT] [CLR/HOME]"
20 PRINT "[CTRL] [4]"
30 X = 1
40 PRINT X
50 X = X + 1
100 GOTO 40
```

Here is how the program will appear on your TV screen when you list it:

```
10 PRINT "  "  
20 PRINT "  "  
30 X = 1  
40 PRINT X  
50 X = X + 1  
100 GOTO 40
```

What do you think this program will do? This program will display an increasing value on the screen; 1, 2, 3, 4, and so on.

What special symbol was displayed in line 20 when you typed the [CTRL] [4] color change? What will this do when the computer reaches this command? When you are typing characters on the keyboard and you press/hold the CTRL key and then press the 4 key, the next characters you type will be colored cyan, or very light blue. However, when the CTRL and 4 keys are pressed in a "message," a special symbol is displayed. It looks like a small triangle. When the computer reaches the statement:

```
20 PRINT "  "
```

in the program, it will change the printing color to cyan. Anything that is then printed will be cyan. Run the program. What is displayed on the TV screen? The TV screen is cleared and the numbers are displayed on the left side of the screen. The numbers are cyan. Stop the program by pressing the RUN/STOP key. Now list your program. What color are the characters in the program listing? The characters are all cyan. Do you know why? There are no other color-change commands in your program, so the TV display will continue to stay cyan until you change it to another color. Can you change the color to black right from the keyboard? Try to do this.

The color can be changed to black by pressing the CTRL key and then pressing the 1 key. This changes the color of the cursor and any characters that are then printed. If you list the program now, the listing will be printed in black, but it may be difficult to read the black letters and numbers on the dark blue background.

Can you add a program line to change the color of the numbers when the value 100 is displayed? How can the computer make this decision? It can check for the condition, $X = 100$. Here is a program line that will change the display to white when the value labeled X reaches 100:

```
60 IF X = 100 THEN PRINT "[CTRL] [2]";
```

When the program is listed, it should look like this:

```
10 PRINT " "
20 PRINT " "
30 X = 1
40 PRINT X
50 X = X + 1
60 IF X = 100 THEN PRINT "[ ] ";
100 GOTO 40
```

After correcting any mistakes, run your program. You can press the CTRL key by itself to slow the display. What happens when the number 100 is displayed? Did the display change color? The number 100 is displayed in white, and so are the numbers that follow it.

Experiment No. 8-3. Reversed Printing

In this experiment, you will find out how the reverse printing operation works and how it can be used in a program. Clear your computer and type in the following program:

```
20 PRINT "[SHIFT] [CLR/HOME]"
40 FOR N = 1 TO 5
60 PRINT N
80 NEXT N
```

Run this program to test it. The numbers 1 through 5 should be displayed in the upper left-hand corner of the TV screen. When the program works properly, change line 20 so that a white color-change operation is included in the message:

```
20 PRINT "[SHIFT] [CLR/HOME] [CTRL] [2]"
```


This will change the display color to white. The program should now look like this:

```
20 PRINT " [ ] "
40 FOR N = 1 TO 5
60 PRINT N
80 NEXT N
```

Run the program again. Do the numbers appear on the screen in white? The numbers should be printed in white on the normal background color. Now change the program so that line 20 also contains a reverse-on operation, RVS ON:

```
20 PRINT "[SHIFT] [CLR/HOME] [CTRL] [2] [CTRL]
[9]"
```

This will change the listing of the program so it looks like this:

```
20 PRINT "  "
40 FOR N = 1 TO 5
60 PRINT N
80 NEXT N
```



Run the program. Are the numbers printed in reverse, as the background color surrounded by white? No, they're not. Unlike the color-changing operations, you cannot set the Commodore 64 to the reverse mode and have it stay there. *The reverse mode must be set for each printing command in which it is to be used.* Here is how you can do it. Change line 20 so it contains only the clear-home and white color-change operations:

```
20 PRINT "[SHIFT] [CLR/HOME] [CTRL] [2]"
```

Change line 60 so that the reverse printing operation is contained in the "message" part of the PRINT command:

```
60 PRINT "[CTRL] [9]" N
```

Check your program with the listing shown here:

```
20 PRINT "  "
40 FOR N = 1 TO 5
60 PRINT "  " N
80 NEXT N
```

Run the program. Are the numbers printed in reverse? You should see them printed in the background color, with a white area around them.

NOTE: If you want to use the reverse printing operation in a program, remember to set it in each of the PRINT commands in which you want to use it. The reverse printing will be set back to the normal mode whenever (1) the Commodore 64 does a line-feed on the display, (2) the RETURN key is pressed, or (3) the program stops. The colors are not changed by these operations, and the cursor's color will stay as it is unless you change it.

The PRINT command can get the computer to do many interesting things on the TV screen just by using the cursor, color, and reverse operations in the "message." All of the letters, numbers, punctuation marks, and graphic symbols may be printed on the

screen to make colorful displays of information or art. By using color in your displays, you add value and interest to games and to education, business, and other programs.

The PRINT command is very useful and flexible, and you will find that it can take care of almost all of your needs to display information on the TV screen. However, there are some times when it would be helpful to have even greater control of the TV screen.

ADVANCED DISPLAYS AND GRAPHICS

The Commodore 64 can display up to 25 lines of information, and each line can have up to 40 characters. So, there are 1000 positions for characters on the TV screen. Do you think it's possible to "fill" them all with information?

Experiment No. 8-4. Filling the TV Screen

This experiment will let you see whether or not you can completely fill the TV screen with characters.

Here is a program that will print 1000 "@" signs on the TV screen. Clear your computer and type in this program:

```
100 PRINT "[SHIFT] [CLR/HOME]";  
120 FOR W = 1 TO 1000  
140 PRINT "@";  
160 NEXT W
```

Run the program. Is the screen completely filled with 1000 "@" symbols? It is difficult to tell, since as soon as the program ends, the READY message is displayed on the TV screen. Clear the TV screen and add the following line to your program:

```
180 GOTO 180
```

This will keep the computer in an "endless" loop so the program will never end and the READY message will not appear.

Run the program again. Are all 1000 "@" signs displayed? It looks as though they might be, but as soon as the last one is printed, the display moves up, leaving two blank lines at the bottom of the display. Stop the program with the RUN/STOP key, clear the TV screen, and change line 120 to:

```
120 FOR W = 1 TO 999
```

Now run the program again. What is displayed on the TV screen? The TV screen is completely filled with "@" symbols, except for the last space in the lower right-hand corner.

When the Commodore 64 displays a character in the last space on a line, or in the last space on the display, it automatically moves the cursor to the next line. At the bottom of the display, it will move the display "up" by 1 or 2 lines. If you had had useful information at the top of the display, the first two lines would have been "lost." This is an annoyance, and it makes it difficult to display information in the last place on a line if you don't want the cursor to automatically move.

DRAWING GRAPHS

Graphs can give you a quick visual indication of how values, prices, and scores are related to one another, and the Commodore 64 can draw graphs for you without much effort. In this section, we'll give you two graph programs that you can use to draw horizontal graphs on your TV screen. In the first program, the computer will simply use horizontal lines of asterisks to represent the values:

```
*****
*****
*****
*****
```

and so on. Here is Graph Program No. 1:

```
10 PRINT "[SHIFT] [CLR/HOME]";
20 DIM DT(25): MAX = -1000000 : MIN = 1000000
30 INPUT "NUMBER OF VALUES =";NV
40 FOR X = 1 TO NV
50 INPUT DT(X)
60 IF DT(X) > MAX THEN MAX = DT(X)
70 IF DT(X) < MIN THEN MIN = DT(X)
80 NEXT X
100 PRINT "[SHIFT] [CLR/HOME]";
110 FCTR = 38/(MAX-MIN)
120 FOR G = 1 TO NV
130 NS = INT((-MIN + DT(G)) * FCTR)
140 FOR Z = 0 TO NS
150 PRINT "*";
160 NEXT Z
170 PRINT
180 NEXT G
200 GOTO 200
```

This program lets you type in your values and it then graphs them on the TV screen for you. An array for 25 values has been set up, since this is the maximum number of lines that can be displayed on the TV screen for the Commodore 64. You can graph only a few values, not all 25 must be used. The computer inputs the values and looks for the minimum (MIN) and maximum (MAX) values. It needs these so it can figure out how to fit all of the information on the screen. The graphs are drawn as horizontal lines of asterisks on the TV screen, as shown previously.

In the next graphing program, the computer will put a title on the graph for you, and it will let you give 4-letter (or number) legends to each piece of information. Graphing Program No. 2 is longer, since it asks some "intelligent" questions and has some error traps. It can take values between -1000000 and +1000000:

```

10 PRINT "[SHIFT] [CLR/HOME]";
20 DIM GL$(24), DT(24)
30 MAX = -1000000 : MIN = 1000000
40 INPUT "GRAPH TITLE"; GT$
50 INPUT "HOW MANY VALUES"; NV
60 IF NV > 24 THEN PRINT "NOT MORE THAN 24
   PLEASE" : GOTO 50
100 FOR X = 1 TO NV
120   PRINT "LEGEND " X;
140   INPUT GL$(X)
160   IF LEN(GL$(X)) > 4 THEN PRINT "UP TO 4
   CHARACTERS" : GOTO 120
180   PRINT GL$(X) "'S DATA";
200   INPUT DT(X)
220   IF DT(X) > MAX THEN MAX = DT(X)
240   IF DT(X) < MIN THEN MIN = DT(X)
260 NEXT X
280 FCTR = 32 / (MAX - MIN)
300 PRINT "[SHIFT] [CLR/HOME]";
320 PRINT TAB(5) GT$
340 FOR G = 1 TO NV
360   NS = INT((-MIN+DT(G)) * FCTR)
380   PRINT GL$(G); : PRINT TAB(5);
400     FOR Z = 0 TO NS
420       PRINT "*";
440     NEXT Z
460   PRINT

```

```
480 NEXT G
500 GOTO 500
```

Here is a sample run of this program:

```
GRAPH TITLE ? TEST SCORES
HOW MANY VALUES ? 8
```

```
LEGEND 1 ? JON
JON'S DATA ? 87
LEGEND 2 ? JAMES
UP TO 4 CHARACTERS
LEGEND 2 ? JIM
JIM'S DATA ? 38
```

and so on, which produces a graph that looks like this:

```
          TEST SCORES
JON *****
JIM *****
JANE *****
BETH *****
CHRS *****
SPRK *****
LUCK *****
SARA *****
```

This program can display something other than an asterisk if you change the character at line 420 so that another character is put between the quote marks.

More complicated graphing programs can be written for the Commodore 64, but these two examples show you what types of things can be done with the BASIC language and the TV display. Color could also be used, and other information could be displayed, too.

SCREEN CONTROLS AND MAPS

The PRINT command is used extensively in programs, such as the graphing programs you just saw, but in the Commodore 64 it has some limitations. Now we will tell you about another way to control the TV display. So far, the screen looks like individual lines with characters on them. You can also think of the TV display as a grid of squares, each of which can hold one character, as shown in

Fig. 8-4. The grid, or "map," is laid out in the same way in which characters are displayed on the TV screen; 40 squares across the top and 25 squares down the side.

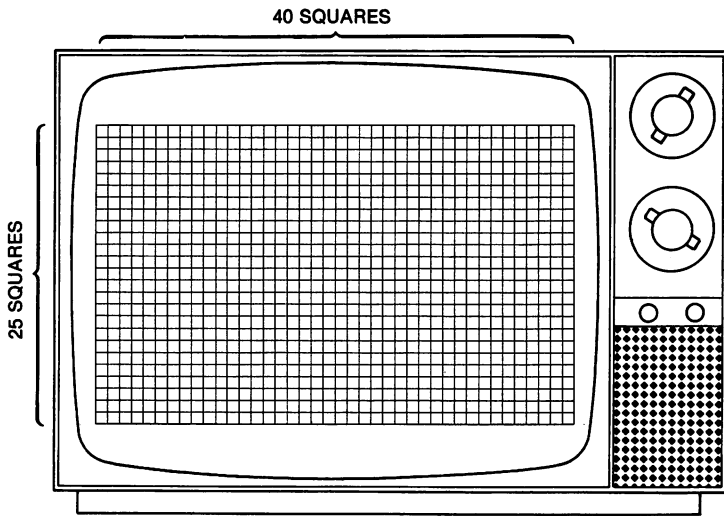


Fig. 8-4. The TV screen grid: 40 characters across by 25 display lines.

This is the way that the Commodore 64 actually arranges the information that you see on your TV set. When information is to be printed on the TV screen, the computer automatically puts the needed characters in the map squares, one by one. It happens very quickly, and it is completely taken care of by the computer. The overall result is that the characters show up in matching positions on the TV screen.

The squares used to hold the TV display information are grouped in a *display map*, and they are numbered in sequence, just like bins in a warehouse or boxes in a post office. In the Commodore 64, the display map numbers start at 1024 and end with 2023, as shown in Fig. 8-5. Any square on the map can be easily located, since each has a unique number or "address." Once you have the map, individual characters can be put in each square to display them on the TV screen. The Commodore 64 has a second map that looks exactly like the display map, except that its addresses start with 55296 and end with 56295. This is the *color map*, and it is used to set the color of each of the characters displayed on the TV screen. Each position on the TV screen has a matching position in the display map and in the color map, as you can see in Fig. 8-6. You can think of the display

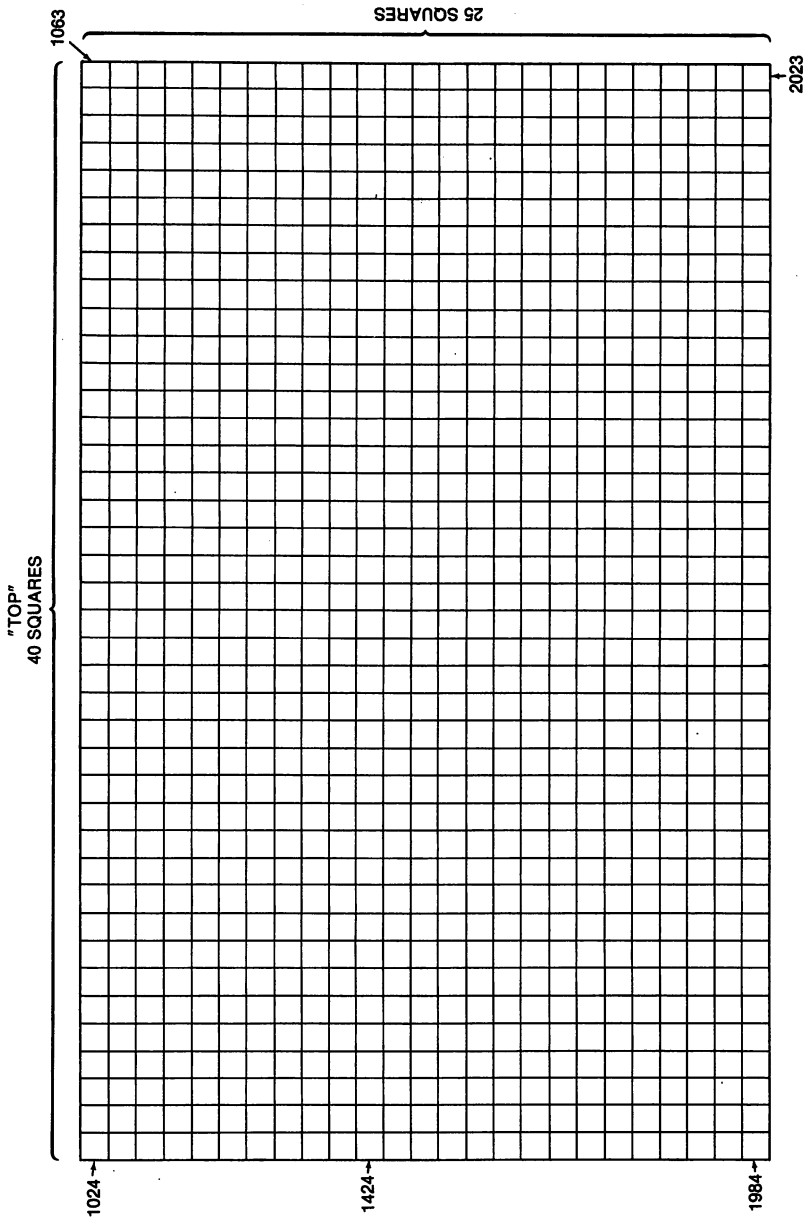


Fig. 8-5. The screen display map.

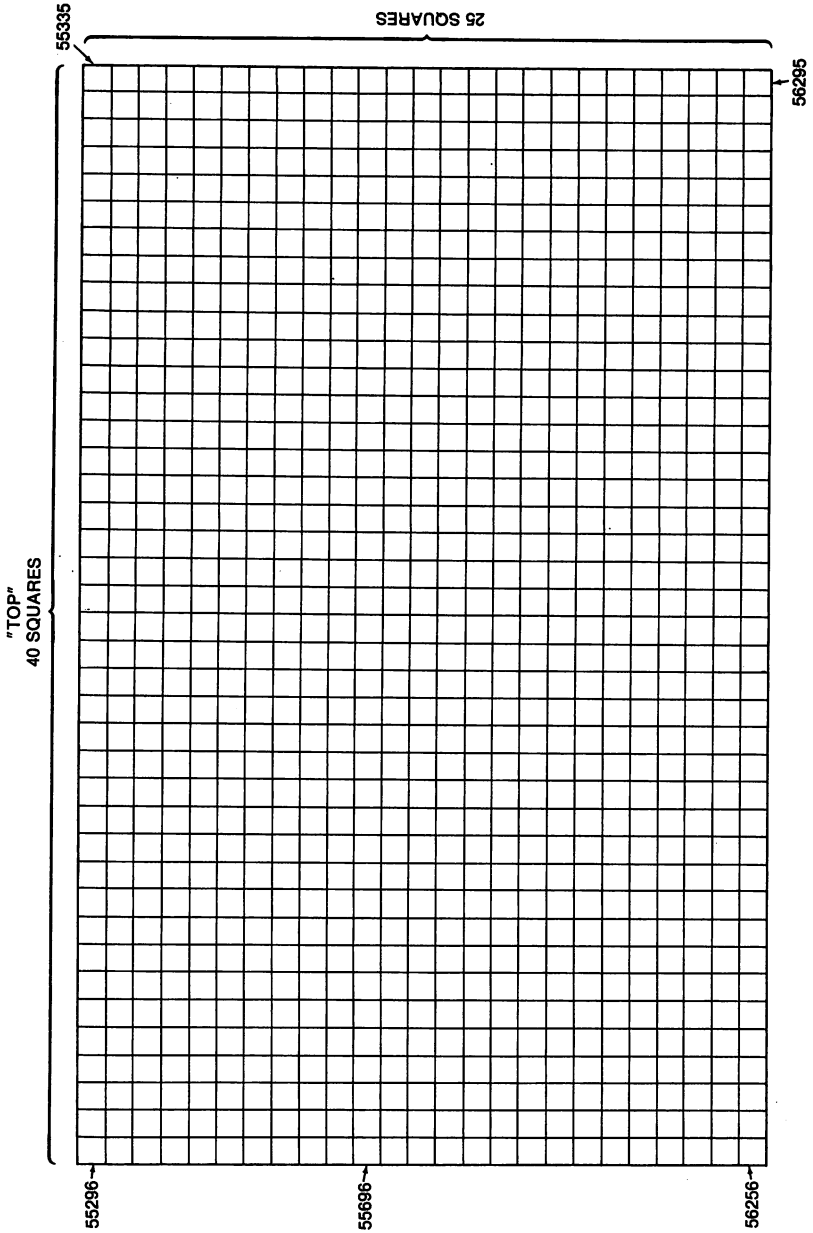


Fig. 8-6. The screen color map.

map as holding the character outlines and the color map as holding colored lights that shine through to the TV screen.

The two maps are used together so that when a character is put in the display map at address 1102, its color must be put in the color map at address 55374, which is right "behind" it, providing the colored light. The addresses in the color map are 54272 greater than the matching addresses in the display map, so it's not too difficult to keep track of them.

If you could look into the squares in the maps, you wouldn't find the actual characters and colors. The Commodore 64 uses a special "screen code" for each character and a "color code" for each color. For example, the screen code for "P" is 16 and the color code for red is 2. So, by placing the proper *screen code* in one of the display-map squares *and* a *color code* in the matching color-map square, the colored character appears on the TV screen. This is shown in Fig. 8-7. The characters and their screen codes are shown in Table 8-5. The Commodore 64 has two sets of characters, either of which

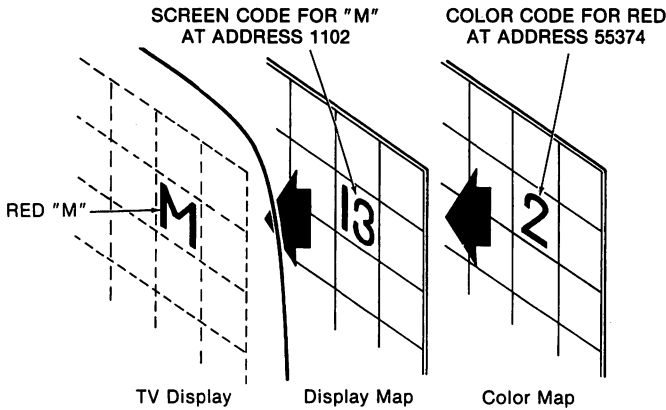


Fig. 8-7. Alignment of the screen display and color maps for TV display.

you can use. We'll show you how to switch between them later in this chapter. The 16 color codes are listed in Table 8-6.

A new command, POKE, is used to "address" a square in the display and color maps and place, or "poke," a code into it. The POKE command looks like this:

POKE address, code

To display a character on the TV screen at a specific spot, the matching display map and color map squares must have a screen

code and a color code poked into them. Two POKE commands, one for the display map and one for the color map, are used to print the letter "M" in red near the middle of the screen, at display map address 1524. The matching color address is $1524 + 54272$, or 55796:

```
100 POKE 1524, 13 : POKE 55796, 2
```

In this example, the screen code (13) was poked into the display map and then the color code (2) was poked into the color map. The same thing happens even if the POKE commands are reversed:

```
100 POKE 55796, 2 : POKE 1524, 13
```

A POKE command can be used to address any of the display-map or color-map squares at any time in a program. When the POKE command is used, its action is independent of the cursor and it will not cause line feeds to take place, nor will it advance or "push up" the display.

Experiment No. 8-5. Using the POKE Command

In this experiment, you will learn how the POKE command can be used to control the display of characters and their colors on the TV screen. You will use the POKE command to control the display and color maps. Clear your computer and type in the following program:

```
220 FOR AD = 1024 TO 2023
240     POKE AD,42
260     POKE AD + 54272,2
280 NEXT AD
300 GOTO 300
```

This program will do two things. The FOR-NEXT loop will go through all of the addresses in the display map, and the first POKE command will put the display code (42) for an asterisk (*) in a display-map square. The second POKE command will put the red color code (2) in the matching color-map square.

Run the program. What is shown on the TV screen? Are all of the positions "filled" with an asterisk? The entire screen fills with red asterisks. Stop the program by pressing the RUN/STOP key and clear the TV screen. Now change line 220 to:

```
220 FOR AD = 1024 TO 2022
```

This should leave the last space on the display "blank." Run the

Table 8-5. Screen Codes for the Display Characters

SET 1	SET 2	POKE	SET 1	SET 2	POKE	SET 1	SET 2	POKE
@		0	U	u	21	*		42
A	a	1	V	v	22	+		43
B	b	2	W	w	23	,		44
C	c	3	X	x	24	—		45
D	d	4	Y	y	25	.		46
E	e	5	Z	z	26	/		47
F	f	6	[27	∅		48
G	g	7	£		28	1		49
H	h	8]		29	2		50
I	i	9	↑		30	3		51
J	j	10	←		31	4		52
K	k	11	SPACE		32	5		53
L	l	12	!		33	6		54
M	m	13	"		34	7		55
N	n	14	#		35	8		56
O	o	15	\$		36	9		57
P	p	16	%		37	:		58
Q	q	17	&		38	;		59
R	r	18	'		39	<		60
S	s	19	(40	=		61
T	t	20)		41	>		62

Courtesy Commodore Business Machines, Inc.

Table 8-5. Screen Codes for the Display Characters (cont)

SET 1	SET 2	POKE	SET 1	SET 2	POKE	SET 1	SET 2	POKE
?		63		T	84			106
		64		U	85			107
	A	65		V	86			108
	B	66		W	87			109
	C	67		X	88			110
	D	68		Y	89			111
	E	69		Z	90			112
	F	70			91			113
	G	71			92			114
	H	72			93			115
	I	73			94			116
	J	74			95			117
	K	75			96			118
	L	76			97			119
	M	77			98			120
	N	78			99			121
	O	79			100			122
	P	80			101			123
	Q	81			102			124
	R	82			103			125
	S	83			104			126
					105			127

Courtesy Commodore Business Machines, Inc.

Table 8-6. Screen Color Codes

Color	Color Code
Black	0
White	1
Red	2
Cyan	3
Purple	4
Green	5
Blue	6
Yellow	7
Orange	8
Brown	9
Light Red	10
Dark Grey	11
Medium Grey	12
Light Green	13
Light Blue	14
Light Grey	15

program and see if this is what happens. The last space should be left blank. Stop the program and clear the TV screen again. Change line 220 back to:

```
220 FOR AD = 1024 TO 2023
```

and run the program. The complete display should be filled again.

The display can also be "filled" from the bottom. Stop the program and clear the TV screen. Change line 220 to:

```
220 FOR AD = 2023 TO 1024 STEP -1
```

and run the program again. The display of asterisks should start at the bottom right-hand corner and end in the upper left-hand corner. It would be difficult to do this type of printing with a PRINT command. Stop the computer, clear the TV screen, and change line 220 back to:

```
220 FOR AD = 1024 TO 2023
```

but don't run the program again. Now, let's change the program so that different colors are selected as the program is running. When the computer is READY, type in the following command:

```
POKE 53281, 1 [RETURN]
```

This will change the screen color to white. We'll tell you more

about changing the screen colors later in this chapter. The white screen will make the colors used in this experiment easier to see.

The random number command (RND) can select a random color code between 0 and 7 that can be poked into the color map. Add the following line to your program:

```
250 CL = INT(RND(1) * 8)
```

and change line 260 to:

```
260 POKE AD + 54272, CL
```

These new program lines will come up with a random number between 0 and 7, and will place it in the color map as the asterisks are printed on the TV screen. Here is a listing of the complete program:

```
220 FOR AD = 1024 to 2023
240   POKE AD,42
250     CL = INT(RND(1)*8)
260     POKE AD + 54272, CL
280 NEXT AD
300 GOTO 300
```

Run the program and watch the display. Are different colored asterisks shown as you expected? There are colored asterisks printed on the screen, but some asterisks seem to be "missing." Do you know why? These "missing" asterisks aren't missing at all. The color code used for them is 1, for white. A white character printed on a white background cannot be seen on the TV display.

Stop the computer, clear the TV screen, and change line 300 to:

```
300 GOTO 220
```

This command will point the computer back to the beginning of the program. What will this do to the TV display? Run the program and find out. The asterisks stay on the screen, but their colors change as the computer goes through the program again and again.

This experiment has shown you how POKE commands can be used to control the TV display so that characters of any color can be displayed anywhere on the TV screen. You also saw an interesting use for the random number operation. If you're interested, you might try and think of a way to avoid printing white asterisks. Once a character has been displayed on the TV screen, you can change its color by changing the color code placed in its matching square in the color map. You can also change the character being

displayed and do many other interesting things with the display maps.

REVERSED CHARACTERS

If you look at the characters in Table 8-5, you'll see that none of them is shown in its reversed mode; that is, the character printed in the background color in a block of another color. Each character can be reversed just by adding 128 to its screen code. For example, 3 is the code for "C" and 131 is the code for a reversed "C." It is easy to switch to the reverse mode by adding 128 to a character's screen code. By subtracting 128 from a reverse character's screen code, the character goes back to normal.

Experiment No. 8-6. A Flashing Sign

Flashing signs are used to get your attention, and computer displays use the same technique. The cursor flashes to show you where it is, and flashing legends and messages can be useful, too. In this experiment, you'll see how a message can be flashed on the screen. Clear your computer and type in this program:

```
50 POKE 53281, 1
100 PRINT "[SHIFT] [CLR/HOME]";
120 DATA 4, 1, 14, 7, 5, 18
140 FOR AD = 1520 TO 1525
160     READ CH
180     POKE AD, CH
200     POKE AD + 54272, 2
220 NEXT AD
```

This program uses a DATA statement to hold screen codes for the letters D, A, N, G, E, and R so that "DANGER" can be printed on the TV screen. The FOR-NEXT loop reads the codes from the DATA statement and pokes them into the display map. The POKE command at line 50 sets the screen to white for you (if it isn't already white), and the POKE command at line 200 sets the color of each letter to red.

Run the program. You should see the word DANGER displayed near the center of the TV screen. If it is not displayed, carefully check your program. To flash the word DANGER on the TV screen, you display it in the same place, but in reverse. This is done by using the same screen codes, but with 128 added to each one. Clear the TV screen and add the following lines to your program:

```

240 FOR T = 1 TO 1000: NEXT T
260 RESTORE
280 FOR AD = 1520 TO 1525
300     READ CH
320     POKE AD, CH + 128
340 NEXT AD
360 RESTORE
380 FOR T = 1 TO 1000: NEXT T
400 GOTO 140

```

These program lines place “reversed” screen codes in the same display map squares that were used in the first part of the program. The difference is that 128 has been added to the original codes. Since the color code has already been poked into the map once, this doesn’t have to be done again. The FOR-NEXT loops at lines 240 and 380 are “do-nothing” loops used to slow the computer so you can see the display change. The RESTORE commands reset the READ command so it starts from the beginning of the list of codes in the DATA statement. Here is the complete program:

```

50 POKE 53281, 1
100 PRINT "[SHIFT][CLR/HOME]";
120 DATA 4, 1, 14, 7, 5, 18
140 FOR AD = 1520 TO 1525
160     READ CH
180     POKE AD, CH
200     POKE AD + 54272, 2
220 NEXT AD
240 FOR T = 1 TO 1000: NEXT T
260 RESTORE
280 FOR AD = 1520 TO 1525
300     READ CH
320     POKE AD, CH + 128
340 NEXT AD
360 RESTORE
380 FOR T = 1 TO 1000: NEXT T
400 GOTO 140

```

Run the complete program and see if DANGER is flashed on the screen. It should be. If it is not, carefully check your program.

This program flashed the word DANGER by changing the display from the normal letters to the reversed letters. Another type of display might turn the letters on and off. Let’s try that, too.

Once the screen codes have been placed in the display map, the characters are "lit" by poking a color code into the color map. In the asterisk display experiment, you saw that if the color code was the same as that for the background, an asterisk wasn't seen. You can turn off characters, or "remove them," simply by setting their color code to the background color code.

Stop the computer, clear the TV screen, and remove lines 200 through 400 from your program. Type the line number for a line to be "erased" and press [RETURN] to remove a line from your program. The lines remaining should be:

```
50 POKE 53281, 1
100 PRINT "[SHIFT] [CLR/HOME]";
120 DATA 4, 1, 14, 7, 5, 18
140 FOR AD = 1520 TO 1525
160     READ CH
180     POKE AD, CH
```

Add the following line to the program:

```
200 NEXT AD
```

Run the program. Does the word DANGER appear on the TV screen? No, it doesn't, since no color codes were placed in the color map as part of this program.

Stop the computer, clear the TV screen, and add the following lines to the program:

```
220 FOR AD = 1520 TO 1525
240     POKE AD + 54272, 2
260 NEXT AD
```

Now run the program. Lines 220, 240, and 260 set the matching squares in the color map to red, so the DANGER message should show up on the TV screen. Now add these lines to the program to make the message flash:

```
280 FOR T = 1 TO 100: NEXT T
300 FOR AD = 1520 TO 1525
320     POKE AD + 54272, 1
340 NEXT AD
360 FOR T = 1 TO 100: NEXT T
380 GOTO 220
```

The complete program will look like this:

```
50 POKE 53281, 1
100 PRINT "[SHIFT] [CLR/HOME]";
120 DATA 4, 1, 14, 7, 5, 18
140 FOR AD = 1520 TO 1525
160     READ CH
180     POKE AD, CH
200 NEXT AD
220 FOR AD = 1520 TO 1525
240     POKE AD + 54272, 2
260 NEXT AD
280 FOR T = 1 TO 100: NEXT T
300 FOR AD = 1520 TO 1525
320     POKE AD + 54272, 1
340 NEXT AD
360 FOR T = 1 TO 100: NEXT T
380 GOTO 220
```

This seems like a lot of trouble to go to to flash a message on the screen, but it shows you how the display of information can be controlled by a program. Since you changed the color of the letters from red to white, back to red, and so on, you can change the color code in line 320 so that DANGER goes back and forth between red and yellow letters. Try it.

SEEING WHAT YOU HAVE DONE

The POKE command is used to put codes in the display and color maps. The Commodore 64 also has an operation that you can use to take a look into the maps to see what code is stored in a particular square, or address. This is the PEEK operation, and it lets you "peek" into any square to get the code that has been put there. Here is what a PEEK command looks like:

PEEK (address)

When you give the PEEK command an address, the computer will *get a copy of the code in that square*. The PEEK command is often used with a label so you can use the coded information from the map in a program. For example, the PEEK command:

```
200 DR = PEEK(55296)
```

will get the color code from the upper left-hand square in the color

map (see Fig. 8-6). The PEEK operation *copies* the code, and it doesn't change the color map in any way.

How could this operation be used in a program? One simple use would be to have the program get screen codes from the display map so the characters could be "reversed." Here is how it might be done:

```
680 SC = PEEK (AD)
700 RC = SC + 128
720 POKE AD, RC
```

We assumed that the screen code wasn't already "reversed." The PEEK command isn't used as often as the POKE command, but it serves a useful purpose, and it's helpful to know that this type of look-and-see operation is available.

MORE CHARACTERS

Two sets of characters are shown in Table 8-5, but so far only Set 1 has been used. You switch to Set 2 by pressing the SHIFT and GRAPHICS keys at the same time. When you do this, you'll see the entire display change to the second set of characters. The characters from Set 2 will continue to be used until you switch the computer back to Set 1. You can also change to the second set of characters from within a program, and this is done with a POKE command that uses address 53272. For example, this instruction will switch the Commodore 64 to the characters in Set 2:

```
100 POKE 53272, 23
```

while this command:

```
200 POKE 53272, 21
```

will switch the Commodore 64 back to Set 1. Unlike the color and reverse printing operations, *the switch from one character set to the other immediately switches the whole TV display to the new character set.*

Since the computer uses Set 1 when it is turned on, you don't have to do anything else to use that set. In most cases, you won't be switching back and forth between the two sets of characters.

SCREENS AND BORDERS

When you turn on the Commodore 64 computer, the color of the square central area is dark blue, and the surrounding border color

is light blue. You can change these colors by using two POKE commands, one for the screen color and one for the border color. Each of the POKE commands uses one of the standard color codes listed in Table 8-6, so there are 256 possible color combinations. The POKE commands are:

POKE 53280, Border color code
POKE 53281, Screen color code

For example, the typed-in command:

```
POKE 53280,5 : POKE 53281, 1 [RETURN]
```

sets up a green border with a white central area in the center of the TV screen. Many programmers use these POKE commands to change the screen colors for different games or programs. The POKE commands can be part of a program, or you can type them in at any time to change the screen colors. Why is it useful to change these colors? We found the dark blue screen color a bit hard on our eyes, so we changed it to white, with grey letters. Changes in the screen colors can be used to show what kind of a program is being run; red for financial, green for games, and so on. Borders might be used in educational programs to tell teachers at a quick glance what level different kids are working on.

So far, you have seen how the computer uses "maps" and codes to control the characters displayed on the TV screen and their colors. You'll find that the Commodore 64 has other maps with their own addresses, and these control other parts of the computer. For example, there is a "map" that controls the sounds the computer can make.

FUN PROGRAMS

Here are two programs that you can type in and run just for fun. One is a maze-drawing program that you can type in and run on your computer. It randomly selects graphic characters and displays them to create different mazes. Some of the mazes may be simple to solve, others may be complex. This program uses the top-, bottom-, left-, and right-line characters. Others such as the "corner" characters could be used to create different types of mazes.

```
100 REM MAZE PROGRAM FOR THE COMMODORE 64  
120 DATA 163,164,165,167  
140 FOR S = 0 TO 3
```

```

160     READ A(S)
180 NEXT S
200 PRINT "[SHIFT] [CLR/HOME]";
220 FOR P = 1 TO 24*40
240     T = INT(RND(1) * 4)
260     PRINT CHR$(A(T));
280 NEXT P
300 GOTO 300

```

Here is a kaleidoscope program that you can run on your computer. It creates an interesting display on a color TV set:

```

100 REM KALEIDOSCOPE PROGRAM FOR THE COMMODORE 64
120 PRINT "[SHIFT] [CLR/HOME]";
140 POKE 53281, 1
160 GR = 160
180 CL = INT(RND(1) * 8)
200 IF CL = 1 THEN GOTO 180
220 Q = RND(0)
240 X = INT(RND(1) * 20)
260 Q = RND(0)
280 Y = INT(RND(1) * 12)
300 A = 1024 + (12-Y)*40 + 20 + X
320 B = 1024 + (12-Y)*40 + 20 - X
340 C = 1024 + 40*(12+Y) + 20 + X
360 D = 1024 + 40*(12+Y) + 20 - X
380 POKE A, GR : POKE A+54272, CL
400 POKE B, GR : POKE B+54272, CL
420 POKE C, GR : POKE C+54272, CL
440 POKE D, GR : POKE D+54272, CL
460 GOTO 180

```

In this program, random numbers select a color and the position to be colored on the TV screen. The RND(0) operation is a new one, but it simply resets the random number part of the computer. This helps prevent the computer coming up with the same *sequence* of numbers, which is possible in a simple program such as this. The graphic character chosen (GR = 160) is just a reversed space (32 + 128). A different character can be used instead.

MORE GRAPHICS?

The Commodore 64 computer is quite powerful when it comes to graphics and "animated" displays for games and recreational pro-

grams. Creating these visual effects takes quite a good knowledge of programming and special programming techniques. If you are interested in these techniques, we suggest that you look for a more advanced book about the Commodore 64, and that you purchase a copy of the *Commodore 64 Programmer's Reference Guide*.

A NOTE ABOUT CODES

In the Special Math Functions chapter, we introduced the American Standard Code for Information Interchange, or ASCII. This code is a standard one that has been adopted by computer equipment manufacturers so that information can be easily transferred from one computer to another. You learned about the CHR\$ and ASC operations that can convert string characters to their ASCII equivalent and back again. The screen codes used in the Commodore 64 computer are different from the ASCII values assigned to each letter, number, and punctuation mark. Most of the special graphic characters that can be displayed with the Commodore 64 have no ASCII equivalent. Likewise, there are no ASCII equivalents for reversed characters. Although you won't be concerned with this right now, *remember that the screen code and ASCII value for a character are not the same thing!*

QUESTIONS

1. What does the SPC, or space, command do?
2. How does the SPC command differ from the TAB command?
3. What happens when you are typing a "message" for a PRINT command and you try and use the CRSR keys?
4. What commands can be used in a PRINT command to control the cursor?

5. What does the END command do? Why is it useful?
6. How do you get the Commodore 64 computer to change the color of the characters it is displaying?
7. When the color is changed, does this change the color of everything being displayed?
8. How can the color be changed from within a program?
9. How do you get the computer to print in reverse? Can you set the computer to the reverse mode and use it as you wish?
10. What two maps control the TV display? How many locations are there in each map?
11. What information must be placed in the two maps to control the TV display?
12. How can a character be "reversed" on the TV screen?
13. What does the POKE command do? What does the PEEK command do?

14. How many sets of display characters does the Commodore 64 computer have? How can you switch from one to the other? Does this "switch" change all of the characters on the TV screen?

PROBLEMS

1. Write a program so that the background color on the TV screen is changed to green.
2. Using POKES, move a red ball ([SHIFT] [Q]) along the top line of the TV screen, from left to right. Once the ball reaches the right-hand side of the TV screen, it should bounce back toward the left-hand side of the screen. The red ball should continue to bounce off the sides of the TV screen.
3. Write a program so that a black diamond ([SHIFT] [Z]) is moved about on the top line of the TV screen in a random manner. This means that the diamond can either (1) stay where it is, (2) move one position to the left, or (3) move one position to the right.
4. Display a sine wave on the TV screen (Fig. 8-8), assuming that the angle varies between 0 and 2π radians (0 and 360°). If you aren't comfortable using the SIN function (from Chapter 7), skip this and the next problem.
5. Modify the program from Problem 4 so that in addition to plotting a sine wave on the TV screen, a coordinate system is also plotted (Fig. 8-9).
6. Write a program so that a red asterisk (*) moves around the edge of the TV screen, in a clockwise manner.
7. Write a program that asks you to enter a number that represents the border color and a number that represents the background color. Once both numbers have been entered, these colors are actually changed on the TV screen. For this problem use the "menu" approach of entering a selection's number shown in Problem 5-5.
8. Write a program that displays the up-arrow character (\uparrow) in the

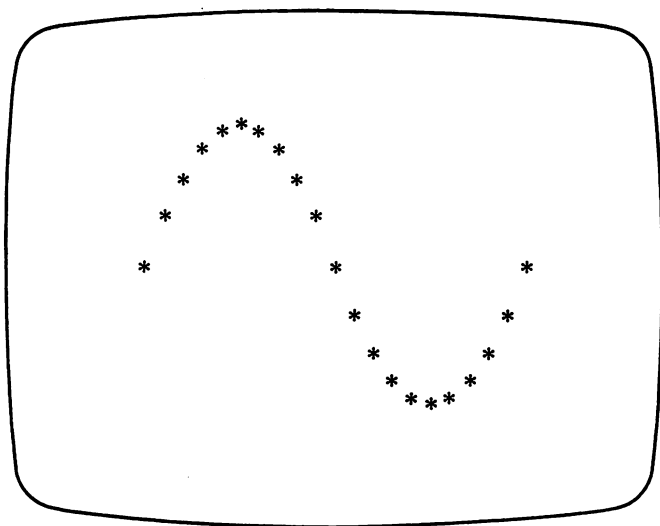


Fig. 8-8. Displaying a sine wave on the TV screen.

middle of the bottom line of the TV screen. By pressing the "V" key, the arrow moves to the left, and by pressing the "N" key, the arrow moves to the right. (HINT: Use the GET\$ command in your program.)

9. Write a program that lets you enter a character (A-Z) from the keyboard, which is then displayed in the center of the TV screen. The cursor keys can then be used to move the character around on the TV screen.
10. Modify the program from Problem 9 so that as the character is moved, it leaves a trail of characters, the same way the *Etch-O-Sketch*® toy works.
11. Modify the program from Problem 8 so that the arrow shoots a white asterisk toward the top of the screen. Once a shot has been taken, no other shots can be taken until the asterisk goes off the top of the screen. As the asterisk moves toward the top of the screen, the "V" and "N" keys should still be able to move the arrow around on the bottom line.
12. Write a program that puts three asterisks on each line of the TV screen, in random places in each line. The color for each line

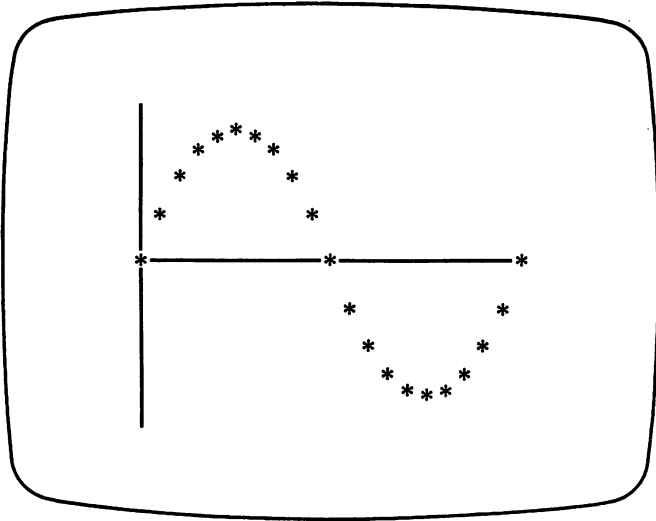


Fig. 8-9. Adding a coordinate system to the sine-wave display.

of asterisks should also be randomly chosen. The program should not allow the screen color to be used, thus “invisible” asterisks are avoided.

13. Write a program so that an asterisk is placed on the left-hand side of the TV screen on a randomly chosen line. The asterisk is then moved from the left-hand side of the TV screen to the right-hand side. Once the asterisk disappears off of the right-hand side of the screen, another asterisk should appear on the left-hand side of the screen on a randomly chosen line, and it, too, should move over to the right-hand side of the screen.
14. Modify the program from Problem 13 so that an asterisk appears randomly on either the left-hand or right-hand side of the TV screen, on a randomly chosen line. The asterisk should then move toward the other side of the screen. Once the asterisk reaches the other side of the screen, this process should be repeated.
15. Modify the program from Problem 14 so that at the beginning of the program the user can enter a skill level between 0 and 9. The higher the skill level, the faster the asterisk travels across the screen.

16. Modify the program from Problem 12 so that once the TV screen is filled, a new line of three randomly placed asterisks will appear at the bottom of the screen. This will cause the top line on the screen to be scrolled off of the screen. The three new asterisks should all be the same (randomly chosen) color.

CHAPTER 9

SOUND OFF, 1, 2, 3, 4

SOUND IS IMPORTANT

If you can use more of your senses in something, the more enjoyable it can be. Pictures of animals just can't be compared to a trip to a zoo where the animals can be seen, heard, touched, and even smelled. Many an early video game used only a black-and-white TV set to display a set of "paddles" and a "ball" that moved around the screen. Later, sound effects and realistic color displays were added, and more and more people started playing video games.

Unfortunately, many computers just use a TV screen to display letters and numbers, so using a computer isn't always as interesting as it could be. In an earlier chapter, you learned how to use colors to call attention to information and to interest people in what the computer is doing. In this chapter, you'll see how the Commodore 64 can make special sounds, so your sense of hearing can be involved, too.

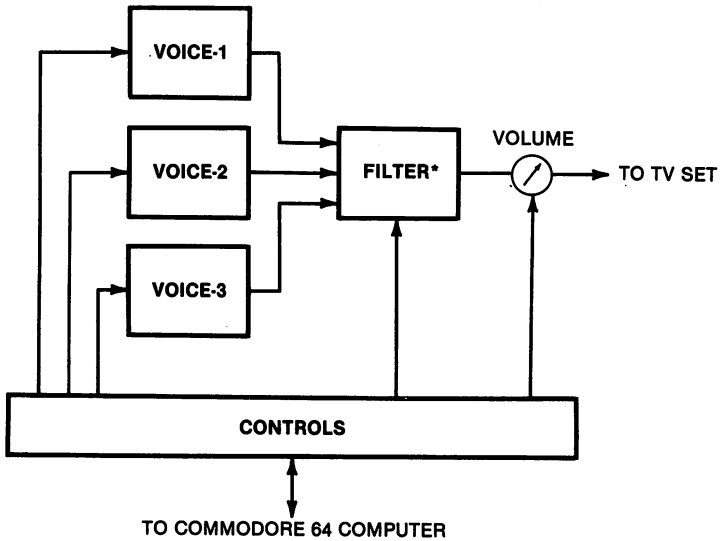
Besides being used in game programs for sound effects, sounds have other important uses in small computers. In some, a quick "tick" is heard each time a key is pressed. If you are typing information without looking at the keyboard, this lets you know that each key has really been pressed. The "tick" is reassuring, and it takes the place of the "snap" you would hear from a typewriter as the type hits the paper.

Sounds can also be used to call attention to something the computer is doing. Perhaps a quick "beep" will let you know you've pressed a wrong key, or a warbling tone will tell you that something special is about to happen. Sounds add a lot to computer systems.

SOUND FROM THE COMMODORE 64

Your Commodore 64 computer can put together or create many sounds, and these sounds can range from simple tones to complex music, all controlled by a BASIC program. The Commodore 64 has three "voices," or sources of sound, and they are built into the computer. The sounds from these voices are transmitted to your TV set and can be heard on its built-in speaker. You can't hear the sounds directly from the keyboard unit. Generating sounds with the Commodore 64 can lead to some complex programming, particularly if you want the computer to create special sound effects or sound like a three-piece band. However, some very interesting tones and sounds can be put together without too much difficulty. In this chapter, we will introduce you to using the Commodore 64 to generate sounds, but not all of the different effects or controls will be explained. For additional information about the many features of the sound generator in the Commodore 64, we recommend Appendix O in the *Commodore 64 Programmer's Reference Guide*. This appendix describes the operation of the sound-generator circuit in the computer. You can also experiment with the voices, trying different effects and combinations of sounds.

A simplified block diagram for the sound generator is shown in Fig. 9-1. As far as we are concerned, the three voices are exactly the same and can generate the same sounds. Since they can be independently controlled, you can use one voice, or you can mix in the other voices to get interesting effects and musical notes. Each voice has a set of seven map addresses that control it and there are four addresses that are used for other voice-control purposes. Some of the more useful addresses are shown in Fig. 9-2. Since the voices are the same, we have shown only the map for VOICE-1, but the ranges of addresses for the other two voices are noted. In the two maps used to control the TV display, you could POKE a character code and a color code into the appropriate locations to have a character displayed on the TV screen. The voice maps work in almost the same way. In Fig. 9-2, two of the addresses (HI TONE and LOW TONE) are used to control the tone that is created by the



*Filter not described or discussed.

Fig. 9-1. Block diagram of the Commodore 64 sound-generating system.

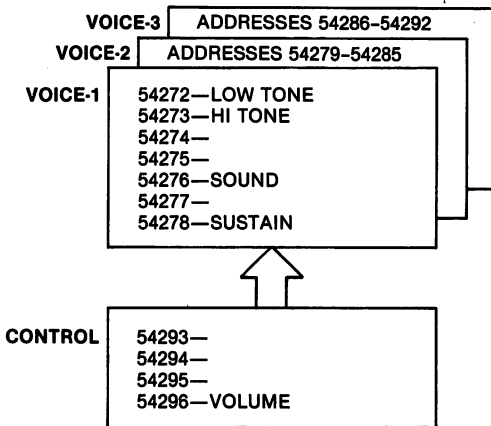


Fig. 9.2. Simplified sound map for VOICE-1.

voice. Both pieces of information must be supplied if the note is to be "played" properly. A list of musical notes and the HI and LOW codes is provided in Table 9-1. If you can read music, you can see that there are seven *octaves* that can be produced by the computer. This means that you can get musical tones for all but the 12 highest

keys on a piano. For example, to set up VOICE-1 for note C-3, you would have to do the following operation to set up the HI tone and LOW tone addresses in your computer:

Table 9-1. HI and LOW Tone Codes for Musical Notes

MUSICAL NOTE	TONE CODE		MUSICAL NOTE	TONE CODE	
OCTAVE	HI	LOW	OCTAVE	HI	LOW
C-0	1	12	C-4	16	195
C#-0	1	28	C#-4	17	195
D-0	1	45	D-4	18	209
D#-0	1	62	D#-4	19	239
E-0	1	81	E-4	21	31
F-0	1	102	F-4	22	96
F#-0	1	123	F#-4	23	181
G-0	1	145	G-4	25	30
G#-0	1	169	G#-4	26	156
A-0	1	195	A-4	28	49
A#-0	1	221	A#-4	29	223
B-0	1	250	B-4	31	165
C-1	2	24	C-5	33	135
C#-1	2	56	C#-5	35	134
D-1	2	90	D-5	37	162
D#-1	2	125	D#-5	39	223
E-1	2	163	E-5	42	62
F-1	2	204	F-5	44	193
F#-1	2	246	F#-5	47	107
G-1	3	35	G-5	50	60
G#-1	3	83	G#-5	53	57
A-1	3	134	A-5	56	99
A#-1	3	187	A#-5	59	190
B-1	3	244	B-5	63	75
C-2	4	48	C-6	67	15
C#-2	4	112	C#-6	71	12
D-2	4	180	D-6	75	69
D#-2	4	251	D#-6	79	191
E-2	5	71	E-6	84	125
F-2	5	152	F-6	89	131
F#-2	5	237	F#-6	94	214
G-2	6	71	G-6	100	121
G#-2	6	167	G#-6	106	115
A-2	7	12	A-6	112	199
A#-2	7	119	A#-6	119	124
B-2	7	233	B-6	126	151
C-3	8	97	C-7	134	30
C#-3	8	225	C#-7	142	24
D-3	9	104	D-7	150	139
D#-3	9	247	D#-7	159	126
E-3	10	143	E-7	168	250
F-3	11	48	F-7	179	6
F#-3	11	218	F#-7	189	172
G-3	12	143	G-7	200	243
G#-3	13	78	G#-7	212	230
A-3	14	24	A-7	225	143
A#-3	14	239	A#-7	238	248
B-3	15	210	B-7	253	46

POKE 54272,97 : POKE 54273,8

The volume of the sound sent from the Commodore 64 to your TV set is controlled by the code at address 54296 (VOLUME), with 15 being the highest volume and 0 being the lowest, or off. In almost all programs, the volume will be set to the maximum (15) and left there. Each voice has its own volume control, which is called SUSTAIN. This lets you set the volume of each voice independently so that sounds can be mixed and combined in interesting ways. The SUSTAIN codes also have a range from 15 for highest volume, down to 0 for off, but these codes are used in a slightly different way, as you'll see shortly.

To set the overall volume, you can do a POKE operation to the VOLUME address in the sound map, address 54296. We will assume that the volume is always set to its maximum:

POKE 54296, 15

To set the volume for VOICE-1, you use the same type of operation with the SUSTAIN address, *but the volume code must be multiplied by 16 before it is poked into the SUSTAIN address in the sound map*. You don't have to worry about why this is done, it's just the way the Commodore 64 takes care of the SUSTAIN information for each of the voices. Here are examples of how the maximum volume for VOICE-1 can be selected:

POKE 54278, 15*16 or POKE 54278, 240

Here is how a code of 7, for about half-volume, would be selected for VOICE-1:

POKE 54278, 7*16 or POKE 54278, 112

The last thing to be done is to select the type of sound that you want the computer to generate. This is done by placing a code in the SOUND address for the voice you are using. This code lets you select one of the four sounds listed here:

- Code 16 Triangle — mellow, flute-like quality
- Code 32 Sawtooth — bright, brassy quality
- Code 64 Pulse — for special tone effects
- Code 128 Noise — hiss

Triangle, sawtooth, and pulse are just technical terms for the way the sounds are generated by the electronic circuits. These terms are fairly common, so we will use them in this chapter. We think that you will be more interested in what they sound like than in what they are called, or exactly how they work. Each voice can

also generate *noise*, which is like the “rushing” or “hissing” sound that comes from a TV set that is tuned to an unused channel. Noise is used to create special sound effects for games and special programs, and you can simulate bomb blasts and explosions with it.

The pulse type of sound is fairly specialized, and we don't think that a person getting started with the Commodore 64 will use it. It is more difficult to use than the triangle, sawtooth, and noise sounds, so we won't talk about it in detail when we get to it later in the chapter.

You can choose the type of sound you want to create and select the code for it. For example, the code for the mellow flute-like triangle sound is 16. Placing this code in the SOUND address does not automatically cause the tone to be sounded on the speaker. *To start a tone, you must add 1 to the SOUND code to tell the computer to turn on that voice.* To stop it, you can simply put the original tone code, or 0, in the SOUND address. For example:

```
POKE 54276, 16 + 1
```

would start a mellow tone at VOICE-1, while:

```
POKE 54276, 16 or POKE 54276, 0
```

would turn it off. Each voice's sound is controlled this way. So, before you can create a sound with the Commodore 64, you must do four things:

1. Set up the overall VOLUME.
2. Set a TONE for the voice.
3. Set the SUSTAIN volume for the voice.
4. Select the type of sound and start the voice.

Experiment No. 9-1. A Simple Tone Test

Sounds aren't really difficult to create and you will find out how to do it in this experiment. You will also find out how to use a tone code and the computer's volume control.

When the sound-creating part of the Commodore 64 is going to be used in an experiment, it is a good idea to *completely clear the sound map.* This can be done with a simple program such as this:

```
10 FOR AD = 54272 TO 54296  
20 POKE AD, 0  
30 NEXT AD
```

Or, the steps can be placed on one line:

```
10 FOR AD = 54272 TO 54296 : POKE AD,0 : NEXT AD
```

If any information is left in the sound map from another experiment or program, this will clear it out, giving you a fresh start. If you decide to experiment with the voices on your own, be sure to clear the sound map before you use it.

Clear your computer for a new program. Turn the volume control on your TV set so that it is at the lowest volume setting. At the highest setting you will hear a hum or a slight hiss. You want the position opposite from this. Type the following program into your computer:

```
10 FOR AD = 54272 TO 54296
20 POKE AD, 0
30 NEXT AD
100 POKE 54296, 15
120 POKE 54278, 15*16
140 POKE 54272, 209: POKE 54273, 18
160 POKE 54276, 17
```

After the sound map has been cleared by the program steps in lines 10 - 30, the program does four things:

1. Sets the overall volume for the sounds to maximum.
2. Sets VOICE-1 SUSTAIN volume to maximum.
3. Sets up a note for VOICE-1.
4. Sets the sound to "triangle" and turns it on.

Run the program and adjust the volume control on your TV set so that the tone can be heard comfortably. If you don't hear the tone, check the program and try it again. The sound map must be cleared and all four operations noted must be done if the tone is to be heard.

How do you think you can turn off the tone? Type in the command:

```
POKE 54276, 16
```

This sets the SOUND code to turn off the tone. Remember that you need to add 1 to the SOUND code to turn on a voice in the Commodore 64 computer. If you use the SOUND code by itself, or zero, the tone is turned off.

Run the program again. You should hear the tone on the speaker again. Press the RUN/STOP and the RESTORE keys together. Does the tone stop? It should. You can always use the RUN/STOP and RESTORE keys together to turn off a tone.

Can you think of any other way to turn off the tone? You can put

the VOLUME code at its lowest setting. For example, the command:

```
POKE 54296, 0
```

will also turn off the tone. To turn the tone back on, type in:

```
POKE 54296, 15
```

Let's use the program already in the computer to test the different volume settings. Remove line 100 from the program and add the following program lines:

```
200 FOR VL = 0 TO 15
220 INPUT Z
240 POKE 54296, VL
260 PRINT VL
280 NEXT VL
```

The complete program should look like this:

```
10 FOR AD = 54272 TO 54296
20   POKE AD, 0
30 NEXT AD
120 POKE 54278, 15*16
140 POKE 54272, 209 : POKE 54273, 18
160 POKE 54276, 17
200 FOR VL = 0 TO 15
220   INPUT Z
240   POKE 54296, VL
260   PRINT VL
280   NEXT VL
```

When you run this program, the volume will first be set to zero. When the computer reaches the INPUT command and displays the ?, press the RETURN key. This will advance the volume code by one, from 0 to 1, and so on up to the maximum volume code, 15.

Run the program and press the RETURN key after each question mark appears on the TV screen. Can you hear the volume of the tone increase each time the RETURN key is pressed? We found that it was difficult to hear much of a volume change once the volume code was between 12 and 15. Change line 220 in your program to:

```
220 FOR T = 1 TO 100 : NEXT T
```

and then run the program. This new program line will let the pro-

gram increase the volume by itself, without making you press the RETURN key to go to the next step.

Remove the print command at line 260 and add the following lines to your program:

```
300 FOR VL = 14 TO 0 STEP -1
320     FOR T = 1 TO 100 : NEXT T
340     POKE 54296, VL
360 NEXT VL
380 GOTO 200
```

The complete program should now look like this:

```
10 FOR AD = 54272 TO 54296
20     POKE AD, 0
30 NEXT AD
120 POKE 54278, 15*16
140 POKE 54272, 209 : POKE 54273, 18
160 POKE 54276, 17
200 FOR VL = 0 TO 15
220     FOR T = 1 TO 100 : NEXT T
240     POKE 54296, VL
280 NEXT VL
300 FOR VL = 14 TO 0 STEP -1
320     FOR T = 1 TO 100 : NEXT T
340     POKE 54296, VL
360 NEXT VL
380 GOTO 200
```

Now run the complete program. Can you hear the sound slowly increase and then decrease in volume? You should be able to, and the sequence will repeat itself again and again. What do you think would happen if you removed the time delay loops at lines 220 and 320? You can try it if you want to.

In this experiment, you have changed the volume of the sound going from the computer to the TV set. You can do this at any time in a program, since it is completely independent of the voices. (NOTE: You can only *decrease* the SUSTAIN volume for individual voices once you turn them on.)

Experiment No. 9-2. Changing the Tone

This experiment will show you how you can change the tone that is created by a "voice" in the Commodore 64. Clear your computer and load the following program into it:

```

10 FOR AD = 54272 TO 54296
20   POKE AD, 0
30 NEXT AD
100 POKE 54296, 15
120 POKE 54278, 15*16
140 INPUT "HI TONE"; HT
160 INPUT "LOW TONE"; LT
180 POKE 54273, HT : POKE 54272, LT
200 POKE 54276, 17
220 GOTO 140

```

This program will let you type in a LOW and a HI tone code, so you can have the computer create any tone you want, within its range. Run the program and when the computer asks for a HI and a LOW tone, type in 1 and 12. This is the lowest musical tone the computer can generate. You may have to increase the TV set's volume to hear it. It was a bit rumbly and scratchy, at least on our TV set. Try typing in several other combinations, or look in Table 9-1 for musical notes.

The HI tone part of the code has the most importance, so small changes in the LO code don't have much effect on the tone. For example, you won't be able to hear the difference between:

HI Tone = 200	and	HI Tone = 200
LOW Tone = 120		LOW Tone = 121

Most TV sets have inexpensive low-quality speakers, so not all tones will be reproduced well. This is particularly true for the higher tones. If you can't hear a high tone, or if a tone seems unusual, it may be due to the type of speaker used in your TV set, rather than due to a problem with your program or the computer. For TV shows, the internal speaker is fine, but it is definitely not hi-fi quality.

Let's change the program so that the computer varies the tone by using a few new program steps. In this program, we will not use the LOW tone location in the sound map. We will leave it set at zero. Stop the computer program and type in the following new program steps:

```

140 POKE 54276, 17
160 FOR HT = 0 TO 255
180   POKE 54273, HT
200 NEXT HT
220 END

```


The complete program should look like this:

```
10 FOR AD = 54272 TO 54296
20     POKE AD, 0
30 NEXT AD
100 POKE 54296, 15
120 POKE 54278, 15*16
140 POKE 54276, 17
160 FOR HT = 0 TO 255
180     POKE 54273, HT
200 NEXT HT
220 END
```

Run this program. What happens to the tone? It increases quickly to a high-pitched note, which continues to be heard. Why is the last tone still on? The last tone was never turned off within the program. It could be turned off by poking a 0 into the SOUND location in the sound map. Change line 160 to:

```
160 FOR HT = 200 TO 250
```

and change line 220 to:

```
220 GOTO 160
```

The complete program should look like this:

```
10 FOR AD = 54272 TO 54296
20     POKE AD, 0
30 NEXT AD
100 POKE 54296, 15
120 POKE 54278, 15*16
140 POKE 54276, 17
160 FOR HT = 200 TO 250
180     POKE 54273, HT
200 NEXT HT
220 GOTO 160
```

Ready for take-off? Run the program. Now, the range of tones has been limited to the higher ones and the increasing tone sequence has been repeated. You can also cause the tones to go to lower notes by adding a few more steps to your program. Change program line 220 to:

```
220 FOR HT = 250 TO 200 STEP -1
```

and add the following program lines:

```
240 POKE 54273, HT
260 NEXT HT
280 GOTO 160
```

The complete program should look like this:

```
10 FOR AD = 54272 TO 54296
20   POKE AD, 0
30 NEXT AD
100 POKE 54296, 15
120 POKE 54278, 15*16
140 POKE 54276, 17
160 FOR HT = 200 TO 250
180   POKE 54273, HT
200 NEXT HT
220 FOR HT = 250 TO 200 STEP -1
240   POKE 54273, HT
260 NEXT HT
280 GOTO 160
```

Run this program and you should be able to hear the frequency increase, decrease, increase, and on and on . . . The upper and lower frequencies are set up in the FOR commands at lines 160 and 220. You can experiment with changing these limits, if you want to.

Experiment No. 9-3. Changing the Voices

In this experiment, you will find out how to use the other voices, VOICE-2 and VOICE-3. You will also be able to hear the difference between the "triangle" and "sawtooth" tones.

Clear your computer for a new program. In this program, VOICE-2 will be used to generate tones. Type in the following program:

```
10 FOR AD = 54272 TO 54296
20   POKE AD, 0
30 NEXT AD
100 POKE 54296, 15
120 POKE 54285, 15*16
140 POKE 54279, 0 : POKE 54280, 200
160 POKE 54283, 17
```

Run this program. What do you hear? A high-pitched tone should be heard from the TV set's speaker. Can you hear any difference between this tone and any of the tones generated by VOICE-1? We

couldn't hear any difference. It would be a bit difficult to switch back and forth between the voices, since the map addresses in the program would have to be changed. Suppose we could have the computer change them for us? Load the following program steps into your computer. Program lines 10-100 are still going to be used:

```
120 INPUT "TONE"; HT
140 AD = 54272
160 FOR X = 1 TO 3
180 POKE AD+1, HT
200 POKE AD+6, 15*16
220 POKE AD+4, 17
240 FOR T=1 TO 1000 : NEXT T
260 POKE AD+4, 16
280 FOR T=1 TO 100 : NEXT T
300 AD = AD+7
320 NEXT X
```

The complete program should look like this:

```
10 FOR AD = 54272 TO 54296
20   POKE AD, 0
30 NEXT AD
100 POKE 54296, 15
120 INPUT "TONE"; HT
140 AD = 54272
160 FOR X = 1 TO 3
180 POKE AD+1, HT
200 POKE AD+6, 15*16
220 POKE AD+4, 17
240 FOR T=1 TO 1000 : NEXT T
260 POKE AD+4, 16
280 FOR T=1 TO 100 : NEXT T
300 AD = AD+7
320 NEXT X
```

In this program, the computer will use the same HI tone code in each of the voices, one after the other.

No specific addresses have been used for the sound map, except for the first address. This may seem like a programming "trick," but it is a way of making programs simpler. Just as you might say the sixth house on the right, the computer can say the sixth address from the start. At line 300, the address is increased by

seven to point to the locations for the next voice. This lets the computer easily switch from one voice to the next.

Run the program and type in a number for the tone. A choice of 200 would be good for a start. Can you hear the three voices turned on and off in sequence? Do they sound different? We couldn't detect any change in the tones between the voices.

Now that this computer program has been set up, let's change it so that only two of the voices are used, but we will use a triangle tone at one and a sawtooth at the other. It will be interesting to hear the difference between them. *Change* the following lines in your program:

```
140 AD = 54272 : SD = 16
160 FOR X = 1 TO 2
220 POKE AD+4, SD+1
260 POKE AD+4, 0
300 AD = AD+7 : SD = SD*2
```

And add this line:

```
340 GOTO 120
```

The complete program should now look like this:

```
10 FOR AD = 54272 TO 54296
20   POKE AD, 0
30 NEXT AD
100 POKE 54296, 15
120 INPUT "TONE"; HT
140 AD = 54272 : SD = 16
160 FOR X = 1 TO 2
180 POKE AD+1, HT
200 POKE AD+6, 15*16
220 POKE AD+4, SD+1
240 FOR T=1 TO 1000 : NEXT T
260 POKE AD+4, 0
280 FOR T=1 TO 100: NEXT T
300 AD = AD+7 : SD = SD*2
320 NEXT X
340 GOTO 120
```

Now run this program and type in a tone code when the computer asks for TONE? Start with a fairly low tone code, of 3 or 4, and increase it in multiples of two or three. Try several tones and then try a code of 100 or so. Can you hear a difference between the

triangle and sawtooth tones? (The first tone is the triangle tone, and the second is the sawtooth tone.) The triangle tones were melodious, while the sawtooth tones were raspy and rough. The sawtooth tones at 100 or so sounded brassy.

USING SOUND IN A PROGRAM

In the experiments, you learned how the three voices in the Commodore 64 computer are controlled. If you are interested in using these voices, we encourage you to try some simple programs of your own. The sound effects you have heard, along with others, can be used in programs to add the sense of hearing to the experience of using a computer. In a typical program, you may be asked to type in a value that the computer will use in some way. If an incorrect value is typed in, a sound could be used to tell you that there is a problem.

In this program, you are asked to type in a value between 0 and 10,000. If the value is outside those limits, the computer will ask for another value. Sound has been used to alert you to an incorrect value.

```
100 REM SET UP SOUND GENERATOR
120 FOR AD = 54272 TO 54296 : POKE AD,0 : NEXT AD
140 POKE 54278,15*16 : POKE 54296, 15
160 Etc . . .

1000 INPUT "TYPE YOUR VALUE"; VA
1020 IF VA>=0 AND VA<=10000 THEN GOTO 1300
1040     POKE 54276, 17
1060     FOR Y=1 TO 15
1080         POKE 54273, 200
1100         FOR T = 1 TO 20 : NEXT T
1120         POKE 54273, 140
1140         FOR T = 1 TO 20 : NEXT T
1160     NEXT Y
1180     POKE 54276,0
1200     PRINT "ONLY VALUES FROM"
1220     PRINT " 0 TO 10000"
1240     GOTO 1000

1300 REM VALUE IS OK, SO USE IT . . .
```

The commands at lines 100 - 140 clear the sound map and set up the SUSTAIN code for VOICE-1 and the VOLUME for the overall

sound generator. The IF-THEN command at line 1020 checks the value to see if it is between 0 and 10000. If it is, the computer goes on to line 1300, where the value is used in some way by the program.

However, if you have typed in a value that is outside the range 0 to 10000, the computer generates a "warbling" tone using program lines 1040 to 1180. After generating the sound, the computer prints a two-line message and you get another chance to type in a value. You can type in this program and try it, but don't type in line 160. Sometimes several sounds are generated in a program for different reasons. The warbling tone just described indicates an incorrect value has been entered. Other tones might tell you that an answer to a question is correct or incorrect. Sounds can also be used as "rewards" in teaching programs. Here are the input and sound parts of a "multiple-choice" test program that uses three sounds: a medium warbling tone when an incorrect *value* is typed in, a high warble for a correct answer, and a low tone for an incorrect answer. This is not a complete program, but it shows how tones can be used. Since the program is a bit complex, it has been broken into segments for you.

```
100 REM SET UP SOUND GENERATOR
```

```
120 FOR AD = 54272 TO 54296 : POKE AD,0 : NEXT AD
```

```
140 POKE 54278,15*16: POKE 54296, 15
```

```
160 Etc . . .
```

```
1000 INPUT "YOUR ANSWER 1-4"; AN
```

```
1020 AN = INT(AN)
```

```
1040 IF AN>=1 AND AN<=4 THEN 2040
```

```
1060 HT = 200 : LT = 100 : GOSUB 5010
```

```
1080 PRINT "ANSWERS FROM"
```

```
1100 PRINT " 1 TO 4 ONLY"
```

```
1120 GOTO 1000
```

```
2000 REM PROCESS THE ANSWER HERE
```

```
2020 REM CA = CORRECT ANSWER VALUE
```

```
2040 IF AN <> CA THEN 2200
```

```
2060 PRINT "GOOD FOR YOU"
```

```
2080 HT = 220 : LT = 190 : GOSUB 5010
```

```
2100 GOTO . . .
```

```
2200 PRINT "INCORRECT"
```

```
2220 HT = 140 : LT = 120 : GOSUB 5010
```

```
2240 GOTO . . .
```

```

5000 REM SOUND GENERATOR SUBROUTINE
5010 POKE 54276, 17
5020 FOR Y = 1 TO 5
5030     POKE 54273, HT
5040     FOR T = 1 TO 50: NEXT T
5050     POKE 54273, LT
5060     FOR T = 1 TO 20: NEXT T
5070 NEXT Y
5080 POKE 54276, 0
5090 RETURN

```

This program expects you to type in a value of 1, 2, 3, or 4 as an answer to a multiple-choice question. The computer inputs the value and then uses the INT operation to remove any decimal fraction. For example, 4.5 would be converted to 4. The program checks to see if the value is between 1 and 4, and if it isn't, a tone is generated and a message displayed. You get another chance to type in a value between 1 and 4.

The second part of the program checks to see if the answer, AN, matches the correct answer, CA. If there is a match, a high tone is generated and the computer goes on. If an incorrect answer is found, a low tone is generated and the computer goes on.

In this sample program, the tone program is used as a *subroutine*, and the main program simply points the computer to the subroutine to generate a tone. Each part of the program that uses this must supply a high tone (HT) and a low tone (LT) code. This simplifies the program quite a bit, and it means that by supplying different high and low tone codes, different effects can be generated with one subroutine. This example shows how sound can be added to a program to increase its value to the person using it.

This program has also shown a good use for a subroutine. The tone-creating instructions were used only once in the program, but three parts of the program can use these steps.

NOISE

A *noise* tone is available from each voice, and it is used to add "hiss" to a sound, or to create "explosions," "blasts," and other sound effects for games and recreational programs.

Experiment No. 9-4. Making Noise

This experiment will give you a chance to see how "noise" can be used for a sound effect in a simple computer program. The "noise"

sounds generated are really the mixture of a tone and noise. Clear your computer and type in this program:

```
10 FOR AD = 54272 TO 54296
20     POKE AD, 0
30 NEXT AD
40 POKE 54296, 15
50 POKE 54278, 15*16
100 POKE 54276, 128+1
120 POKE 54273, 100
```

The noise-generating section of the Commodore 64 computer may not operate properly unless it is reset. Several things can take place to cause problems with the noise generator, so we suggest that you type the following line into your computer:

```
POKE 54276,8 : POKE 54276,0
```

This will clear the noise generator in VOICE-1 and get it ready to use.

Once you have cleared the noise generator, run your program. You should hear some rushing or hissing noise on the TV set's speaker. Once you have heard the noise, change program line 120 as follows:

```
120 FOR D = 1 TO 255
```

and add the following lines to your program:

```
140 POKE 54273, D
160 NEXT D
180 GOTO 120
```

The complete program should look like this:

```
10 FOR AD = 54272 TO 54296
20     POKE AD, 0
30 NEXT AD
40 POKE 54296, 15
50 POKE 54278, 15*16
100 POKE 54276, 128+1
120 FOR D = 1 TO 255
140     POKE 54273, D
160 NEXT D
180 GOTO 120
```

Run this program. You should be able to hear the noise change in

tone, from a low rumble to a high-pitched hiss. This cycle will be repeated again and again.

Now, *remove line 180 from your program*, and make the following changes:

```
120 INPUT "NOISE CODE"; NC
140 POKE 54273, NC
160 GOTO 120
```

Here is the complete program for you:

```
10 FOR AD = 54272 TO 54296
20   POKE AD, 0
30 NEXT AD
40 POKE 54296, 15
50 POKE 54278, 15*16
100 POKE 54276, 128+1
120 INPUT "NOISE CODE"; NC
140 POKE 54273, NC
160 GOTO 120
```

The changes will let you type in your own code for the noise generator, so you can type in HI tone codes between 0 and 255 to see what effect they have on the noise produced. Remember that the LOW tone code stays 0. Run the program and try it with several values, starting with 1 and going up to about 10 or so. Then try some other values: for example, 15, 20, 50, 100, 150, and 200. What change do you hear in the noise? For the low values, there is a rumbling sound. As the numbers become larger, the sound changes to a high-pitched hiss.

NAME THAT TONE!

The range of useful *musical* tones, notes, or frequencies is listed in Table 9-1, so you can get the HI and LOW tone codes for notes that you need. However, you may want to have the computer create some other tone, or frequency, that falls somewhere between or outside the range of those tones found in the table. There is a formula that lets you calculate the codes needed for a tone noted in hertz (Hz); for example, 2350 Hz. For the Commodore 64, the upper frequency limit is 4000 Hz.

A frequency must be converted into the HI (HT) and LOW (LT) codes used in the sound map, and the following BASIC program will do it for you:

```

1000 INPUT "FREQUENCY"; FQ
1020 NB = FQ / 0.06097
1040 HT = INT(NB / 256)
1060 LT = INT(NB-(HT*256)+0.5)
1080 Etc . . .

```

You can poke the LT and HT codes into the sound map later on in your program, or you can display them on the TV screen so they can be noted for later use. By using this short program, you get the tone codes so the Commodore 64 computer can produce non-musical tones.

THE PULSE TONES

The fourth type of tone that you can generate with the Commodore 64 is called *pulse*. This type of tone is like the triangle and sawtooth tones, except that the computer needs more information. Each of the voices has two PULSE WIDTH locations in its map, as shown in Fig. 9-3. The pulse width can be a number between 0 and

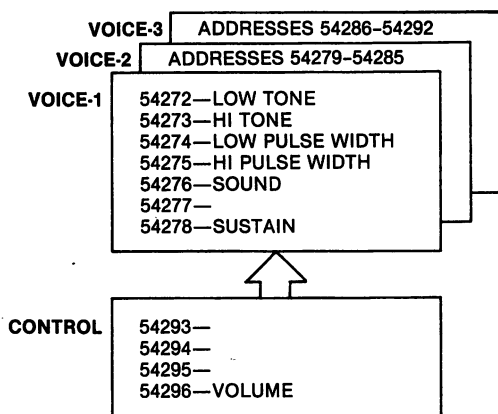


Fig. 9-3. Modified sound map for VOICE-1 showing the two PULSE WIDTH addresses.

4095. This tells the computer how long the pulses are to be. In order to put the pulse-width information into the two locations, you need to do a few simple math operations. These operations break apart the values between 0 and 4095 so that they can be poked into the proper map locations.

Once you have chosen a pulse width, PW, the following program steps will put it into the correct VOICE-1 map addresses:

```
1000 H = INT(PW / 265)
1020 L = INT(PW-(H*256)+0.5)
1040 POKE 54275, H : POKE 54274, L
```

These operations are very similar to those used to get tone codes for a particular frequency. You can change the POKE command addresses shown above if you want to use VOICE-2 or VOICE-3. We didn't hear much of a difference between the triangle and sawtooth sounds and the pulse sounds. However, the pulse sounds are used in some musical effects, and you can find examples in the *Commodore 64 Programmer's Reference Guide*.

You can run the following program if you want to hear the pulse sounds for a particular tone code:

```
100 FOR AD = 54272 TO 54296
120     POKE AD, 0
140 NEXT AD
200 POKE 54296, 15
220 POKE 54278, 15*16
240 INPUT "TONE CODE"; TC
260 POKE 54273, TC
280 POKE 54276, 64+1
300 FOR H = 0 TO 15
320     POKE 54275, H
340     INPUT Z
360 NEXT H
380 GOTO 240
```

This program will let you type in your tone code and it will sequence through different pulse-width levels. Each time you press the RETURN key, the computer will go from one pulse width to another, from the lowest (0) to almost the highest (about 3800 out of 4095). Sixteen levels can be heard this way. In our opinion, if you are beginning to use the Commodore 64 and learn about the sound generators, or "voices," you will be better off using the triangle and sawtooth tones.

ATTACK!

Musical instruments can play the same notes, but they don't generate the same types of tones. If they did, all instruments would sound alike. The differences between instruments are due to the way they produce sounds. In some instruments, a note reaches its

full volume very quickly, within a few thousandths of a second. In others, it can take some time to reach maximum volume. Likewise, when a musician stops playing a note, it can rapidly decrease in volume, or the note can linger for a while. The effects of changing volume in different ways, from instrument to instrument, are called *attack*, *decay*, *sustain*, and *release*, and they are shown in Fig. 9-4.

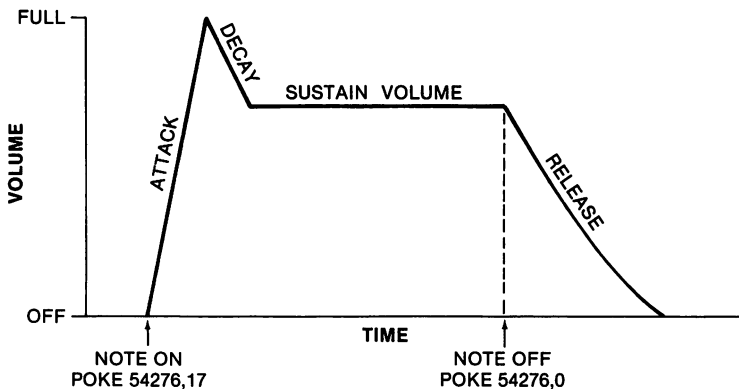


Fig. 9-4. The effect of attack, decay, sustain, and release rates on the volume.

The *attack* is the rate at which the volume is turned on, and the *release* is the rate at which it is turned off. In between, the sound has decreased a bit at a *decay* rate, and it is maintained at a *sustain* volume.

You can make many different selections as to the attack, decay, and release *rates* as shown in Table 9-2. Each portion of the sound has 16 different settings, from 2 milliseconds to 8 seconds for the attack time, and from 6 milliseconds to 24 seconds for the decay and the release times.

Remember that “sustain” refers to a volume, and not to a time or rate. The sustain volume can be set to one of 16 settings, from 0 to 15, or off to full volume. You have already been using a sustain level of 15, for full volume, in the experiments. Although you didn’t realize it, you also used attack, decay, and release rates. They were set to their fastest settings, 0, so you probably didn’t hear any “odd” sound effects.

The examples in Fig. 9-5 show some of the different types of volume sequences that you can produce from the Commodore 64 computer. By changing the shape, or “envelope” of the sound, the computer can sound like many different musical instruments. Several

Table 9-2. Attack, Decay, and Release Rates and Their Codes

CODE	ATTACK RATE	DECAY/RELEASE RATE
0	2 ms	6 ms
1	8 ms	24 ms
2	16 ms	48 ms
3	24 ms	72 ms
4	38 ms	114 ms
5	56 ms	168 ms
6	68 ms	204 ms
7	80 ms	240 ms
8	100 ms	300 ms
9	250 ms	750 ms
10	500 ms	1.5 s
11	800 ms	2.4 s
12	1 s	3 s
13	3 s	9 s
14	5 s	15 s
15	8 s	24 s

ms = milliseconds; 100 ms = 1/10th second

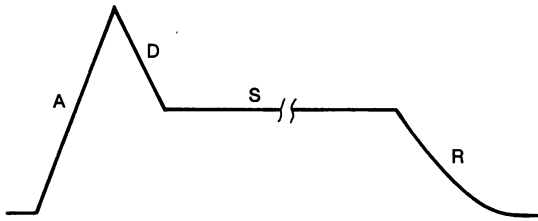
different types of musical instruments and the necessary settings for them are listed in Table 9-3.

Table 9-3. Some Musical Instrument Settings for the Commodore 64

INSTRUMENT	SOUND	ATTACK-DECAY CODE	SUSTAIN-RELEASE CODE
Piano	Pulse*	9	0
Flute	Triangle	96	0
Harpicord	Sawtooth	9	0
Xylophone	Triangle	9	0
Organ	Triangle	0	240
Calliope	Triangle	0	240
Accordion	Triangle	102	0
Trumpet	Sawtooth	96	0

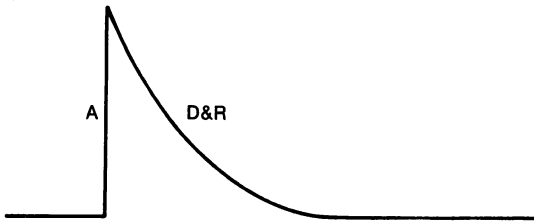
*Pulse Width: HI = 0, LOW = 255

The attack, decay, and release codes are poked into the sound map, as shown in Fig. 9-6. The sound map for each voice is now complete. Since the ATTACK and DECAY, and the SUSTAIN and RELEASE codes share addresses in the map, you must do a cou-



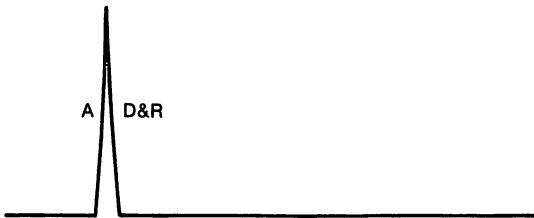
Attack = 500 ms
 Decay = 300 ms
 Sustain = 10
 Release = 750 ms

(A) Woodwind, brass, and string instruments.



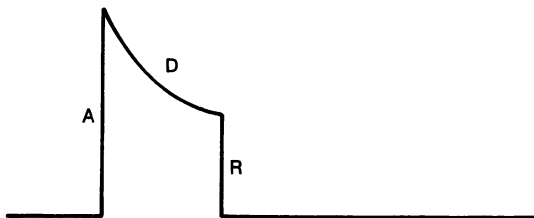
Attack = 2 ms
 Decay = 750 ms
 Sustain = 0
 Release = 750 ms

(B) Cymbals and drums.



Attack = 38 ms
 Decay = 72 ms
 Sustain = 0
 Release = 6 ms

(C) Xylophones and bells.



Attack = 2 ms
 Decay = 750 ms
 Sustain = 0
 Release = 6 ms

(D) Harpsicords and pianos.

Fig. 9-5. Different attack, decay, sustain, and release rates change the sounds for different instruments.

ple of simple math operations to get the codes in the correct form so they can be used. You have already seen that the SUSTAIN

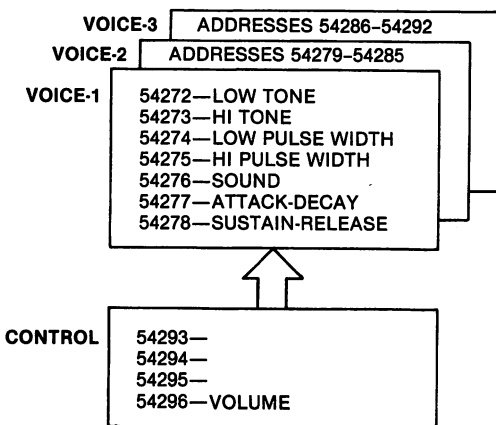


Fig. 9-6. Modified sound map showing all addresses for VOICE-1.

code is multiplied by 16 before it is poked into the sound map. Here are the needed operations for VOICE-1:

POKE 54277, (ATTACK Code*16+DECAY Code)
 POKE 54278, (SUSTAIN Code*16+RELEASE Code)

Except for the addresses in the POKE commands, the operations are the same for the other two voices. Using the information in Table 9-2, here is how the computer would be set up for:

Attack rate = 16 milliseconds	ATTACK Code = 2
Decay rate = 6 milliseconds	DECAY Code = 0
Sustain volume = half volume	SUSTAIN Code = 7
Release rate = 3 seconds	RELEASE Code = 12

POKE 54277, (2*16+0)
 POKE 54278, (7*16+12)

The information for the instruments listed in Table 9-3 has already been multiplied and added, so to set the Commodore 64 for a flute-like sound, the following operations would be used:

ATTACK-DECAY = 96 SUSTAIN-RELEASE = 0
 POKE 54277, 96
 POKE 54278, 0

You can use the information in the table, or you can experiment with settings for the rates and the sustain volume of your own.

The time that a note is played, or its "length," can also be set.

The tone is started when you tell the computer what type of sound you want, by selecting either noise, triangle, sawtooth, or pulse, and adding one to its code. This starts the tone sequence. The computer "attacks" the tone, increasing it to its full volume at the ATTACK rate you selected. After the maximum volume has been reached, the computer lets the tone "decay" to the SUSTAIN volume level. The computer will continue to sound the note at the sustain level for as long as you want. When you turn off the note by clearing the SOUND address to 0, or by poking in one of the sound codes *without one added to it*, the computer knows that you want the tone turned off. It turns the note off at the RELEASE rate that you set, allowing the volume to finally reach "off." For some types of sounds, only the attack and decay rates are used. The sustain volume is set for 0 (off) and the release rate is very fast. Most of the instruments listed in Table 9-3 use only the ATTACK and DECAY settings.

Experiment No. 9-5. Using the Attack and Decay Rates

In this experiment you will have a chance to try different settings of the attack and decay rates for noise tones. Since noise isn't used too frequently, you will have a chance to hear several special sound effects.

Load the following program into your computer:

```
10 FOR AD = 54272 TO 54296
20   POKE AD, 0
30 NEXT AD
40 POKE 54276, 8 : POKE 54276, 0
100 POKE 54296, 15
120 INPUT "TONE"; TN
140 INPUT "ATTACK CODE"; AC
160 INPUT "DECAY CODE"; DC
180 POKE 54277, (AC*16+DC)
200 POKE 54273, TN
220 POKE 54276, 129
240 FOR T = 1 TO 2000 : NEXT T
260 POKE 54276, 0
280 GOTO 120
```

This program will let you type in a HI tone code for the noise, and values for the attack and decay rates. You can look at Table 9-2 for the rates and their codes. The program first clears the sound map and then clears the noise source (line 40). The rest of the pro-

gram is fairly standard, and similar to the sound programs used in other experiments in this chapter.

Run the program. Type in a TONE code of 10, ATTACK code of 0, and DECAY code of 12. What do you hear? Remember to adjust the volume control on your TV set so you can hear the sound.

With codes of 10, 0 and 12, a low noise tone has been selected, along with a fast attack rate and a slow decay rate. It sounded to us like an explosion or a cannon firing. Here are some other settings you can try:

TONE	ATTACK CODE	DECAY CODE	SOUND HEARD?
5	0	12	
200	0	9	
10	10	12	
100	12	12	
100	10	5	

We heard a low explosion, a gun firing, surf on a beach, and paper ripping. Perhaps you thought of other things to go with the sounds. Try some other settings, too. If the computer tends to "cut off" your sound, "lengthen" the time delay loop at line 240 by increasing the upper limit to 4000, or so. This will make the computer spend a longer time in this loop, so the sound can be completed.

Here is a simple program that will play a short tune. It was originally listed in the *Commodore 64 Programmer's Reference Guide*, but we have modified it so that it is easier to follow, and you can type in your own attack and decay rates to see what effect they have on the tune. Type the program into your computer and try it.

```
500 FOR AD = 54272 TO 54296
520     POKE AD, 0
540 NEXT AD
560 POKE 54296, 15
580 INPUT "ATTACK RATE"; AC
600 INPUT "DECAY RATE"; DC
620 POKE 54277, (AC*16+DC)
640 READ HT, LT, DR
660 IF HT < 0 THEN RESTORE : GOTO 580
680 POKE 54272, LT : POKE 54273, HT
700 POKE 54276, 33
720 FOR T = 1 TO DR : NEXT T
740 POKE 54276, 0
760 FOR T = 1 TO 50 : NEXT T
```

```

780 GOTO 640
900 DATA 25,177,250,28,214,250
910 DATA 25,177,250,25,177,250
920 DATA 25,177,125,28,214,125
930 DATA 32,94,750,25,177,250
940 DATA 28,214,250,19,63,250
950 DATA 19,63,250,19,63,250
960 DATA 21,154,63,24,63,63
970 DATA 25,177,250,24,63,125
980 DATA 19,63,250,-1,0,0

```

Run the program and use an attack rate of 0 and a decay rate of 9. What does the tune sound like? What type of instrument do you hear? Here are some other attack and decay rates you can try:

ATTACK CODE	DECAY CODE	INSTRUMENT SOUND?
3	9	
4	7	
9	0	
0	4	
3	8	
3	5	

You can also change the sound from sawtooth (33) to triangle (17) at line 700 in the program:

```
700 POKE 54276, 17
```

Now try the attack and decay settings listed above. It is also interesting to hear the noise sounds for this tune. Change line 700 to:

```
700 POKE 54276, 129
```

Does this sound like someone hammering boards to the beat of the short tune?

This program is fairly simple to change for another tune. The notes are listed in the DATA statements as HI tone code, LOW tone code, and "time." The time is in multiples of approximately 62 or 63; that is, 63, 125, 250, 500, 750, and so on. You can substitute your own codes for new notes and times to get the computer to play other tunes.

In this chapter, we have introduced you to the sounds that the Commodore 64 computer can produce. There are many other sound effects and types of sounds that the computer can put together

from the three voices. There are also some other ways to use the voices that we haven't talked about. These are a bit complex, and probably more that most people will use. Some games and entertainment programs make use of many different sounds, and you will be able to copy many of them by doing some experimenting and "fooling around." That's part of the fun of learning to use a small computer.


QUESTIONS

1. How many sources of sound does the Commodore 64 computer have?
2. What kinds of sounds can be created?
3. Can you control the volume of the sounds? If so, how do you do it?
4. How many different tones can each "voice" create?
5. Is there any overlap between the tones generated by each "voice"?
6. What is "noise"?
7. Can all of the voices be used at the same time?
8. Can you suggest some uses for sound in computer programs?

9. What four things must be set up in the sound map before you can get a sound?
10. How are different musical instruments “played” by the computer?

PROBLEMS

1. Write a program that plays one of 10 possible tones when the keys 0 through 9 are pressed. You can choose any tones that you like, along with the volume value, the sound channel or “voice” used, and the waveform.
2. Write a program that generates a “jet plane” (whoosh) sound.
3. Write a program that lets you enter numbers for one of the “voices’.” Ordinarily, the numbers entered will be between 1 and 65,535. As these numbers are entered, they are stored in an array until the number 0 is entered, at which time the values entered will cause the appropriate sounds to be generated. Each tone should be played for the same amount of time.
4. Modify your solution to Problem 3 so that along with the values that are entered, a number that represents the *duration* of the tone can also be entered. Once the value 0 is entered, the “tune” is played.
5. Modify the solution to Problem 4 so that as keys are pressed, the appropriate tone is also generated. If the tone isn’t what you want, you can enter other numbers. Only when the value 0 is entered is the tone value saved. The computer then lets you enter the duration of the tone, which is then played. You can continue to enter different “durations” until you get the proper sound, at which time a 0 is entered so that the duration is saved in the array.

- 
6. Write a program that generates random tones for random durations of up to one second per tone.



CHAPTER 10

ACCESSORIES FOR THE COMMODORE 64

There are many useful accessories for your Commodore 64 computer that can be added to it so it can do new and interesting things. These accessories range from plug-in cartridges to floppy-disk storage systems, and their prices range from about \$25 to several hundred dollars. In this chapter, the plug-in cartridges, the cassette recorder, the graphic printer, the joystick control, and the floppy-disk storage unit will be discussed. You will be given some programs that you can use to control the cassette to save information on it, and you will see how you can use the joystick. Some printer control operations are also listed for you, along with some of the useful disk operations.

Several experiments are provided in the cassette section, and you can do these if you have a Commodore Cassette Unit and are interested in how the cassette works. If you are only interested in using the recorder to save and load *programs*, you can skip over the cassette recorder experiments.

PROGRAM CARTRIDGES

Plug-in cartridges are used to preprogram the Commodore 64 with ready-to-run programs for games, education, home finance, and other uses. The cartridges plug into the recessed, open slot at

the rear right side of the keyboard case. A typical cartridge is shown in Fig. 10-1, and one is shown inserted into the computer in Fig. 10-2.

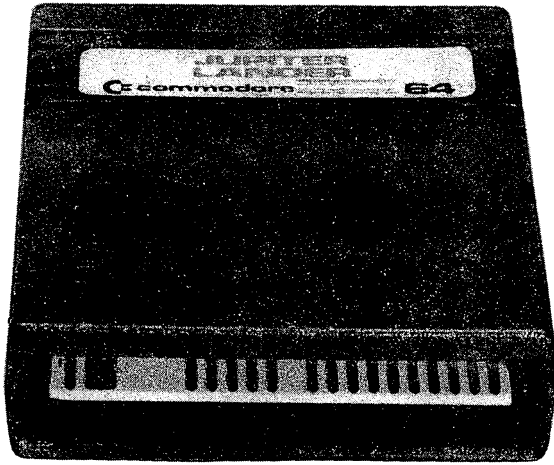


Fig. 10-1. A typical plug-in cartridge for the Commodore 64.

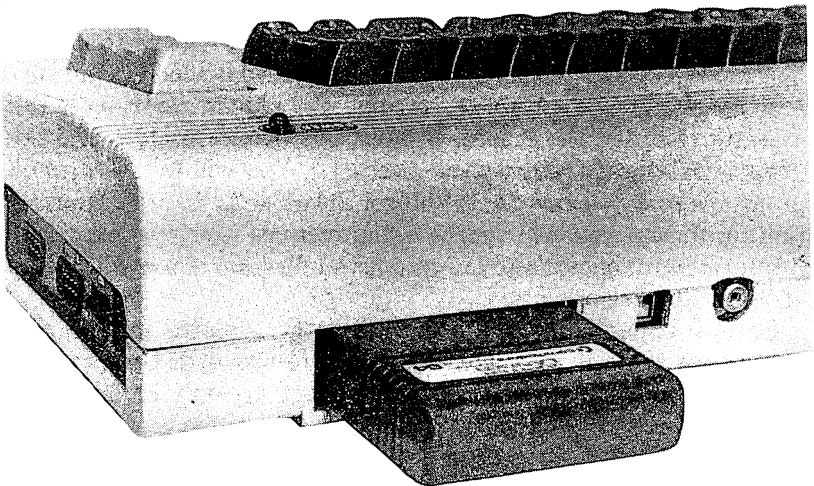


Fig. 10-2. A cartridge inserted into the Commodore 64.

Most of the programs that are available in cartridges will “take over” the computer so the special program starts as soon as the computer is turned on. Other plug-in cartridges, such as an

assembly-language monitor program, a tool for advanced programmers, are started by using a special command. Although cartridges will hold programs almost forever, they can be destroyed if you plug them in or take them out of the computer when the computer is turned on. Turn off the power before a cartridge is changed.

Many programs are available in cartridge form, so it is easy (but not necessarily inexpensive) to have many interesting programs that can be plugged in and used quickly. Most of the popular computer magazines contain advertisements for companies that produce cartridges for the Commodore 64 computer.

THE CASSETTE UNIT

Besides plug-in cartridges, you will find that the cassette recorder is one of the most useful accessories for your computer. The cassette recorder is called the C2N Cassette Unit by Commodore, and it is easily connected to the computer, as shown in Fig. 10-3. The C2N cassette recorder was designed specifically to work

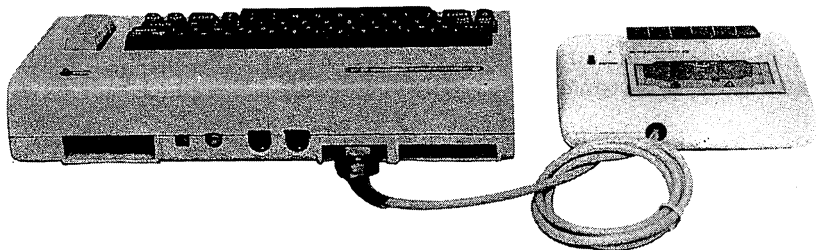


Fig. 10-3. The cassette recorder connected to the Commodore 64.

with Commodore-brand computers such as the Commodore 64, and a regular audio cassette recorder cannot be used without modifications or extra add-ons. We will call the C2N Cassette Unit the cassette recorder, or just recorder. (At the computer end of the connecting cable, you may find a long piece of silver, braided wire. This is not used in Commodore 64 systems, and you can let it hang free, or you can tape it to the cable to keep it out of the way.)

The cassette recorder is easy to use and it will let you save both programs and information so that they can be put back into the computer at another time. Many commercial programs are available on cassette tapes instead of in cartridges, so you will need the recorder if you want to use these programs.

BASIC programs that you have written can be stored for later

use by recording them on a cassette tape. This is easy to do, and you can store several programs on one tape. Good audio-quality cassette tapes are recommended. Since it is unlikely that you will record an hour's worth of information, you can use the shorter audio cassettes, marked C-5 (5 minutes) or C-10 (10 minutes).

Instructions that tell you how to store a program on the cassette tape are contained in your computer instruction manual, and in the C2N Cassette Unit instruction manual. Three commands are used: SAVE, LOAD, and VERIFY. The Commodore 64 saves your program twice on the tape, placing the second recording right after the first. This provides the computer with a backup copy it can use if it has problems reading the first one. After you have recorded a program, the VERIFY command can be used to check the tape to be sure that the program has been recorded correctly. We recommend verifying your programs, even though it takes a little extra time to rewind the tape and have the computer check it.

When programs are to be saved, verified, and loaded, you can give them a name so that they can be easily identified by the computer. If you are putting only one program on each tape, you don't need to do this, but be sure you carefully label each cassette. In any case, putting a name on the tape right along with the program makes the program easy to identify and locate. The name may have up to 16 characters, and any of Commodore 64's characters, numbers, letters, or symbols may be used. Unlike labels used in your programs, the Commodore 64 uses *all* 16 characters in a name to locate a program on a tape.

SAVING INFORMATION ON A CASSETTE

The SAVE, LOAD, and VERIFY commands are used only to save, load, and verify *programs*. If you want to use the cassette recorder to save information, such as values and strings, you will have to use two new commands, OPEN and CLOSE. The recorder can be thought of as a drawer that will hold your information. Before you can use it, it must be opened, and when you are finished, it must be closed. The OPEN and CLOSE commands are used to control some of the other Commodore 64 accessories, and each accessory has been given a number so the computer knows which one is being used. The computer has preset the cassette recorder to be device #1. The computer uses device code #1 for its own purposes, and you don't have to be concerned with this number.

When the recorder is to be used, the computer must be told whether you are going to put information on the tape; that is, "write" information, or whether you are going to get information from the tape; that is, "read" information. The *read* and *write* operations each have their own code: 0 for read and 1 for write.

Information is stored on the tape as a "file," and you can give each of your files a "file name" so they will be easy to locate. This means that several files can be saved on the same cassette tape. The command to "open" the cassette recorder looks like this:

```
OPEN your id number, 1, read/write code, "file  
name"
```

Once the cassette recorder has been "opened," you can refer to it by using the identification (id) number *you gave it* in the OPEN command. This makes it easy to point the computer to the cassette recorder when you want information transferred back and forth. Here is a typical example of how the OPEN command is used:

```
OPEN 9,1,1,"BANK"
```

This command tells the computer to "open" the cassette recorder so that a file named "BANK" can be recorded on a tape. The cassette recorder is identified as #9. This number was chosen at random, and another number would do just as well, for example:

```
OPEN 12,1,1,"BANK"
```

Once information has been placed on a tape, the cassette recorder must be "closed" until you want to use it again. The CLOSE command is simple; CLOSE9 for the first example and CLOSE12 for the second one.

Getting information to and from a tape is very easy. The PRINT and INPUT commands are used, just as they were when information was displayed on the TV screen and input from the keyboard. The only difference is that you identify the recorder by using the identification number you gave it in the OPEN command. When the INPUT and PRINT commands are used with the keyboard and the screen, identification numbers are not used. Here is an example in which 100 data values are saved on a cassette tape with the file name "NUMBERS." The recorder has been given the identification number, 9:

```
120 OPEN 9,1,1,"NUMBERS"  
140 FOR NB = 1 TO 100
```

```
160 PRINT NB
180 PRINT#9, NB
200 NEXT NB
220 CLOSE 9
```

The OPEN command tells the computer to set up the cassette recorder so that the file called "NUMBERS" can be *recorded* on the tape. It also tells the computer that *you* are going to call the recorder "#9" later on in your program. The PRINT#9, NB command tells the computer to "print" the value labeled NB on the tape. Once all 100 values have been recorded, the CLOSE 9 command tells the computer that you are finished with the cassette recorder.

It is your responsibility to place a cassette tape in the recorder, rewind the tape to the start, and follow the directions that the computer automatically displays on the TV screen. We recommend that you practice recording and loading some simple programs using the SAVE, VERIFY, and LOAD commands before you try using the recorder to save other types of information.

Most audio-quality cassette tapes have a clear or colored plastic "leader" at the start of the tape. If you rewind a tape, you can see this leader in the opening in the side of the plastic case. The computer will generally go past the leader before it starts to record information. However, if you have difficulty getting information stored on the tape, we recommend rewinding the tape and resetting the counter wheels on the cassette recorder (press the small black button). This will put the count to 000. Now "play" the cassette until the count reaches the 010 mark. This should advance the tape past any plastic leader so the cassette is ready to record information.

Getting information back off a tape is not difficult. The difference is that the recorder must be "opened" so that the information can be read, and an INPUT command must be used to read the information from the tape:

```
500 OPEN 9,1,0,"NUMBERS"
520 INPUT#9, DV
540 PRINT DV
560 GOTO 520
```

The read/write code in the OPEN command is now a 0, since this program *reads* information from the cassette recorder into the computer. This particular program will read information from the tape,

but it will never stop. There are no instructions in the program or on the tape that tell the computer there is no more information on the tape. When information is read from the tape into the computer, the computer must have a way of knowing that all of the information has been received. In the preceding example, only 100 values were saved, so a FOR-NEXT loop could be used to count the values as they are received. Here is a program that shows how this can be done:

```
500 OPEN 9,1,0,"NUMBERS"  
520 FOR NV = 1 TO 100  
540     INPUT#9, DV  
560     PRINT DV  
580 NEXT NV  
600 CLOSE 9
```

Now the computer searches the tape for the file called "NUMBERS" and uses a loop to count off the first 100 values from it. After these values have been received, the CLOSE command turns off the recorder and "closes" it so it can be used later. The information from the tape doesn't have to be displayed. It can be placed in an array, or used in some other way.

Experiment No. 10-1. Saving Information

In this experiment you will find out how you can save information on a cassette tape so that it can be used later by the computer. You will need a C2N Cassette Unit (recorder) and a blank audio cassette tape in this and the following cassette experiments.

Turn off your computer and be sure that the cassette unit is properly connected to the Commodore 64. If it is not connected, refer to the operating instructions that came with the cassette unit. Once the recorder has been connected and checked, continue to the next step.

There is an opening on the cassette tape and you can see the narrow, brown tape or plastic leader pass through it. On the opposite edge of the cassette, you will see two square areas near the corners. To use the cassette in this experiment, there must be plastic tabs in these square areas. If either of the plastic tabs is missing, leaving a square hole, another cassette must be used. A broken tab will prevent you from recording information on the tape.

Turn on your computer, place the cassette tape in the recorder, and rewind it by pressing the REWIND button. After the tape has

been rewound, press the STOP button. Clear your computer for a new program and type in the following program:

```
100 OPEN 7,1,1,"DATA"  
120 FOR DV = 0 TO 100  
140     PRINT DV  
160     PRINT#7, DV  
180 NEXT DV  
200 CLOSE 7
```

Run the program. The computer will display the message "PRESS RECORD & PLAY ON TAPE" on the TV screen telling you to press the RECORD and PLAY buttons on the recorder. Press these buttons *at the same time*. They should both stay down. What does the computer do? The TV screen goes "blank" and the recorder starts. The recorder stops and the information on the TV screen reappears. You should be able to see the counting numbers on the left side of the TV screen. When the computer reaches 38 or so, the screen goes blank again and the recorder starts again. The Commodore 64 cannot use the TV display and the cassette recorder at the same time. To use the recorder, the TV screen is "blanked," becoming the border color all over. Eventually the numbers reach 100, after the screen has been blanked several times. When the recorder finally stops, the READY message is displayed on the TV screen.

When the READY message is displayed, press the STOP button on the recorder and rewind the cassette tape. You have saved the numbers from 0 to 100 on the tape. In the next experiment you will find out how you can read the numbers back into the computer.

In this experiment, you found that when the recorder is "opened" so that you can save information on a tape, the screen is blanked and the recorder starts to run immediately. The computer runs the tape forward a bit to put some space between the last file that was recorded, if any, or to get past any plastic leader at the start of the tape. The computer also puts the name of the data file on the tape so it can be identified later when you want to read it.

The computer did not wait for all of the information to be displayed before it started to record the information. The computer works much the way we do when we use a clothes washer. We don't wash each piece of clothing, one at a time, we wait until we have a full load and then run the washing machine. The computer does not record each value, one at a time. Only when the computer has enough information will it send a complete "block" to the

recorder. This saves time and space on the tape. Once the computer has accumulated a complete "block" of information, it automatically blanks the TV screen and records the information on the tape. If the computer doesn't have a full "block" of information to be recorded, it will not send the information to the recorder until it reaches a CLOSE command that "closes" the recorder. This is why the CLOSE command is so important. It causes the computer to save any last pieces of information that don't make up a complete "block."

Experiment No. 10-2. Getting Data from the Cassette

In this experiment, you will see how data stored on a cassette tape can be read into the computer. Clear the computer for a new program. The cassette tape prepared in the previous experiment will be used in this experiment. If you don't have a tape with that information on it, go back and do Experiment No. 10-1. Type in the following program:

```
300 OPEN 8,1,0,"DATA"  
320 FOR L = 0 TO 100  
340     INPUT#8, DV  
360     PRINT DV;  
380 NEXT L  
400 CLOSE 8
```

Be sure that your tape has been rewound, then run this program. The TV screen will display the message, "PRESS PLAY ON TAPE," telling you to press the PLAY button on the cassette recorder. Press *only* the PLAY button! It should stay down. The recorder starts to operate, and the computer blanks the TV screen. You will see that the recorder starts and stops as "blocks" of information are read in and displayed on the TV screen. When the values have been received by the computer, the READY message will be displayed and you can see the numbers. Some of the numbers are "broken" at the right edge of the display area on the TV screen. Change the following line in your program:

```
320 FOR L = 200 TO 300
```

Rewind the tape and run the program again. The same display of numbers from 0 to 100 should be seen on the TV screen. The loop count values were changed just to show you that these values and the values stored on the tape are not related. Change line 300 to:

```
300 OPEN 8,1,0,"NMBR"
```

Rewind the tape and run the program. What happens? When the PLAY button is pressed, the TV screen is blanked and the cassette recorder starts. The screen flashes quickly several times, but the numbers 0-100 are never displayed. The cassette recorder continues to run.

Press the RUN/STOP key on the keyboard and press the STOP button on the recorder. Do you know why no values were displayed? The information was recorded on the tape as a file called "DATA." The computer is told to "open" the recorder for a read operation, and to look for a file called "NMBR." The computer cannot find the file called "NMBR," so it will continue searching for it right up to the end of the tape! Change line 300 back to:

```
300 OPEN 8,1,0,"DATA"
```

and change line 320 to:

```
320 FOR L = 0 TO 50
```

Now the program looks like this:

```
300 OPEN 8,1,0,"DATA"
```

```
320 FOR L = 0 TO 50
```

```
340     INPUT#8, DV
```

```
360     PRINT DV;
```

```
380 NEXT L
```

```
400 CLOSE 8
```

Rewind the tape and run this program. Follow the directions for the cassette recorder displayed on the TV screen. What values are eventually displayed? Only the values from 0 to 50 are displayed. Even though there is more information on the tape, you can take only a small part of it if that's all you want.

In this experiment you saw how the computer could read information from a cassette tape. The file name used in the OPEN command must match a file name used to record information on the tape. A loop was used to control the amount of information taken from the tape. In some cases, you may not know ahead of time how much information is to be stored in a file, so some flexible and adaptable method of reading and writing must be used. A special value or character can be put at the end of a file so that when the computer reads the character, it knows that the end of the file has been found. Here is a sample program that gets strings of characters from the keyboard and puts them on the tape in a file called "STRING." When the computer gets a one-character string, *,

from the keyboard, the computer stops. The asterisk is the last character in the file named "STRING":

```
200 OPEN 9,1,1,"STRING"  
220 INPUT W$  
240 PRINT#9, W$  
260 IF W$ <> "*" THEN GOTO 220  
280 CLOSE 9
```

Here is how the strings can be read back into the computer:

```
500 OPEN 9,1,0,"STRING"  
520 INPUT#9, W$  
540 PRINT W$  
560 IF W$ <> "*" THEN GOTO 520  
580 CLOSE 9
```

In this program, the computer tests each string to see if the string is a single asterisk. If it is, the end of the file has been found, and there is no more information to get from the tape. The program "closes" the recorder as the last operation, so the recorder can be used somewhere else in the program. A "marker" is used to end a cassette tape file when you don't know how much information is to be saved.

Experiment No. 10-3. Saving Strings on a Tape

Saving strings of different lengths on a cassette tape isn't difficult. You will see how it is done in this experiment. You will also see how a "marker" can be used to end a file. Clear your computer for a new experiment and rewind the tape in the cassette recorder. Type the following program into your computer:

```
200 OPEN 9,1,1,"STRING"  
220 INPUT CS$  
240 PRINT#9, CS$  
260 IF CS$ <> "*" THEN GOTO 220  
280 CLOSE 9
```

This program will let you type in a string, which will then be saved on the tape. If you type an asterisk,*, it will be saved on the tape, too, but it will also cause the computer to go to line 280. The CLOSE 9 command "closes" the recorder and records any remaining information that doesn't make up a complete "block."

Start the program and follow the instructions on the TV screen for the recorder. The screen will go blank, and the recorder will run

for several seconds. When the screen information appears again, a question mark will be displayed on the TV screen. When you see the question mark, type in your strings. Don't use any special symbols or punctuation marks in your strings, and remember to end each string by pressing the RETURN key. Type in several strings, such as:

```
? THIS IS AN EXPERIMENT
? MY NAME IS FRED
? MY ADDRESS IS GREENLAWN
? WHAT TIME IS IT?
```

When the next question mark appears on the TV screen, type * [RETURN]. What happens? The recorder will probably run for a while, and then the READY message will appear on the TV screen. When the READY message appears, rewind the tape.

Type the following program into your computer. It will be used to read the strings from your tape.

```
500 OPEN 9,1,0,"STRING"
520 INPUT#9, RS$
540 PRINT RS$
560 GOTO 520
```

Rewind the tape and then run the program by typing RUN 500 [RETURN]. Follow the cassette instructions displayed on the TV screen. After pressing the recorder controls and giving the computer a chance to get the information from the tape, what is displayed on the TV screen? You should see your original strings displayed on the TV screen. You *may* see other information, too, or you may get an *error message*, such as;

```
?STRING TOO LONG ERROR IN 520
```

Why do you think the other information or the error message was displayed? There may be other information left on the tape from old programs or data that were saved sometime earlier. The program does not have any way of knowing where to stop the tape, so it keeps the recorder running, reading this "unknown" information from the tape. To stop this from happening, the program needs to be changed to look for the asterisk. Here are the program lines to *add* to your program:

```
560 IF RS$ <> "*" THEN GOTO 520
580 CLOSE 9
```

Rewind the tape and run the program again. What do you see on the TV screen when the recorder finally stops? The original strings are seen. No other information or error message is seen. When the computer saw that an asterisk had been received from the tape, the program "closed" the recorder and stopped it. Save your tape with the STRING file on it for use in the next experiment.

THE CASSETTE AND THE GET COMMAND

The GET command is used to get individual characters from the keyboard, and it does the same thing with a cassette tape. (You may remember that the GET command gets a "null" or "nothing" character if a key isn't pressed when the computer "looks" at the keyboard.) When used with the recorder, the GET command gets characters from the tape, one at a time. There are no "null" characters between the characters on the tape, or anywhere else in the information. Since the GET command gets *single characters* from the tape and the keyboard, strings and values must be put back together from the individual characters. Short BASIC programs can do this.

In most cases, the INPUT command will be used to control the recorder, since this command gets a complete string or a complete value from the tape. When the INPUT command is used, no special operations are needed to put the information back in a meaningful form.

It isn't difficult to end a file with a "marker," and this can be done with a few extra software steps. However, if you are using a tape from someone else's Commodore 64 computer, there may be no "marker" at the end of their data file. Don't worry, the Commodore 64 automatically puts a null character at the end of each data file. The null character can be looked for as a file is read from the tape using a GET command. Here is how it can be done for strings:

```
700 OPEN 9,1,0,"STRING"  
720 GET#9, R$  
740 IF R$="" THEN GOTO 800  
760 PRINT R$  
780 GOTO 720  
800 CLOSE 9  
820 etc . . .
```

This program gets individual characters from the tape and checks each one to see if it is a null. If it isn't a null, the program

displays the character and gets the next one. If a null is found, that's the end of the file, so the recorder is "closed" and the program ends. The value of the GET command is in getting information from a tape when you don't know how much information there is in a file.

When this technique is used with *values* that have been stored on a tape, the program is more complex, since individual digits must be put back into strings, and the strings converted to the values originally stored. Here is how it is done:

```
1000 OPEN 7,1,0,"DATA": B$ = ""
1020 GET#7, H$
1040 IF H$ = CHR$(13) THEN GOTO 1140
1060 IF H$ = "" THEN CLOSE 7 : GOTO 1200
1080 B$ = B$+H$
1100 GOTO 1020
1120 REM GET THE VALUE OF THE STRING
1140 X = VAL(B$) : B$ = ""
1160 PRINT X
1180 GOTO 1020
1200 etc . . .
```

This program first "opens" the cassette and then "clears" the string labeled B\$. The computer checks for two conditions. If a null character is received from the tape, the computer stops the recorder and goes to the program steps starting at line 1200. When the computer puts values or strings on a tape with a PRINT#-type command, it places a RETURN character between the values or strings to separate them. The return character is CHR\$(13), and if it is found, it means that the computer has reached a "separator" between two values or strings that have been put on the tape. The computer then converts the *string of individual digits* into a real value, X. This value is displayed, but something else could have been done with it, too. Perhaps it could be stored in an array for later use. The B\$ = "" operation clears the string B\$ so it starts "empty" for the next string that is to be converted to a value.

Experiment No. 10-4. Using the GET Command with the Recorder

This experiment will demonstrate how the GET command can get individual characters from a tape. The cassette tape with the STRING file from the previous experiment will be used. If you do not have a cassette tape with that file on it, go back and do the pre-

vious experiment. Clear your computer for a new program and type in the following program:

```
400 OPEN 9,1,0,"STRING"  
420 GET#9, H$  
440 PRINT H$  
460 GOTO 420
```

Rewind the tape and run the program. Follow the directions displayed on the screen for the recorder. As you press down the PLAY button on the cassette recorder, press the CTRL key on the computer and hold it down. This will slow down the speed of the display, but it will be a while before you see anything happening on the TV screen. What is displayed? The screen displays the original strings, one character at a time, with the characters going down the left side of the TV screen. Does the program or the recorder stop? The recorder continues to run, and no READY message is seen on the TV screen. If your tape was used previously to store other information, you may see other characters displayed on the TV screen, too.

The GET command gets individual characters from the tape. *It does not put the characters together to form the complete strings that you originally put on the tape.* Here is a new program you can use to link the individual characters back into the original strings:

```
400 OPEN 9,1,0,"STRING"  
420 GET #9, H$  
440 IF H$ = CHR$(13) THEN GOTO 600  
460 IF H$ = "" THEN GOTO 700  
480 TS$ = TS$+H$  
500 GOTO 420  
600 PRINT TS$ : TS$ = ""  
620 GOTO 420  
700 CLOSE 9  
720 END
```

You can type in this program if you want to see how it works to put the strings back together again.

This program gets the individual characters from the tape. Characters are linked at line 480 into a total string, TS\$. If a RETURN character, CHR\$(13), is found, that means that the end of a string has been found, and the complete string can be displayed (line 600). The TS\$ string is reset to "nothing" to give it a fresh start for the next string.

If a null character is found, that means that the end of the file has been found and the recorder is "closed."

Rewind your tape and run the program. You should see the complete strings displayed on the TV screen.

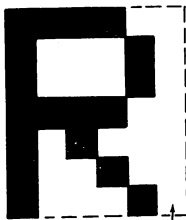
A program to do basically the same thing with values stored on a tape has been provided in this section. The only extra operation needed for values is to convert from a string of digits to a real value that the computer can use.

The recorder will not be used again in this chapter, so you can remove the tape and disconnect the recorder, if you want to, but *turn off the power first*. Some of this programming is a bit advanced, but it is useful. For example, if you are trying to keep track of household expenses for the last 12 months, it would be a lot of work to type in many of the same values every month. By using the recorder, you can save the values for the past 12 months on a tape. You can also save your household calculation program, so everything is on one cassette tape. Student grades, sales reports, car expenses, patient information and other things can be stored on a tape using the types of programs shown in this section.

THE GRAPHIC PRINTER

The Commodore VIC-1525 Graphic Printer is a useful accessory for your Commodore 64 computer, since the printer gives you the opportunity to actually print information, program listings, and graphics on a sheet of paper. The user's manual supplied with the printer is fairly complete, so we won't go into details about connecting the printer to the computer or setting it up. We will give you some information about how the computer and printer are used together.

The printer is a dot-matrix printer that uses small needles to form the individual characters. The dots are used in a 6-column, 7-row format, as shown in Fig. 10-4 for the letter "R." The printer



THIS COLUMN ALWAYS BLANK
TO SPACE CHARACTERS

Fig. 10-4. A 6 by 7 dot matrix for the letter "R."

can print 80 characters in a line, which is fairly standard among computer printers. The printer can duplicate all of the characters, symbols, and graphic characters that can be displayed on the TV screen, and characters can be printed in "reverse," too. Of course, the printer can't print in color.

STARTING THE PRINTER

The printer is just like the cassette recorder in that it must be "opened" and "closed" with the OPEN and CLOSE commands. The Commodore 64 computer can use up to two printers, and device codes 4 and 5 have been set aside for them. If only one printer is to be used, code 4 should be used, and this is set on a small switch on the back of the printer where the computer-printer cable is connected. The OPEN command for the printer looks like this:

OPEN your id number, 4, character set code

The identification (id) number you assign to the printer can be anything you choose, as long as it hasn't already been used to identify some other device, such as the cassette recorder. The character set code is also called a *secondary address*, and it lets you select the set of characters that will be displayed on the printer. Commodore calls these two sets of characters the "CURSOR UP" and "CURSOR DOWN" sets. The CURSOR UP set is the one normally used on the TV screen (Set 1), and it has a code of 0. The CURSOR DOWN set has a code of 7, and it corresponds to Set 2 for the TV screen display. Here are examples of the OPEN commands for both character sets:

OPEN 33, 4, 0(id #33, Set 1 characters)

OPEN 52, 4, 7(id #52, Set 2 characters)

The identification numbers, 33 and 52, have been chosen at random.

The printer can be used to get a printed result from a program, and this is often called "hard copy," which just means that you can hold onto the copy and save it for later use. The PRINT# command is used to control the printer, and here is an example of a simple program that prints 10 numbers on a line:

```

100 OPEN 46, 4, 0
120 FOR T = 1 TO 10
140 PRINT#46,T;
160 NEXT T
180 CLOSE46

```

The semicolon suppresses the printer's line feed, so that all of the numbers are printed on one line. When this program is run, *the numbers are not printed on the TV screen*. They are only printed on the paper in the printer. Since it is often better to test a program using the TV screen (it's faster and doesn't use paper), it will be a bother to try and convert all of the PRINT commands to PRINT# commands when you want to switch over to the printer for a "hard copy" of the program results.

The CMD command lets you switch *all* of the printing operations over to the printer, and only a single CMD command is needed, right at the start of the program. For example, the following program can be used to print a message on the TV screen:

```

200 PRINT "*****"
220 PRINT "*                *"
240 PRINT "*   TEST MESSAGE   *"
260 PRINT "*                *"
280 PRINT "*****"

```

Two commands can be added to this program so that the message is printed on the printer, instead:

```

160 OPEN 43, 4, 0
180 CMD43
200 PRINT "*****"
220 PRINT "*                *"
240 PRINT "*   TEST MESSAGE   *"
260 PRINT "*                *"
280 PRINT "*****"

```

The CMD43 command switches all of the PRINT commands to print their information on the device we've called 43; the graphic printer. Since the printer can print 80 characters on a line, long printing lines with more than 40 characters will "wrap around" on the TV screen when the program is listed.

When the CMD command is used, *all* of the printing is switched

over to the printer, so even the READY message will be printed on the paper. To switch the computer back to the TV screen, you simply use a PRINT#43 command at the end of your programs. (We assumed that your id #43 is still being used, as in the preceding examples.) Here is another example of how this can work when a line of letters, A - Z, is printed on the printer:

```
500 OPEN 43,4,0
520 CMD43
540 FOR LT = 65 TO 90
560 PRINT CHR$(LT);
580 NEXT LT
600 PRINT#43
620 CLOSE43
```

The OPEN and CMD commands set up the printer and switch printing over to the graphic printer. The letters are printed on a line, and the PRINT#43 command is a “dummy” command that switches back to the TV display for normal computer use. The CLOSE command simply “closes” the printer, since it won’t be used again in the program.

The CMD command is useful when you want to print *everything* on the printer. If you want to print some information on the printer and some on the TV screen, you will need to use the PRINT and PRINT# commands individually.

In the preceding printing program, the CHR\$ command was used to “convert” a value into its equivalent string character, 65 = A, 66 = B, and so on. The VIC-1525 printer uses some special string characters to set it up for special printing operations. The codes are listed in Table 10-1. For example, the CHR\$(14) “character” sets the printer so that it prints double-wide characters. The double-wide characters are useful for labeling tables, charts, and figures, and for chapter headings in manuscripts and reports.

There are also CHR\$ “characters” that can be used to switch to and from the CURSOR UP and CURSOR DOWN sets of characters, set printing positions, and display graphic information on the paper.

You can list your programs on the printer once it has been opened. The following can be typed in to do it:

```
CMD43 : LIST [RETURN]
```

This tells the computer to send the listing to the printer. However, when the listing has been completely printed, the READY

Table 10-1. Special Printer Control Codes for the VIC-1525 Graphic Printer

Code	Description
CHR\$(8)	Enter graphics mode ¹
CHR\$(10)	Line feed after printing
CHR\$(13)	Carriage return ²
CHR\$(14)	Start double width
CHR\$(15)	Start standard width
CHR\$(16)	Tab setting ¹
CHR\$(17)	Cursor Down (Set 2) characters
CHR\$(18)	Start reverse printing
CHR\$(26)	Repeat graphics ¹
CHR\$(27)	Specify dot address ¹
CHR\$(145)	Cursor Up (Set 1) characters
CHR\$(146)	End reverse printing

¹These operations require additional commands or information.

²Carriage-return returns printing head to the start of the same line, without advancing the paper.

message will be printed on the printer and not on the TV screen. To switch back to the TV, just type:

PRINT#43 [RETURN]

and the computer will again use the TV screen.

The use of the printer to print the standard graphic symbols found on the keyboard is not difficult, and these characters can be put right in PRINT and PRINT# commands. The printer can also be used to print complicated graphs and special characters that can be set up in programs. Although there are several examples in the printer user's manual, we don't recommend that you try and use or understand these programs, since they are *quite complex*, and it won't be obvious from the program listings what is being done. The special graphics modes for the printer aren't the type of thing that we'd recommend to beginners who are just becoming familiar with BASIC programs and the BASIC commands.

THE JOYSTICK CONTROLS

A joystick is another useful accessory for your Commodore 64, since it is used in many games to move a "player" or other object on the TV screen. A typical joystick is shown connected to a Commodore 64 computer in Fig. 10-5. The Commodore 64 has two joy-

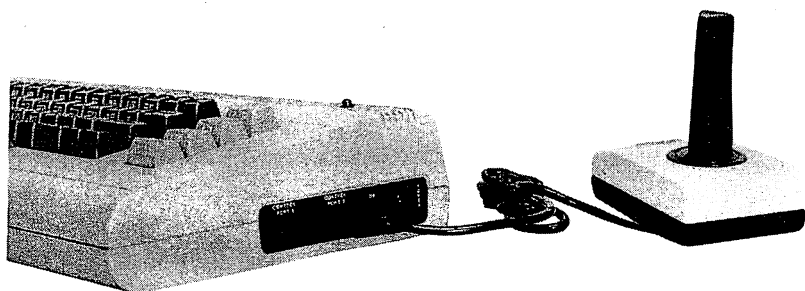


Fig. 10-5. A joystick connected to CONTROL PORT 2 on the Commodore 64.

stick connectors on the right side of the keyboard, and they are marked "CONTROL PORT 1" and "CONTROL PORT 2."

The joystick unit contains four switches that are attached to the "stick," and as the stick is moved, the switches are actuated. The four switches are located in the NORTH, EAST, SOUTH, and WEST positions, as shown in Fig. 10-6. The joystick can be placed

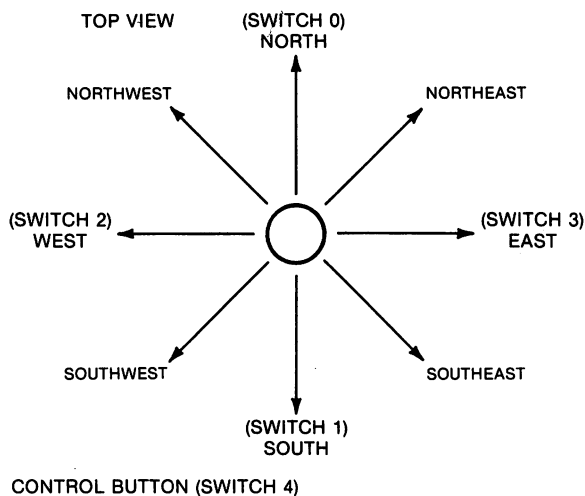


Fig. 10-6. Joystick positions can be related to compass directions.

in between adjacent positions, actuating two switches, so the NORTHWEST, NORTHEAST, SOUTHWEST, and SOUTHEAST positions are possible, too.

Most joysticks have a "fire" or control button that is used to tell the computer to shoot missiles, launch rockets, and cause other things to happen. This control button is a separate switch that is independent of the joystick, and it can be pressed at any time.

Although joysticks are most frequently used with games, they have other uses, too. For example, the joystick might be used to point to answers in a multiple-choice test. Instead of numbering the possible answers, they are placed in NORTH, SOUTH, EAST, and WEST positions on the TV screen. Moving the joystick moves a colored square to the selected answer, and pressing the control button tells the computer to go ahead and accept that choice. People who have limited physical movement can control many things with a simple joystick, having the computer make decisions based on the joystick's position. The joystick can be used in more ways than as a simple game control. The five joystick switches are electrically connected to the computer, and they can be "looked at" by using a BASIC program. Each joystick has its own "address" within the computer: 56320 for Control Port 1 and 56321 for Control Port 2. Here is a program that can be used to give the positions of the joystick and the control button, as values:

```

1000 REM SET UP JOYSTICK MAP ADDRESS
1020 AD = 56321
1040 JS = PEEK(AD) AND 15
1060 FB = (PEEK(AD) AND 16) / 16
1080 PRINT JS, FB
1100 GOTO 1040

```

This program will display values that correspond to the positions shown in Fig. 10-7. These values can be used in IF-THEN or ON

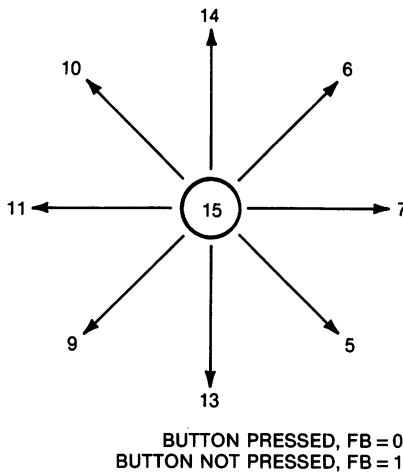


Fig. 10-7. Joystick positions and values for the BASIC control program.

commands to tell the computer what to do with the different joystick positions (JS). The control button value (FB) will be 0 when the button is pushed, 1 when it isn't. This program displays the values of JS and FB on the TV screen. (NOTE: To change the program for a joystick connected to Control Port 1, set AD = 56320 in line 1020.) You may clear your computer for a new program and type in the preceding joystick program if you want to see how the joystick works. Plug your joystick into the Control Port 2 connector on the right side of the computer's keyboard case, as shown earlier in Fig. 10-5.

There are other ways to figure out the position of the joystick, and one is listed in the *Commodore 64 Programmer's Reference Guide*, along with more information about exactly how the joystick works.

THE FLOPPY-DISK UNIT

The Commodore 64 computer can store information and programs on the cassette unit, and the computer can also use a floppy-disk storage device. A floppy disk is a circular, flat piece of plastic coated with magnetic material similar to that used on the tape in a cassette. Information is recorded on the disk in almost the same way it's recorded on a cassette tape. The magnetic disk is permanently enclosed in a flexible, protective plastic container, so the disk itself won't be damaged or pick up dirt. Two disks are shown in Fig. 10-8. One of the disks has been opened just to show you what the inner disk actually looks like. Be careful with the disk, and bend or flex it *as little as possible*. You should NEVER open a disk unless you are about to throw it in the garbage. Floppy disks come in several sizes, with 5¼-inch disks being used in most small computers, including the Commodore 64. Each of the disks used with the Commodore 64 computer can store 174,000 pieces of information, with each "piece" being a letter, digit, graphic symbol, punctuation mark, and so on. Up to 144 programs can be saved on a disk, but to actually get this many on one disk, the programs would have to be very short. When information is stored on a disk, it is often called a *file*.

Floppy disks are used by placing them in a *disk drive*, which is quite a bit like a phonograph. The information is read from "tracks" on the disk, but unlike the grooves on a phonograph record, the tracks are invisible to us. The electronic circuits in the "disk drive" take care of recording (saving) and reading (recalling)

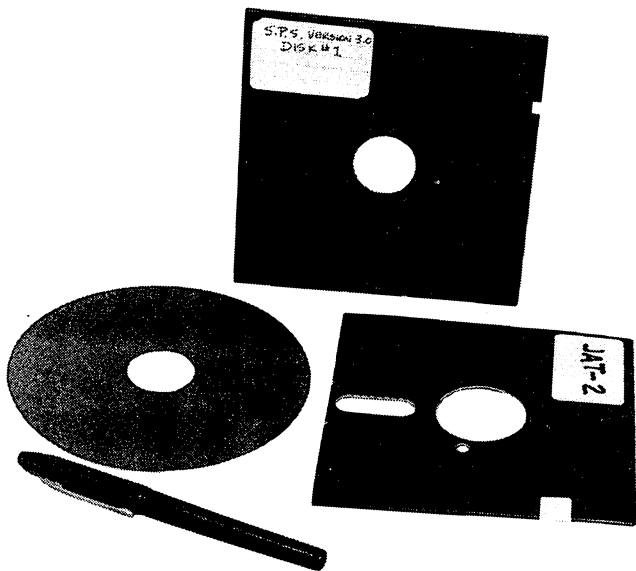


Fig. 10-8. Two 5 1/4-inch floppy disks, with one shown out of its protective cover.

the information. The Commodore 64 uses the VIC-1540 or VIC-1541 Single Drive Floppy Disk drive unit, which is manufactured by Commodore for its line of computers. A typical VIC-1541 unit is shown in Fig. 10-9. We'll call this a disk drive.

There are several advantages to using a disk drive instead of a cassette recorder. The disk drive is fairly fast, and it can store and recall programs and information quickly. If you have saved a program near the end of a cassette tape, you will have to let the computer run through all of the other programs on the tape until it reaches the one you want. The disk drive doesn't have this limitation, since it can go from one program to another very quickly. You can pick up the arm on a phonograph and move it from song to song on a record, and the disk drive does just about the same thing with a floppy disk.

DISK-DRIVE SETUP

The floppy-disk unit plugs into the back of the Commodore 64 computer, and it also plugs into a wall outlet to get power. There are no special controls to set on the disk drive or the computer, so we'll just refer you to the disk-drive user's manual for any other hookup information you need.



Fig. 10-9. The VIC-1541 floppy-disk drive.

When the disk drive is connected to the computer and to a wall outlet, you can turn it on, and the green light on the front will be lit. The power switch is located on the back of the disk drive. There is also a red light on the front of the disk drive, and this will be lit when the computer is actually using the disk to save or recall information. You'll see how this works later in this section.

NOTE: Some of the user's manuals supplied with the disk drives tell you that you must not remove a disk when the green light is on. *This is incorrect.* The disk must not be removed when the *red light is on*. The green light is just a power-on indicator.

Disks are inserted into the disk drive with the label up and on the edge of the disk that is closest to you. There is an open slot on the protective cover and this edge goes into the computer first, as shown in Fig. 10-10. Disks come with a small notch on one edge. Some disks may have this covered with a piece of tape, which tells the disk drive that it must not put any information on the disk. This protects the information on the disk so you can't wipe it out by trying to put something else on the disk. This is called *write protect*, and most prepackaged programs available from computer dealers and computer stores have this tape in place on the disk. Blank disks with no programs or information on may not have the tape stuck over the notch. Without the tape stuck over the notch, the disk drive recognizes that it may save information on that disk. If you

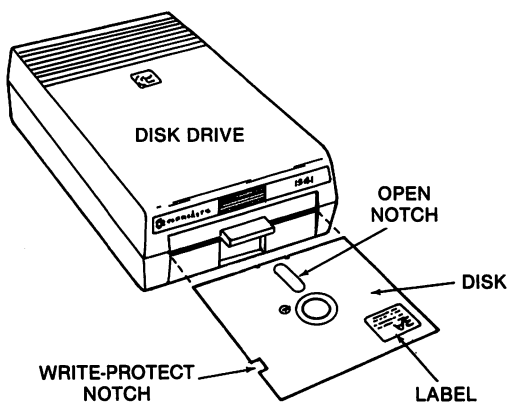


Fig. 10-10. Insert the floppy disk with the open notch toward the drive and the label up and toward you.

purchase disks and find that the notches are “open,” you’ll probably find some special stickers included with the disks. The stickers must be opaque; that is, they must be able to block out light.

Here are some experiments you can do with your VIC-1541 disk-drive unit, so you’ll be familiar with how the disks can be used with your Commodore 64 computer.

Experiment No. 10-5. Setting Up a New Disk

In this experiment, you’ll find out how to *format* a disk so that it can be used with the VIC-1541 disk drive and the Commodore 64 computer system.

The Commodore 64 and the VIC-1541 disk drive should be properly connected, and each should have its power turned on. Take a blank disk with no information on it and check it to be sure the tape covering the *write protect notch* has been removed. **DO NOT USE THE DEMONSTRATION DISK PROVIDED WITH YOUR DISK SYSTEM!** Insert the blank disk into the disk drive by pressing it in until it stops. The disk will disappear into the slot and it will be held in place. If the disk pops out of the slot, you need to press it in further. Gently press down on the short plastic bar that is just above the disk slot. This will lower a “gate” that latches in place, holding the disk in the unit. To remove the disk, gently press this small plastic bar in, toward the disk drive. This will unlatch the “gate,” so it moves up and the disk pops forward. **DO NOT CLOSE THE GATE WITHOUT A DISK IN PLACE.** Practice

inserting and removing your disk several times, so you know how to latch a disk in place and how to remove it.

Place a blank disk in your disk drive and type in the following commands on a single program line:

```
OPEN63,8,15 : PRINT#63,"NEW0:TEST DISK,JT" :  
CLOSE 63
```

Note that a *zero* follows directly after NEW. This line will look like this on the TV screen:

```
OPEN63,8,15 : PRINT#63,"NEW0:TEST DISK,J  
T" : CLOSE 63
```

Once this line has been entered, press the RETURN key. The disk drive will probably make some clicking noises and you may hear it make other low noises or a buzz as it formats the disk. These noises are normal for the format operation. As the disk is being formatted, the red light should be lit. It will take about a minute and 20 seconds for the disk drive to *format* the disk so that it's ready to use.

The red light shows you that the disk drive is "busy," and that the disk is being used. *You must not remove a disk when the red light is lit. If the red light flashes, this means that there is a disk error. You can cause an error by trying to format a write-protected disk; one with the notch taped over.* To correct this type of error, just remove the tape, insert the disk, and type in the disk format instructions again.

The commands used with the disk drive first "open" it, just as the cassette recorder and printer were opened, and assign the disk drive our identification number, 63. We chose this at random; other identification numbers can be used instead, as long as they are between 2 and 127. The second command, PRINT#63,"NEW0:TEST DISK,JT," tells the disk drive to *format* this disk so we can use it to record information later on. If the disk had been used previously, any old information stored on it is erased.

The NEW command can be abbreviated with an N followed by a zero, so the command can be simplified a bit:

```
OPEN 63,8,15 : PRINT#63,"NO:TEST DISK,JT"  
CLOSE 63
```

If you are interested, here is what the commands cause the disk

drive to do. The NEW0: operation tells the disk drive that it is to clear out the disk for new programs and information.

TEST DISK is the name we have chosen for this disk, but you can choose your own names for your disks, with up to 16 characters per name. This names the overall disk, and we suggest that you use different names for your disks, just so you can tell them apart. The two letters that follow, JT, give the disk a two-letter identification code that it can use for its own purposes. Again, each disk should be set up with its own set of two letters.

When the disk has been formatted so that programs and other information can be stored on it, the READY message will be displayed on the TV screen, and the red light will be off. You can remove the disk from the disk drive and format another one, or you can leave it in the computer for use in the next experiment.

SAVING, LOADING, AND VERIFYING PROGRAMS

Saving a program on a disk is almost the same as saving a program on a cassette tape. However, the disk keeps its own list of the programs that have been stored on it, so you don't have to keep a list on paper. This makes things simple, since you can ask the computer to get the list of programs from the disk and display it on the TV screen for you. This type of list is called a *disk directory*, or more often just a *directory*. The directory in a Commodore 64 computer system with a disk is limited to 144 program names. Once programs have been saved on the disk, it is easy to load them into the computer to either run them or make additions and corrections. You can also verify your programs to be sure that they have been saved correctly.

Experiment No. 10-6. Saving, Loading, and Verifying a Program

In this experiment, you will find out how you can store a program on a disk, and how you can load the program into the computer from the disk. You will also see how to verify that the program has been stored correctly.

If you removed your formatted disk from the disk drive, insert it now. If you don't have a formatted disk, go back and do Experiment 10-5. Once the formatted disk has been inserted in the disk drive, type in the following program:

```
20 PRINT "COUNTING"  
40 FOR T = 0 TO 10
```

```
60 PRINT T
80 NEXT T
100 END
```

Run the program to be sure that it works, printing COUNTING and the numbers 0 - 10 on the TV screen. Correct any errors, and type in the following command to save the program COUNTING on the disk:

```
SAVE "COUNTING",8
```

Press the RETURN key and the computer will display:

```
SAVING COUNTING
```

The red light on the disk drive will be lit, and you may be able to hear the disk drive make a whirring sound. When the program has been saved, the computer will display the READY message, and the red light will be turned off. The SAVE command is very similar to the one used to save programs on the cassette recorder. The only difference is that when programs are saved on the disk, the SAVE command must be followed by a comma and the number 8. This lets the computer know that you want to save the program on the disk and not on the cassette. Here are several examples of commands used to save programs on a disk:

```
SAVE "TESTING", 8
SAVE "CHECKING ACCT", 8
SAVE "LAB CALCS", 8
```

Now that you have saved your program on the disk, it is a good idea to verify it, just to be sure that it has been saved properly. To do this, just type in:

```
VERIFY "COUNTING",8
```

The computer prints the message:

```
SEARCHING FOR COUNTING
VERIFYING
OK
```

```
READY.
```

after it has found and verified that the program in the computer and the program saved are exactly the same. Type in the VERIFY command without the comma and the 8, just to see what happens:

```
VERIFY "COUNTING"
```

Without this "extra" information, the computer assumes you want to verify the program on the cassette recorder, so it displays the message:

```
PRESS PLAY ON TAPE
```

Press the RUN/STOP key to get out of the cassette-verifying program and then list your program. It should look like this:

```
20 PRINT "COUNTING"  
40 FOR T = 0 TO 10  
60 PRINT T  
80 NEXT T  
100 END
```

Remove the END command. Just type the line number, 100, and press the RETURN key. Now the program should look like this:

```
20 PRINT "COUNTING"  
40 FOR T = 0 TO 10  
60 PRINT T  
80 NEXT T
```

Type the command:

```
VERIFY "COUNTING",8
```

and see what the computer does. Since the program has been changed, do you think the computer will verify that the program in the computer is the same as the one saved on the disk? The computer displays this on the TV screen:

```
VERIFY "COUNTING",8  
SEARCHING FOR COUNTING  
VERIFYING  
?VERIFY ERROR  
READY.
```

Since the program in the computer no longer matches the program on the disk, the computer cannot verify them. The VERIFY ERROR message lets you know that the program on the disk doesn't exactly match the program in the computer. If this happens after you save a program on the disk, you'll want to save your program again, and we'll show you how to do this shortly.

Clear your computer using the NEW command and type LIST, just to confirm that there are no program lines saved in the computer. To get your program back again, type in:

LOAD "COUNTING",8

The computer displays:

LOAD "COUNTING",8

SEARCHING FOR COUNTING

LOADING

READY.

You can use the LIST command to have the program that you loaded from the disk displayed on the TV screen. This shows you that the program really did come from the disk. Run your program just to be sure it works properly.

We chose the name "COUNTING" for the program used in the previous experiment, but any other name could have been used. In most cases, you'll want to choose a name that tells you what the program does. Names such as PROGRAM-1, PROGRAM-2, and so on aren't as useful as KEYBOARD TEST, CHECKING ACCT, and so on.

SAVING A CORRECTED PROGRAM

If you are going to write fairly long programs, you'll want to save them on a disk so they can be recalled later and tested. If you recall a program from the disk and correct an error, you cannot put the program back on the disk using the same "name" for it. This is a limitation of the disk drive, and at first it seems to be difficult to correct programs and put them back on the disk. You might have to make up new names as you go along, testing, correcting, testing, correcting, and so on, calling the programs COUNT-1, COUNT-2, COUNT-3, and so on, as corrections are made. This would take up a lot of the disk's storage space very quickly, and it wouldn't be very handy.

You can use a special command to rewrite a program onto the disk using the same "name" for it. For example, if you have recalled a program named "CHECKING" from the disk and have made changes in the program, you can use the same name to store the program back on the disk by using this type of command:

SAVE "@0:CHECKING",8

The @0: characters let the disk know that the new program called "CHECKING" is replacing the old one with the same name

on the disk. If you have a verify error when verifying a program that has been saved onto the disk, you can try to save it again by using a *new name*, or you can type in the SAVE command with the @0: characters in front of the original name. The choice is yours.

THE DIRECTORY OF PROGRAMS

The VIC-1541 disk drive can be told to list its *directory* of the programs stored on a disk, providing a list of names of the programs stored. To get this list, you can type the following command:

```
LOAD "$",8
```

and the disk drive will load the names into the computer for you, displaying:

```
SEARCHING FOR $  
LOADING  
READY.
```

on the TV screen. To display the list of names, just type LIST. One of the problems with using the LOAD "\$",8 command is that this erases any programs that you have in the computer when the "\$" information is loaded in. Likewise, if the listing of the *directory information* is in the computer when you type in a program, it can cause problems, and the program probably won't run properly.

This can be overcome by using a special program that has been put on the demonstration disk that comes with your disk drive system. On our demonstration disk, this program was called "C-64 WEDGE." This provides some special features that let you do disk-related tasks more easily. One of the things you can do is have the directory of programs on the disk displayed on the TV screen without interfering with your programs that are in the computer. To use the WEDGE program, first remove any disk from the disk drive and insert the demonstration disk. List its directory by typing LOAD "\$",8 to be sure that the WEDGE program is on the disk. In our system, we typed in:

```
LOAD "C-64 WEDGE",8
```

to get the WEDGE program into the computer. Type RUN to run it. Once the WEDGE program has been loaded and run, you can type >\$ to have the directory typed on the TV screen. This information won't interfere with any of your programs, and you can use this operation to type out the disk's directory at any time.

CLEARING AN OLD FILE

If you have an old program that you don't need any longer, you can erase it from your disk by using the SCRATCH command. Clearing old programs and files gives you extra storage space on a disk, and lets you "clean up" a disk by getting rid of old programs. To remove a program called "EST REV A" from the disk, just type in the following command:

```
OPEN 67, 8, 15 : PRINT#67,"SCRATCHO:EST REV A"  
CLOSE 67
```

You can abbreviate SCRATCH as just S:

```
OPEN 67,8,15 : PRINT#67,"SO:EST REV A" CLOSE 67
```

Again, remember that a zero follows the SCRATCH command or the letter S. After you use the SCRATCH command, you can list the directory with the >\$ command. The EST REV A program will not be in the directory.

RENAMING OR COPYING A FILE

You can rename and copy your programs or files by using simple commands much like the SCRATCH command already described. Suppose that a program called "TEST 32" is now ready to be given the name "RAILROAD GAME." You could load the program into the computer and then save it using the new name:

```
LOAD "TEST 32",8
```

```
READY.
```

```
SAVE "RAILROAD GAME",8
```

Then you'd have to go back, verify it, and "scratch" the program called "TEST 32." If you just want to put a new name on your program or file, you can rename it by using the following type of command:

```
OPEN 72,8,15 : PRINT#72,"RENAMEO:RAILROAD  
GAME=TEST 32" CLOSE 72
```

You can abbreviate RENAME with an R:

```
OPEN 72,8,15 : PRINT#72,"RO:RAILROAD GAME=TEST  
32"  
CLOSE 72
```

Copying a program makes a duplicate on the disk, and you must give the copy or duplicate program a new name. Unlike the renaming operation, the old program stays on the disk after it has been copied. In the following example, the TESTING program is copied and the copy is named "HARRY":

```
OPEN 70,8,15 : PRINT#70,"COPY0:HARRY=TESTING"  
CLOSE 70
```

The COPY command can be abbreviated with a C:

```
OPEN 70,8,15 : PRINT#70,"CO:HARRY=TESTING"  
CLOSE 70
```

At the end of this operation, there is a program named "TESTING" and one named "HARRY" on the disk. They are exactly the same.

If you value your programs, we suggest making duplicate copies of them *on different disks*. If a disk is damaged, you'll have a *backup* copy that you can use. Some games and commercial programs may be *copy-protected*, so you may not be able to make backup copies of them. We'll talk more about this in the next chapter.

SAVING AND LOADING DATA FROM A DISK

Like the cassette recorder, the disk drive can be used to save and load information consisting of values and strings. The programs used with the disk drive are a bit more complicated, since the disk must be set up for several operating conditions, and many special disk operations can be added to these programs to check for disk problems, errors, and so on. If you are interested in this type of programming, you can use the simple programs that we've provided as starting points, and refer to the user's manual for more information.

The first program sets up the disk drive for a file called "TEST," and it then puts 100 values into the file for later use. In our example, a FOR-NEXT loop was used to quickly come up with the 100 values (VLU), but values from a checking account, student-grading, or business accounting program could be saved this way, too. Here's the program for you:

```
220 OPEN 2,8,2,"@0:TEST,S,W"  
240 FOR VLU = 1 TO 100
```



```
260 PRINT#2, VLU
280 NEXT VLU
300 CLOSE 2
320 END
```

You can recall this information from the disk very quickly, using a program that inputs the values:

```
400 OPEN 2,8,2,"O:TEST,S,R"
420 FOR VLU = 1 TO 100
440 INPUT#2, NBR
460 PRINT NBR
480 NEXT VLU
500 CLOSE 2
520 END
```

In the program example that follows, five values can be typed in from the keyboard. They are saved in a file called "VALUE-5":

```
20 OPEN 2,8,2,"@0:VALUE-5,S,W"
40 FOR VN = 1 TO 5
60 INPUT "VALUE TO SAVE = "; VTS
80 PRINT#2, VTS
100 NEXT VN
120 CLOSE 2
140 END
```

Getting these values from the computer takes only a short program:

```
520 OPEN 2,8,2,"O:VALUE-5,S,R"
540 FOR NMBR = 1 TO 5
560 INPUT#2, X
580 PRINT X
600 NEXT NMBR
620 CLOSE 2
640 END
```

These programs can be used to point you in the right direction if you choose to put together your own programs to use the disk drive. There are many other things that you can do with the disk drive, but we'll leave these for readers who want to get more involved with programming the computer and reading through the computer jargon in the disk-drive user's manual. We don't think that most people will be using the disk drive for more than loading

and saving programs, or for storing information from a commercial program package.

In this section, we have given you an overview of the disk drive, and you should be able to load, save, and verify programs without difficulty. You can also load in the WEDGE program from your demonstration disk so that printing the disk directory doesn't erase or destroy your BASIC programs.

**SUPPLIERS AND DISTRIBUTORS OF PLUG-IN CARTRIDGES,
PROGRAM CASSETTES, AND DISKS FOR THE COMMODORE 64
COMPUTER**

Academy Software
P. O. Box 9403
San Rafael, CA 94912
415-499-0850

Human Engineered Software
71 Park Lane
Brisbane, CA 94005

Info-Designs, Inc.
6905 Telegraph Road
Birmingham, MI 48010
313-540-4010

Microphys Programs
1737 West Second Street
Brooklyn, NY 11223

Micro Systems Development, Inc.
11105 Shady Trail, Suite 104
Dallas, TX 75229
1-800-527-5285

Micro-Ware Distributing, Inc.
1342 B Route 23
Butler, NJ 07405
201-838-9027

Precision Technology, Inc.
P. O. Box 15454
Salt Lake City, UT 84115
801-487-6266

Professional Software, Inc.
51 Fremont Street
Needham, MA 02194
617-444-5224

Pyramid Computerware
278 Warren Street
Edgewater Park, NJ 08010
609-386-9353

Skyles Electric Works
231G South Whisman Road
Mountain View, CA 94041
415-965-1735

Southern Solutions
P. O. Box P
McKinney, TX 75069
214-542-0278

CHAPTER 11

COMPUTER CARE— HARDWARE AND SOFTWARE

By taking good care of your computer, you can extend its useful life by many years, and it will reward you with good service and operation. Most “computer care” is common sense, but most *computer users* ignore this important area, and they are more likely to take better care of garden tools and household appliances. Taking care of your computer also means a careful evaluation of software for it. In the last part of this chapter, we will suggest some ways to evaluate software products to be sure you get what you want. Some of this evaluation is common sense, too, and other people may have their own ways of testing and checking software.

HARDWARE CARE

One of the first things to do is to protect the computer from physical abuse. If youngsters are going to use the computer to play games, run educational programs, or do something else, they need to be told that the computer is a delicate piece of electronic equipment, and that it must be taken care of. Most people need to be reminded of this from time to time, since as they become more and more familiar with the computer, they will take it for granted. Be sure that users don't bang on the keys and that they don't hit the computer if something goes wrong. As silly as it sounds, it does happen.

A Special Place

A good way to protect your computer is to set aside a special place for it. If you are using the computer on the kitchen table, there is always the possibility of dropping or damaging the computer when it is put away during meals or other activities. If a desk or small table can be set aside for your "computer center," this will decrease the possibility of damage to the computer since it won't be moved as much.

Once your computer has been set up in a special place, you'll have a convenient place for all of the other computer materials that you're bound to collect: books, magazines, program cartridges, cassettes, and so on. A neat, logical layout is helpful, and storage bins or small sets of drawers are recommended as a way of organizing your materials. A disorganized work area means that program listings, cassettes, and special notes can be lost or damaged under the "junk pile." Cassettes and disks store information and programs using magnetic material. If you don't take good care of the cassettes and disks, the information on them can mysteriously disappear. Don't leave cassettes and disks near electrical equipment, and don't put them on top of the computer or TV set.

Most cassettes come in their own plastic cases. Be sure that the cassettes are returned to the cases when you are finished using them. Don't leave a cassette in the recorder for any longer than is necessary. Disks and cassettes can be further protected by using some sort of a "file" for them. Many record stores sell cassette organizers, and most computer stores have similar storage cases for disks. If you value your programs and information, take care of your cassettes and disks.

When you set up your computer equipment, place the cables and wires neatly. You can coil unused lengths of wire and cable, securing them with plastic bag ties or rubber bands. Keeping the wires and cables behind the computer equipment decreases the chances that something will get tangled in them and that someone will mistakenly unplug them.

The Commodore 64 uses an antenna switch to connect the TV antenna (or cable) or the computer's TV cable to the TV set. If the TV set you are using is going to be used by others for normal TV watching, remember to switch back to the "TV" or the "ANTENNA" position when you are finished using the computer. This will avoid someone looking for you when the midnight late show comes on and they find, "the TV isn't working right."

Static

If you find that you are getting shocks from static electricity every time you move across the room in which you have the computer, it's a good idea to do something about it to protect your computer equipment. You might first try changing your shoes, since the material on the soles may be the culprit. If that doesn't reduce the static electricity, try using another chair, since plastic or plastic-covered chairs often generate static electricity. You can also use a humidifier in the computer room. Static electricity is reduced when the humidity is increased, so static is most often a problem during dry weather (usually during winter). Your nasal passages and throat will also thank you.

Protection

There are some other steps you can take to keep your computer running smoothly. One is the use of dust covers for the equipment. Plastic, nonstatic dust covers are recommended for all of your computer equipment, particularly the keyboard, disk drives, and printer. Other equipment may be covered, but the items just listed are the most prone to damage. Dust covers don't only protect the equipment from dust, but from deodorant, wax, polish, and other aerosol sprays that can leave a film on equipment, causing malfunctions.

Dust covers can also protect against accidents such as liquid spills, cigarette ashes, and other types of material (Fig. 11-1). Make it a rule not to eat, smoke, drink, or do other noncomputer things around your computer. The authors have seen a can of soda disappear into a printer mechanism and have seen the disastrous effects of nondairy creamer on a small computer. It is easy for crumbs and small pieces of "junk" to accumulate between the keys. Such material can also get on your disks and cassettes, causing problems when you try to retrieve or store information and programs. The two photographs in Fig. 11-2 illustrate the difference between a clean and a dirty disk "head," the part that actually reads and writes the information to and from the disk surface.

Power

It is a good idea to use a "plug strip" as the power source for your computer equipment. Many of these devices have a master switch and a circuit breaker, so all of the equipment can be controlled from one place. With this type of a setup, you won't go away

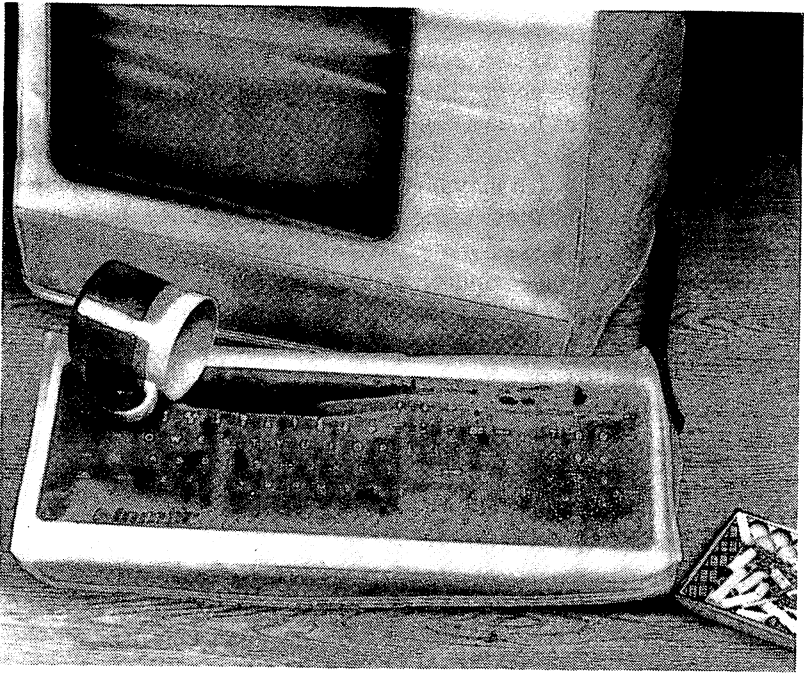


Fig. 11-1. A cover can protect a small computer from dirt, ashes, and other "pollution." (Courtesy Inmac)

on a trip and suddenly remember that the computer is still on. Remember that in the Commodore 64 computer, the "power cube" that is plugged into the wall outlet *has power connected to it for as long as it is plugged in.* The power switch on the Commodore 64 just connects the cube's power to the computer. If you're going to turn off the computer for a while, we recommend unplugging the power cube or using a "plug strip" to turn off all the equipment. A typical power strip is shown in Fig. 11-3. These are available from hardware and electrical supply stores.

Power surges aren't normally a problem, although there are companies that advertise surge protectors that are built into plug adapters and strips. Your local situation will determine whether or not you need this kind of protection. You can ask some of the local computer users about their experiences.

Lightning often strikes power lines, and it can damage delicate electronic equipment that is plugged in, *even if the equipment is turned off.* We have seen television sets that have been damaged

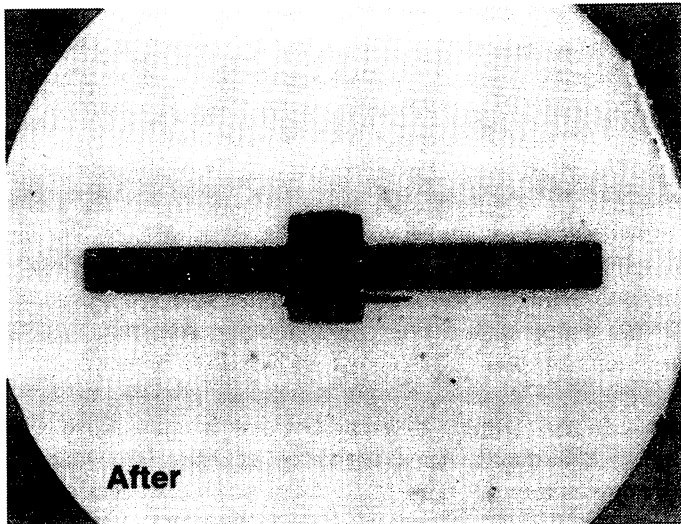
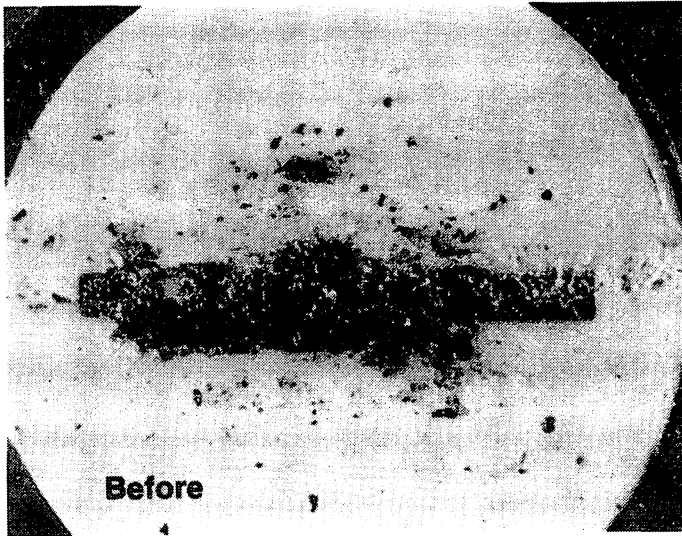


Fig. 11-2. Clean and dirty disk read/write heads. (Courtesy Radio Shack, a Division of Tandy Corp.)

by nearby, indirect lightning strikes to the power line. If lightning storms occur in your area fairly frequently, it might be wise to unplug your computer equipment when you aren't using it.

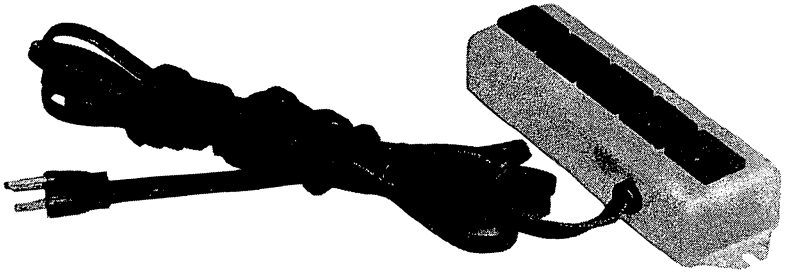


Fig. 11-3. A power strip provides a central source of power.

Clean Up

All computer equipment needs to be cleaned once in a while. You can easily dust the keyboard unit and television set with a vacuum cleaner, but this isn't recommended for cassette and floppy-disk units. Printers can be dusted carefully with a vacuum cleaner on a low suction setting. Vacuuming can remove paper lint and dust that can cause problems. When dusting, don't use any commercial spray materials that leave a film or residue. If anyone else will be cleaning near the computer equipment, remind them NOT to use such products on the equipment. A commercial window-cleaning product can be used to clean the TV screen, but take the TV set out of the "computer center" so that spray droplets of the cleaner don't get into the other equipment.

Cleaning disk drives and cassette units calls for care. Special kits are available for cleaning both of these devices, with cassette head-cleaning kits available at most record and radio-TV stores. Cleaning kits for floppy disk drives are available from many computer suppliers, and a typical kit is shown in Fig. 11-4. This kit contains a special cleaning disk and cleaning solvent. The cleaning solvent is squirted onto the cleaning disk and the disk is placed into the disk-drive unit. The disk is then activated so that the cleaning pad gently removes any dirt and residue from the disk-reading mechanism. This takes about 30 seconds, and it is a worthwhile task, prolonging the life of both the disk-drive unit *and* your disks. Disk heads should be cleaned *once a week*, or more frequently if the disks are used heavily.

Troubleshooting

Most computer manufacturers provide service for the equipment they sell, either through a direct service facility or through service



Fig. 11-4. A typical disk cleaning kit. (Courtesy 3M Co.)

outlets. In most cases, you will have to deliver your computer equipment to the service center, either by shipping it, or by hand-carrying it. We suggest checking the information supplied with the computer for service information, or you can call or write the Commodore service centers to get more information about having your computer serviced:

Commodore Computer Service Center
950 Airport Road
West Chester, PA 19380

or

Commodore Computer Service Center
390 Reed Street
Santa Clara, CA 95050

Commodore suggests that you call first, before sending your unit

for servicing. The latest number we have is (408) 727-3754. You can check with your computer dealer for any other servicing information.

If servicing is required, be sure to send a complete description of the problem along with the piece of equipment to be repaired. A note telling the service people that the equipment doesn't work isn't very helpful. If the problem can be localized, it will speed the repair job and get the computer back to you quickly. Be sure to carefully pack your equipment and *insure it*, so it is covered for any shipping damage, or if it is lost.

It isn't too difficult to try and track down some computer problems on your own. The first thing is to be sure that the computer is set up properly, and that you aren't doing something odd to it. For example, check the cables and cords to be sure they are all firmly mated or "seated" in position. Also check to make sure all of the equipment has been turned on. Many people forget to turn on power or connect needed accessories. If the computer still isn't working properly, set up just the computer and the TV set and run a simple BASIC program. Something as simple as typing a few numbers on the TV screen will do fine as a test.

If the basic computer system is operating properly, reconnect the accessories, one at a time, and continue to test the computer. If you have reconnected the cassette unit, try loading and saving a program to test the system. This will help you localize the problem. For example, (1) you have your system connected, except for the printer, and all seems to be operating properly; then (2), the printer is connected, and the system doesn't work. Set up the computer with just the TV and the printer and try it again. If the printer still doesn't work, the problem may be in *either* the computer or the printer.

If you know of another person with a Commodore 64 who lives close by, you might arrange to try your computer *and* printer with the other person's equipment. This may narrow the problem even further. Many towns and communities have enough Commodore 64 users so a club or users' group has planned activities and even a newsletter. A similar group may exist in your town. Sales people at the store may know about such a group, or you may see a meeting notice in a local newspaper. There are several computer magazines that contain lists of local interest groups and clubs. You'll find people in these groups who have a wide range of interests, and many of them will be happy to help you.

SOFTWARE

Software has been said to be the most important ingredient of any computer system. It takes a great deal of time to put together computer programs, check them, and get them to work properly, and you will find that software represents your biggest computer investment, even if you purchase only a few programs, or "packages," as they are often called. In this section, some of the details of program selection and evaluation will be described. It isn't particularly difficult to evaluate a simple game or recreational program, but programs for special applications can cost several hundred dollars, so you can't afford to make the wrong choices.

What's Available

Once you have decided that a particular type of program is needed, it is a good idea to try and find out what programs are available to meet your needs. For example, if you are interested in an address-file program, you will have to look for that specific type of program. If you subscribe to a magazine about computers, particularly the Commodore-64, you may find several manufacturers or distributors who sell the type of program you are looking for.

A local user's group or computer club may be able to tell you about someone who has a similar program or who may have looked at several. Most people are glad to tell you about their experiences.

Information and References

Once you have found some programs that sound interesting, ask the manufacturers and suppliers for information about them. The responses you get are often good indicators of what the programs are like. A professional response with interesting informative literature generally means that the company operates in a professional manner. On the other hand, photocopied typewritten information that is unreadable or full of computer terms may mean that the company doesn't understand its market or its potential customers. Use the information about the programs to make comparisons between them. How quickly do the programs run? How much information can they use? Your questions should be based on your needs. For example, if you are looking at a word processing program, you want to know how many pages of typewritten material can be saved on a disk or cassette. You may also want to know if the program requires a special printer, or if a standard Commodore printer can be used.

Ask the manufacturer, distributor, or dealer for the names of several people who are using the program. Most dealers will share this information with you, and these people will be able to give you an unbiased opinion about the program. Ask them how they like the program, how they are using it, how long they have been using it, and so on. Be sure to ask them what they dislike about the program. Also ask if they have had any problems with the program, with the dealer, or with the manufacturer. If one or two of these people are located in your area, you might ask if you could visit them and actually see how the program works. Don't ask for a copy of the program to take home and try. This is asking the other person to violate the copyright on the program, and it is illegal.

Demonstrations and Documentation

Visit several dealers, if you can. Ask for demonstrations of the computer program and also ask to look at the user's manual or other written materials that come with the program. This is called "documentation," and it is what you will use to guide you when you use the program. One thing to look for is clearly written information that is easy to read and understand. If it seems to have been written for a computer expert, more than likely the program will be set up the same way — for an expert.

The written materials and instructions are probably the most important part of a computer program, since they tell you how to effectively use the program. Unfortunately, many program manufacturers do a poor job of preparing a manual for the user. In looking at a manual, check for an index so you can quickly locate information. A set of examples is also important, since it lets you see how the program works and what it actually looks like when it is running. Many manuals contain exercises that you can do to become familiar with the program, along with photographs or examples of the TV screen display.

If a visit to a dealer isn't possible, you should at least review the instructions for the program package. Many software suppliers realize that people want to look at this material, so it is sold separately. In some cases, suppliers will give you credit for this purchase if you decide to buy the complete software package within a limited time. A smaller number of manufacturers supply demonstration or "demo" copies of their programs so you can try them. These "demo" programs may not be able to do everything the regular program can, but they will give you a good idea of how the program operates.

Testing Programs

If you can actually try the program, so much the better. You'll be able to see how it will work in your application. No program is perfect in the sense that it does everything exactly as you want it to. Of course, the program should give the correct results, but it may display the results on the bottom of the screen, while you'd rather have them at the top. These things are usually minor, unless you find that the final result of the program is not what you want.

If a dealer will not supply you with a program that you can test, you may be able to try the program in his store or office. Other users may let you try the program at their office or home, giving you an hour or two to use it. A few hours of testing time is a worthwhile "investment."

If you are spending a considerable amount of money to buy the program, and if you expect to use the program frequently, testing is almost mandatory. How you test the program depends on what kind of program it is. Business accounting programs and word processing programs do different things, so they are tested differently. During your test, make an effort to cause problems for the computer, to see what happens. For example, if the computer asks for a YES or NO answer, type something else to see if the computer will "trap" your incorrect answer and give you another chance to type in a correct answer. If the computer does something unexpected, there may be other flaws in the program, too. Try as many combinations of commands and conditions as you can.

As you test a program, be sure that it is easy to use and that the "menus" displayed on the TV screen are easy to understand and are meaningful. For example, if the program displays this type of menu at one time:

MORE DATA TO BE ENTERED?

1. YES
2. NO

TYPE 1 OR 2

and this at another:

DISPLAY RESULTS AGAIN?

0. YES
1. NO

TYPE 0 OR 1

it will be difficult to remember whether a 1 is a YES or a NO answer. The answers should be consistent, and in this example it

would have been much easier to just type YES or NO, or, Y or N. If the program is difficult to use, you will spend as much time mastering it as actually using it. Even though many people have "standardized" some difficult-to-use programs, this doesn't mean that they are the best ones available.

Many programs are confusing just because of the many different things they can do. Many people find that they can do a very good job without many of the special operations provided. In many cases, a simpler less-expensive software package will take care of your needs as well as a more-expensive package that has operations you won't use.

Updates and Revisions

Before you purchase a program, ask the dealer or supplier if it is the latest version. You might ask if a revised or updated program is expected in the near future. Sometimes, minor "bugs" or problems are found in a program, and the manufacturer modifies the program to take care of this. Many manufacturers continue to change their programs to make them easier to use, to change the display format, and so on, in response to their customers' needs. Ask whether updated programs are going to be available, and what the terms are. Here are some typical arrangements:

1. The current program is the only one available. No revisions, updates, or changes are going to be developed or provided.
2. New programs or documents may be available, but you will have to buy them just as if you were buying a new program.
3. New programs and manuals may be available, and there is a small charge for exchanging your "old" program for the new one.
4. New programs and manuals may be available, and the exchange is free for the first six months you own the program.

The last two choices are the best, since they tell you that the manufacturer is interested in continuing to work with you, and that you are a valued customer.

Some manufacturers provide a "hot-line" telephone service that you can use if you have a problem or difficulty in using the program. Ask if this is available for the software packages you are looking at. This type of service is expensive, so it adds to the cost of the program. Don't expect to have this kind of service for an inexpensive program or game.

You might also ask if there is a users' group that is centered

around the software packages you are interested in. Some of the most popular programs have spawned their own groups, so additional information, hints and assistance is available from an amateur group. Some dealers and suppliers are familiar with software, so you might also ask if they provide any local assistance to their customers. This is a good reason to deal with a local dealer instead of a mail-order dealer.

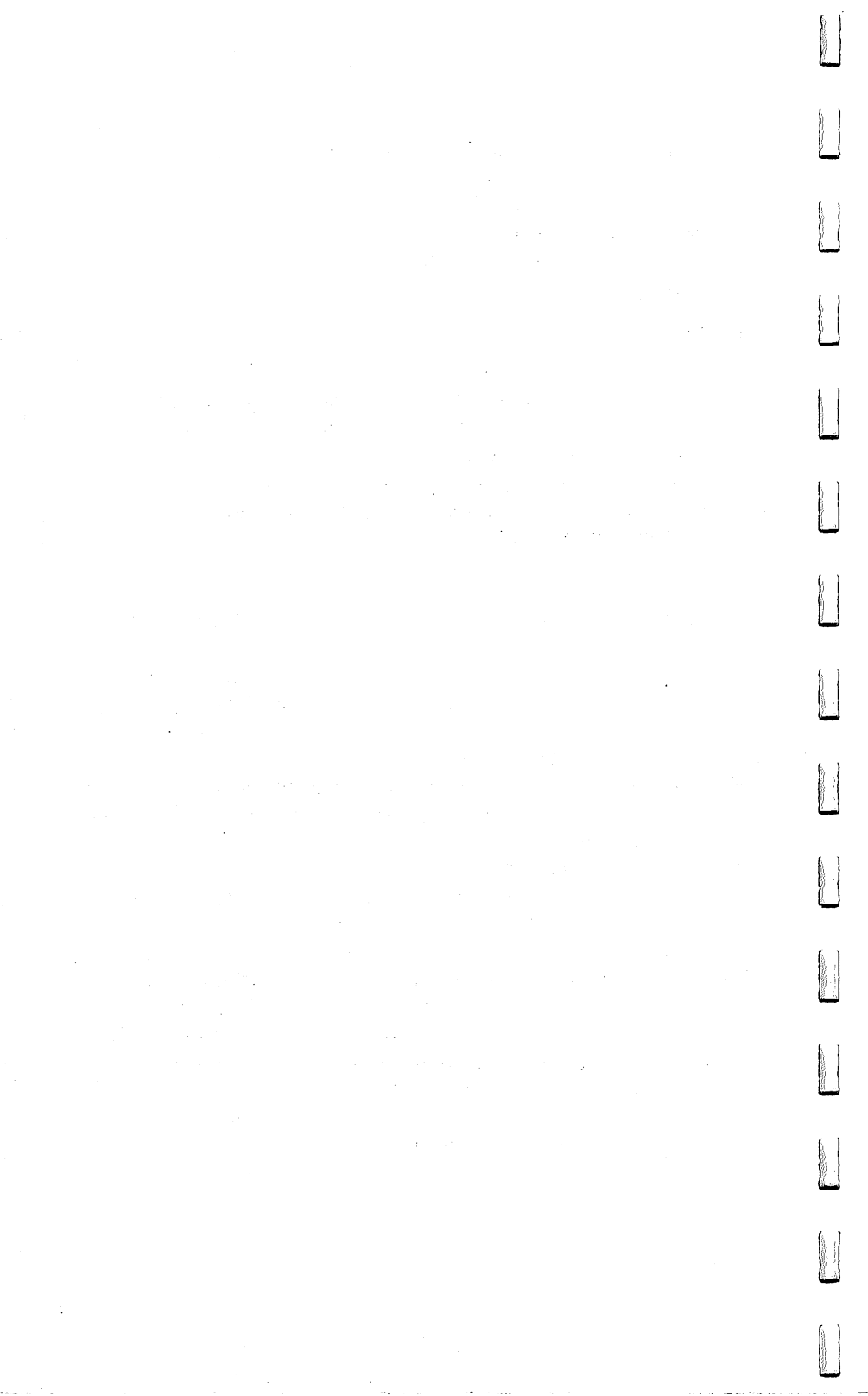
Flexibility

If you expect your uses for your computer to increase, as they almost always do, you want to be sure that the program will be able to expand, too. For example, a program for teachers that will handle up to 25 students is going to be useless if the next class has 27 students in it. It is often difficult to think about the future and how things may change, but programs should be adaptable to new situations and requirements.

Protection

We know one person who buys phonograph records and immediately makes a tape recording of them. He plays the tapes, saving the record as a "master" or "source," so it won't be damaged by day-to-day use. It is a good idea to do the same thing with programs. Be sure that you can copy or duplicate any programs you buy to provide "backup" copies. In most cases, the original is set aside for an emergency, and the backup copies are used in the computer. Since some manufacturers protect their programs by making it difficult or impossible to copy them, ask the supplier if you will be able to make backup copies for your own use. If the answer is no, ask how you get backup copies of the program. If such copies aren't readily available, look elsewhere for programs.

It is a good idea to make backup copies of your own programs and information. This preserves them so that if a disk or cassette tape is ruined, you still have your information. Disks and tapes don't last forever, although most people have very good luck with them, using them for years. One company we know of recommends throwing out disks after only a month's use. These disks are used every day, so they go through a lot of use very quickly. Don't expect tapes and disks to last forever.



APPENDIX A

COMMODORE 64 ERROR CODES

COMMON ERROR CODES

BAD SUBSCRIPT — The computer tried to use a subscript that didn't exist in the array. For example, $A = RD(57)$ where the array, RD, only goes from RD(0) to RD(40).

CAN'T CONTINUE — The computer cannot continue after you typed the CONT command. You may have changed something in the program itself, or the program may not have been started. You can't continue after an error message, either.

DIVISION BY ZERO — The computer just can't divide zero into another number. Neither can you, since the result is infinity.

EXTRA IGNORED — You typed in something "extra" when the computer asked for information. The "extra" thing depends on what type of information you are typing in: string or value.

ILLEGAL DIRECT — You have asked the computer to do something it cannot do. For example, you can tell the computer to PRINT 5+89 right from the keyboard, but you can't tell it to INPUT X : PRINT X*80, unless this is put in a program with a line number.

ILLEGAL QUANTITY — You have asked the computer to do something with a number that is too big or too small for it to han-

dle. The computer can handle numbers up to 1 with 35 zeros after it, and down to a 1 with 35 zeros before it!

NEXT WITHOUT FOR — You always need to use NEXT and FOR together. The computer will tell you if you have forgotten the FOR command.

OUT OF DATA — This error takes place when you try and get more pieces of information from a DATA statement than are actually there. Make sure you don't try and READ more information than there is in the DATA statement.

OUT OF MEMORY — You completely filled up the computer's memory. The solutions are to cut your program into smaller chunks or save some information on tape or disk.

OVERFLOW — The result of an operation is just too big for the computer to handle. Look for errors in your math, or have the computer work with smaller numbers. Since the computer can count the number of water molecules in a *cubic kilometer* of water, you're talking about a big, big number.

REDO FROM START — The computer expected a value, and you typed in some other character. The complete entry has been ignored, so just type it in again and try and get it right.

RETURN WITHOUT GOSUB — The computer found a RETURN command in the program, but the program never told it to GOSUB. Check your program and be sure that you have a GOSUB command for the subroutine. If you have unused subroutines, that's fine, but just be sure that the computer hasn't gotten to them with a GOTO or other command. Remember to use the END command to stop the computer when necessary so it doesn't go off into other programs.

STRING TOO LONG — Strings saved in the computer can have up to 255 characters. Strings input with an INPUT W\$ command can have up to 89 characters in them.

SYNTAX — This means that something was messed up and the computer couldn't understand what you wanted it to do. Check the line noted in the error message.

NOT-SO-COMMON ERROR CODES

BAD DATA — The computer expected to receive numeric data from a "file" or peripheral device. It got non-numeric characters, or a string, instead.

DEVICE NOT PRESENT — You have told the computer to use a peripheral that hasn't been hooked up or turned on yet.

FILE NOT FOUND — The computer has looked at a disk or tape, but it couldn't find the file you asked it to read. The file name cannot be found.

FILE NOT OPEN — You can't use a file without opening it first. Go back and be sure that you have the appropriate OPEN commands in your program.

FILE OPEN — You have tried to open a file that is already open. You can't open something unless it's closed. Check to be sure that you closed your files, or that you haven't opened them twice.

FORMULA TOO COMPLEX — Split your formula into smaller pieces. You have asked the computer to do too much at one time.

LOAD . . . — The computer is having a problem loading your program from the cassette recorder.

NOT INPUT FILE — You have tried to get information from an output-only file. The printer is an output-only device, so don't try and get information *from* it.

NOT OUTPUT FILE — You have tried to output data to an input device.

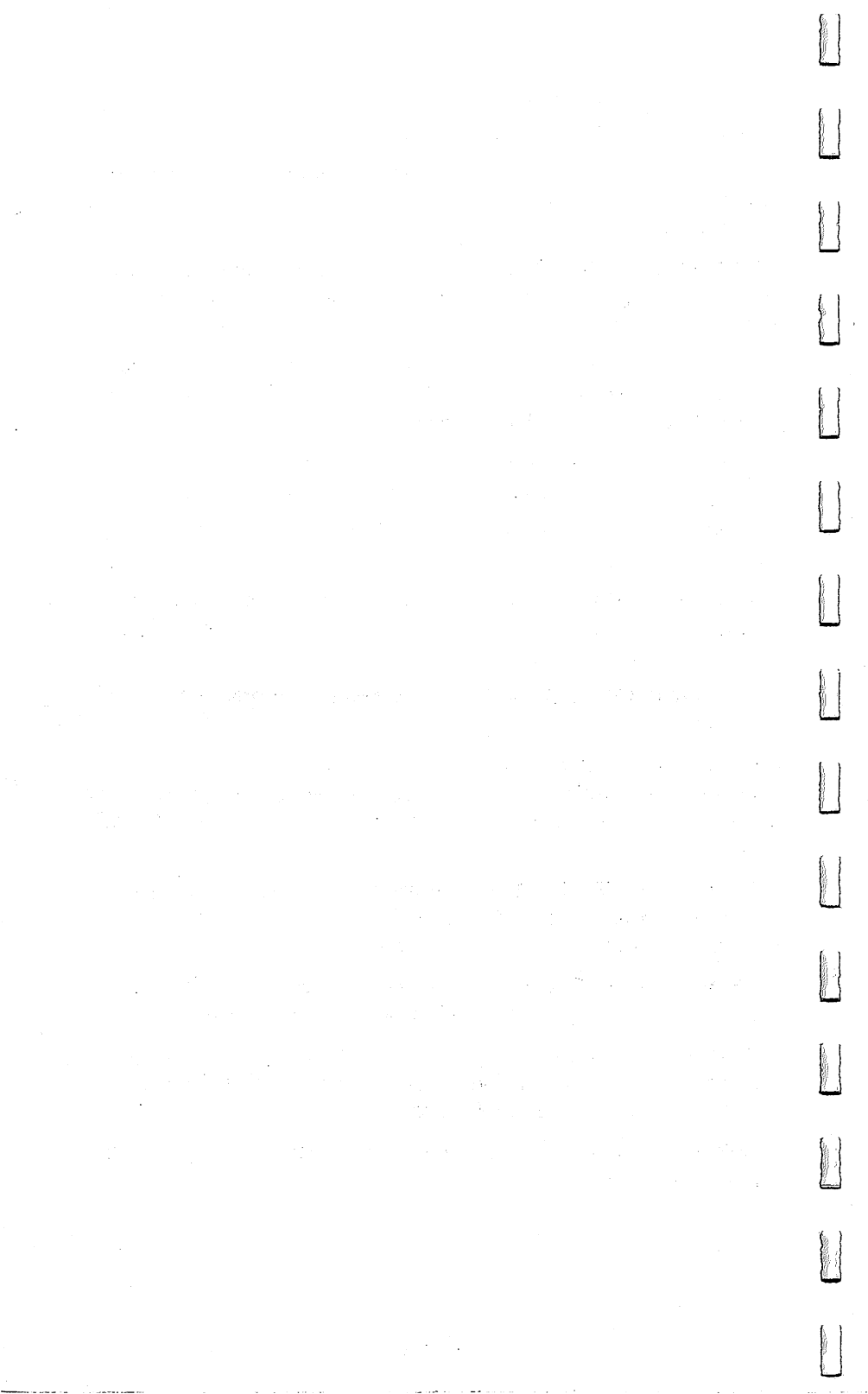
REDIM'D ARRAY — Once you set up an array, you can't change its size within the program. If you need to change the size of an array, stop the program, change the DIM command, and rerun the program.

TYPE MISMATCH — You have tried to use a value in place of a string, or a string in place of a value. The two are separate types of information, so check what you are doing.

UNDEF'D FUNCTION — The computer was told to do a "special function," but you never told it what the function was.

UNDEF'D STATEMENT — You told the computer to go to a line number that isn't included in your program. This type of error occurs with GOTO and GOSUB commands.

VERIFY . . . — The computer cannot verify your program, saved on tape or disk.



APPENDIX B

RESERVED WORDS FOR THE COMMODORE 64

ABS	GET	ON	SPC(
AND	GET#	OPEN	SQR
ASC	GOSUB	OR	STATUS
ATN	GOTO	PEEK	STEP
CHR\$	IF	POKE	STOP
CLOSE	INPUT	POS	STR\$
CLR	INPUT#	PRINT	SYS
CMD	INT	PRINT#	TAB(
CONT	LEFT\$	READ	TAN
COS	LEN	REM	THEN
DATA	LET	RESTORE	TI
DEF	LIST	RETURN	TI\$
DIM	LOAD	RIGHT\$	TO
END	LOG	RND	USR
EXP	MID\$	RUN	VAL
FN	NEW	SAVE	VERIFY
FOR	NEXT	SGN	WAIT
FRE	NOT	SIN	π



APPENDIX C

ANSWERS TO QUESTIONS

CHAPTER 1

1. To use channel 3, set the TV channel selector switch to channel 3 and set the switch on the back of the Commodore 64 keyboard unit to the channel-3 position. This is with the switch pushed over toward the large open cartridge slot. Remember to move the TV antenna switch to the COMPUTER position.
2. There are *printing* and *action* keys on your Commodore 64 computer. The printing keys print one or more characters on the TV screen. The action keys can perform actions on their own; for example, the CLR/HOME key; or they can change the operation of the printing keys; for example, the GRAPHICS key doesn't do anything by itself, it just lets you print special graphic characters.
3. The SHIFT key has two uses:
 - (a) It lets you print the upper symbol for those keys that have an "upper" and a "lower" symbol on their key tops.
 - (b) It lets you print the right-hand graphic symbol for those keys that have a graphic symbol on their front surface.
4. The CLR/HOME key can be used by itself to move the cursor

to the upper left-hand corner of the TV screen's display area. When used with the SHIFT key, the CLR/HOME key clears the display area *and* moves the cursor to the upper left-hand corner.

5. The two cursor control keys, CRSR, are used to move the cursor on the TV screen. The cursor can be moved down, right, up, or left. The SHIFT key must be used to move the cursor up or left. When the cursor is moved, no characters are "erased."
6. Yes, several of the keys "repeat" their action. The space bar and the two cursor control keys are examples.
7. The INST/DEL (insert/delete) key is used to correct errors. You can use it to remove or "erase" characters and to insert new ones on the TV display. The insert operation uses the SHIFT key.
8. The GRAPHICS key is located in the lower left corner of the keyboard, and it looks as though it has a large "C" with an equal sign on it: C=. It lets you type the left-hand graphic symbols for the keys that have graphic symbols on the front of them.
9. Colors are changed by using the CTRL key and the number keys, "1" through "8." The colors are noted on the front of these keys. You must press and hold the CTRL key when you press the color keys. You can also press and hold the GRAPHICS key and one of the color keys to change to eight other colors, although most of these won't show up well. These details are described in Chapter 8.
10. The SHIFT and "6" keys will print the "and" symbol, &, on the TV screen. No color change takes place. The CTRL key and a number key must be used to change the color of the cursor.
11. No, changing the color of the cursor doesn't change the color of anything else on the screen.

CHAPTER 2

1. The Commodore 64 can process both *values* and *strings of characters*.

2. In general, computers are used to *process* information and to *transfer* information.
3. Of the 12 labels, several are not valid. These are \$LABEL, 31ST STREET, and 3STATE\$. Here is why they cannot be used:
 - (a) \$LABEL (Labels cannot start with a dollar sign.)
 - (b) 31ST STREET (Labels cannot start with a number.)
 - (c) 3STATE\$ (Labels cannot start with a number.)
4. Yes, there is a conflict between SPAGHETTI and SPELLER, since the computer would see both as the label SP for use with a value. There is no conflict between SPEND\$ and either SPAGHETTI or SPELLER, since SPEND\$ is a label for a string, and its two-letter label would be SP\$.
5. There are several errors in these labels and information. They are:
 - (a) TEST = \$56 (This must be TEST = 56. The dollar sign cannot be used as part of a value.)
 - (b) TIME = "TEN OF FIVE"\$ (This must be: TIME\$ = "TEN OF FIVE". The dollar sign is in the wrong place.)
 - (c) TM = 56.89 (This is correct.)
 - (d) LINK\$ = NUMBER OF TESTS (The string must be enclosed in quotes: LINK\$ = "NUMBER OF TESTS")
 - (e) SEEDS = 78 (This is correct.)
 - (f) LINES = "10 LINES PER INCH" (The label, LINES, must have a dollar sign after it to label a string: LINES\$ = "10 LINES PER INCH")
6. There are errors in several of these commands. The corrections have been underlined for you:
 - (a) INPUT "YOUR NAME, PLEASE"; NAME\$
 - (b) PRINT "TEST RESULTS"_
 - (c) PRINT "BALANCE IN ACCT = " _ BAL (No semicolon needed)
 - (d) INPUT "TODAY'S SPECIAL"; SPEC
 - (e) INPUT "ENTER THE YEAR"; YR\$
 - (f) PRINT "THIS IS A COMMODORE 64"
7. An entry with an incorrect line number can be erased by simply typing the incorrect line number and [RETURN]. This "erases" the line from the computer program.

8. You can finish the line, type [RETURN] and retype it, or you can use the INST/DEL key to "back-up" and erase an error.
9. To start a BASIC program, just type RUN [RETURN].
10. To list a program on the TV screen, simply type LIST [RETURN].

CHAPTER 3

1. So far, the Commodore 64 can do addition, subtraction, multiplication, and division.
2. The Commodore 64 does the multiplication and division operations in a program step first, and addition and subtraction operations second.
3. You can put almost as many program steps on a line as you want. Programs with too many steps are difficult to "read" and understand, so don't try and cram too many on a line.
4. Individual program steps are separated by colons when they are combined in a single program line.
5. Parentheses are used to separate math operations so they can be easily broken down. Individual operations are easy to understand when parentheses are used, and there is no question about which operations are done in what order.
6.
 - (a) $? = 5 * 12 + 4$ (Answer: 64)
 - (b) $? = 3 * 4 + 12 / 5 * 8$ (Answer: 31.2)
 - (c) $? = (((4 * 6) / 3) + 18) - 7$ (Answer: 19)
7. REM stands for REMark, and it is used to put a comment or note in a program so that the programmer will understand why something was done, what value is being used, and so on. The program doesn't *do* anything with a remark, it skips over it to the next real program step.
8. The INPUT command lets you have the computer get information from the keyboard. A label must be used with an INPUT command so the computer knows how to identify the information.
9. The computer always uses labels to identify and locate information.

10. The INST/DEL (insert/delete) key is used to help you correct program lines and other information on the TV screen. The INST/DEL key uses the cursor as its "marker." The changes only go into effect after the RETURN key is pressed.

CHAPTER 4

1. The GOTO command causes the computer to go to a specific line in the program. It doesn't care where the line is or what command is there.
2. The GOTO command must be followed by a line number that is really part of the program.
3. The GOTO command will cause an error condition when the line number used is not found by the computer. The error tells you that something (the line number) is not properly defined in the GOTO command.
4. The GOTO command can point the computer to any line number in the program.
5. You can get out of an "endless" loop by pressing the RUN/STOP key. You can also pull the power plug to the computer, but that will "erase" your program!
6. You can use the RUN/STOP and the RESTORE keys to get the computer out of an INPUT command when it's waiting for information from the keyboard. You can pull the plug, too, but that is not the recommended solution.
7. The Commodore 64 can evaluate, or test, almost any statement that can be answered with true or false.
8. The statements are used in IF-THEN commands. The computer evaluates the statement to see if it is true or false. The answer is used to make the decision.
9. The conditions of equal-to, greater-than, and less-than can be tested. These conditions can be combined; for example, less-than OR equal-to.
10. Any of the BASIC commands can follow the THEN in an IF-THEN command. Multiple commands can be used, too, as long as they are separated by a colon.
11. The AND and OR operations let the computer test for several

conditions in a single IF-THEN command. For example, IF (A = GR) AND (FX > 6) THEN . . . The NOT operation reverses the true-false result when a statement is evaluated by the computer. For example, the statement "7 = 7" is true, while the statement "NOT (7 = 7)" is false.

12. The RND(1) operation is used to get a random number between 0 and 1. Other operations are used to "scale" the value and to "strip off" any decimal fractions that aren't wanted.
13. You can remove the decimal fraction part of a value by using the INT operation. For example, PRINT INT(15.962) would display 15 on the TV screen.

CHAPTER 5

1. Just use (press) the CLR/HOME key in the message part of the PRINT command:

```
130 PRINT "[CLR/HOME]"
```

This gives you a "reversed S" and it looks like this:

```
130 PRINT "S"
```

2. You can combine printing operations on a single line by using a semicolon after each PRINT command. For example:

```
200 PRINT "TESTING";  
220 PRINT " 1, 2, 3"
```

will print:

```
TESTING 1, 2, 3
```

on the TV screen.

3. The TAB command is used to space columns of information on the TV screen in an orderly form. The TAB(5) command moves the cursor five spaces away from the left margin.
4. You cannot move the cursor to the left with a TAB operation. Once you have done a TAB(15) operation to column 15 on the TV screen, you can't move back to column 8 on the same line with a TAB(8) operation.
5. The ON command acts like a group of IF-THEN commands. It checks a label to see if it is equal to 1, equal to 2, equal to 3, and so on.

6. The ON command would be used when integer answers of 1, 2, 3, 4, and so on are expected. These results are used to point the computer to specific line numbers in a program. If the condition is not met, the program just continues with the next following instruction.
7. The FOR-NEXT command is used to count the number of passes through a program loop. You must set the starting and final count, and you must give the loop counter a label. For example:

```
20 FOR TX = 1 TO 14
30 PRINT "*";
40 NEXT TX
```

This program would print 14 asterisks on a line on the TV display.

8. You can use almost any size steps you want to. You must specify them in the FOR part of the command with a STEP size:

```
20 FOR TX = 5 TO 200 STEP 5
```

Fractional and negative steps can be used also:

```
30 FOR GM = 1 TO 50 STEP 0.5
```

or

```
40 FOR DS = 100 TO 20 STEP-2
```

9. A nested loop is one loop within another:

```
20 FOR T = 1 TO 20
30   FOR GH = 1 TO 10
40     INPUT F
50     PRINT F*12
60   NEXT GH
70   PRINT "*"
80 NEXT T
```

10. A subroutine is a "piece" of a program that is used over and over again by different parts of a "main" program. It is easier to put the group of often-used instructions in a subroutine than to duplicate the steps everywhere they are needed in the main

program. A subroutine might be used to calculate the sales tax on several different types of sales transactions.

11. An array is a collection of similar information that has an overall label or name. It is used to store or save information that would require many different labels. Arrays are particularly useful for saving check values, game scores, test results, and so on.
12. Arrays are flexible since you can use a label as a subscript to identify a piece of information in the array. In this way, you can easily change the subscript used to point to the information. In effect, you are changing the label so it can point to new information. For example, the following program would get seven values from the array called DR and print them on the TV screen:

```
400 FOR AX = 1 TO 7  
420 PRINT DR(AX)  
440 NEXT AX
```

There is no easy way to do this with nonarray labels. The arrays used in the Commodore 64 can save up to several hundred pieces of information. If you are going to go above 11 pieces of information, INFO(0) to INFO(10), you'll need to use a dimension statement, DIM, at the start of your program.

13. The DATA statement lets you put data right in your program without labeling it. The READ statement gets the information from the DATA statement, one piece at a time, just as if it were a list of information. Once you get the information this way, you can print it, process it, or do almost anything you want with it. The RESTORE command points the computer back to the start of the DATA statement, so the READ command will get information from the start of the list again.

CHAPTER 6

1. All string labels end with a dollar sign; for example, EST\$.
2. Yes, a string of up to 89 characters can be input with an INPUT command. The INPUT command must use a string label: INPUT WET\$.
3. Strings are combined with a "plus" sign (+). This links the strings as if they were written one after another:

A\$+TR\$+"FUN"+RZ\$.

4. Yes, strings can be combined in any order you want.
5. The comma, quote, space, and colon are ignored by an INPUT command. The GET command can be used to input them in a string.
6. The most common decisions are based on comparing two strings to see if they are the same, or not the same. The greater-than and less-than comparisons don't make a lot of sense for strings.
7. The LEN command will give you the number of characters in a string, or its length. All of the characters except the quotes are counted. For example, there are seven characters in this string: "TXSD.8*"
8. The left three characters and the right six characters can be obtained from the string CAT\$ by using the LEFT\$ and RIGHT\$ operations: LS\$ = LEFT\$(CAT\$,3) and RS\$ = RIGHT\$(CAT\$,6).
9. You can get the middle five characters from G\$ = "QUESTIONS" by using the MID\$ operation: MS\$ = MID\$(G\$,3,5). This gets the middle five characters, ESTIO, starting with the third one from the left "end" of the string.
10. If the GET command is done by the computer and no key is pressed, the computer gets a "null" or "nothing" character. It has no meaning in a string and is totally ignored.
11. A six-digit, 24-hour digital clock is built in. It tells time to the nearest second and you can use it by using the TI\$ string label.
12. A real-time clock is one that continues to keep accurate time no matter what the computer is doing (unless it's turned off).
13. Yes, values and strings can be interchanged, but this only makes sense for changing values into strings of numbers, and *vice versa*. You cannot change the string "BLUE SKY" into a value.

CHAPTER 8

1. The SPC command moves the cursor to the right. The number of spaces to be moved is included in the command. The SPC command is used in a PRINT command to move the cursor.

2. The SPC command moves the cursor from its present position, while the TAB command moves the cursor based on the left edge of the display. For example, the TAB(7) command moves the cursor seven spaces to the right from the left edge of the display, while SPC(7) moves the cursor seven positions to the right *from its present position*, wherever that is.
3. When you try and use the CRSR keys while typing the “message” part of a PRINT command, special symbols are displayed on the line. This means that the computer will only move the cursor when it reaches this message in the program. Each cursor movement has its own special symbol, as shown earlier in Table 8-1.
4. There are many commands and keys that can be used — the four cursor control keys, the CLR/HOME key, the space key, and the SPC and TAB commands. There are many ways to control the position of the cursor on the TV screen.
5. The END command tells the computer that it has reached the end of a program. It is useful when there are several programs in the computer at one time. The END command prevents the computer from running from one program into the next.
6. The color of the display can be changed by using one of the color keys, located on the number keys, 1 - 8, and the CTRL or GRAPHICS keys. These color-change operations can be used in the “message” part of a PRINT command, too.
7. When the color is changed, only the cursor’s color changes. After the cursor has changed its color, anything typed or printed is shown in the new color. Information, displays, or graphics already on the TV screen are not changed.
8. You can change the color of the information to be printed by using the CTRL or GRAPHICS keys and the color keys within the “message” part of a PRINT command.
9. The RVS ON and RVS OFF keys can be used to control the printing in reverse. These can be typed directly from the keyboard, or the actions can be placed in the “message” part of a PRINT command. The computer does not stay in the reverse mode until it is changed back to the normal mode. There are several built-in computer actions that change it back. In general, you must set the reverse mode each time you need it.

10. The TV is controlled by the display and color maps. There are 40×25 , or 1000 locations in each map.
11. Special codes must be placed in *both* maps to control the TV display. The display map requires a screen code for the character to be displayed, and the color map requires a color code for the color to be used. This information must be placed in the corresponding "squares" in the map for a single location on the TV display.
12. A character can be reversed by adding 128 to its screen code. Subtracting 128 from a reversed character's screen code returns the character to normal.
13. The POKE command lets you place a code in a map, while the PEEK command lets you get a *copy* of the code from a location in a map.
14. The Commodore 64 has two sets of characters, Set 1 and Set 2, as shown in Table 8-5. Normally, Set 1 is used. You can switch from set to set by using the GRAPHICS and SHIFT keys together, or you can use the POKE 53272, 23 command to get Set 2, and POKE 53272, 21 command to get Set 1. Switching from one set to the other changes the entire display.

CHAPTER 9

1. The Commodore 64 has three separate "voices" or sources of sound.
2. Each of the voices can create four different types of sound: triangle, sawtooth, noise, and pulse.
3. Yes, you can control the volume. You can set the overall volume by using the volume control on the TV set, or you can set the volume by poking a control code (0 to 15) into the volume address (54296) in the sound map. You can also control the SUSTAIN volume of each voice.
4. Each voice can create 65,536 different tones, using codes of $HI = 0$, $LOW = 0$, to $HI = 255$, $LOW = 255$.
5. Yes, all of the tones overlap. That is, each voice is the same as the others, covering the same range of tones.
6. Noise is a collection of random sounds all mixed together. The

result is a “hiss” or “rumble,” depending on the tone codes used.

7. Yes, all of the voices can be used at the same time, but only one type of sound can be created for each voice. Some interesting effects are possible, and it can be fun to experiment with the sound part of the Commodore 64 computer.
8. There are many uses, beyond the ones we described. Sounds can call your attention to something, tell you that a limit has been reached, sound an alarm, “beep” and “bop” for games, and on and on.
9. After clearing the sound map, you must:
 - (a) Set up an overall **VOLUME**.
 - (b) Set up tone codes for the voice being used.
 - (c) Set up a **SUSTAIN** level.
 - (d) Set up the type of sound you want, and add one to its code.

You can also use the **ATTACK**, **DECAY**, and **RELEASE** codes, if you want to. Remember that if you select the *pulse* type of sound, you must provide a set of *pulse width* codes for the voice being used.

10. Different musical instruments are played by setting up various attack, decay, and release rates, along with a sustain volume. Other special sound effects can also be created by mixing several different kinds of sounds, using several voices at the same time.

APPENDIX D

SOLUTIONS TO SELECTED PROBLEMS

CHAPTER 3

Problem 3-1 Listing

```
10 INPUT "FIRST NUMBER";F
20 INPUT "SECOND NUMBER";S
30 INPUT "THIRD NUMBER";T
40 PRINT
50 PRINT "ANSWER IS";(F+S)*T
60 END
```

Problem 3-1 Sample Run

```
FIRST NUMBER? 8
SECOND NUMBER? 4
THIRD NUMBER? 5
```

ANSWER IS 60

READY.

Problem 3-3 Listing

```
1000 PRINT "HOW MANY DOLLARS DO YOU WANT TO"
1010 INPUT "CONVERT"; D
1020 PRINT
1030 PRINT "YOU WILL GET"; 2.5*D; "SWISS FRANCS"
1040 PRINT "FOR THIS"
1050 END
```

Problem 3-3 Sample Run

HOW MANY DOLLARS DO YOU WANT TO
CONVERT? 100

YOU WILL GET 250 SWISS FRANCS
FOR THIS

READY.

HOW MANY DOLLARS DO YOU WANT TO
CONVERT? 25.3

YOU WILL GET 63.25 SWISS FRANCS
FOR THIS

Problem 3-6 Listing

```
10 PRINT "HOW MUCH DOES THE FIRST PACKAGE"  
20 INPUT "WEIGHT ";FW  
30 INPUT "ITS PRICE ";FP  
40 PRINT  
50 PRINT "HOW MUCH DOES THE SECOND PACKAGE"  
60 INPUT "WEIGHT ";SW  
70 INPUT "ITS PRICE ";SP  
80 PRINT  
90 PRINT "FIRST PACKAGE COSTS"  
100 PRINT "$";FP/FW; "PER UNIT WEIGHT"  
110 PRINT  
120 PRINT "SECOND PACKAGE COSTS"  
130 PRINT "$";SP/SW;"PER UNIT WEIGHT"  
140 END
```

Problem 3-6 Sample Run

HOW MUCH DOES THE FIRST PACKAGE
WEIGHT ? 24
ITS PRICE ? 1.49

HOW MUCH DOES THE SECOND PACKAGE
WEIGHT ? 36
ITS PRICE ? 1.85

FIRST PACKAGE COSTS
\$.0620833333 PER UNIT WEIGHT

SECOND PACKAGE COSTS
\$.0513888889 PER UNIT WEIGHT

Problem 3-9 Listing

```
10 INPUT "HOW MANY DRINK CANS DO YOU HAVE";N
20 PRINT
30 PRINT "ASSUMING 14 CANS/LB AND $1.28/5 LBS"
40 PRINT
50 PRINT "YOU WILL RECEIVE $"(N/14)*(1.28/5)
60 PRINT
70 END
```

Problem 3-9 Sample Run

HOW MANY DRINK CANS DO YOU HAVE ? 300

ASSUMING 14 CANS/LB AND \$1.28/5 LBS

YOU WILL RECEIVE \$ 5.48571429

READY.

HOW MANY DRINK CANS DO YOU HAVE ? 70

ASSUMING 14 CANS/LB AND \$1.28/5 LBS

YOU WILL RECEIVE \$ 1.28

Problem 3-11 Listing

```
10 PRINT "ALL DIMENSIONS ARE IN FEET !!!"
20 PRINT
30 INPUT "LENGTH ";L
40 INPUT "WIDTH ";W
50 PRINT
60 PRINT (L*W)/43560 "ACRES"
70 END
```

Problem 3-11 Sample Run

ALL DIMENSIONS ARE IN FEET !!!

LENGTH ? 300

WIDTH ? 456

3.14049587 ACRES

READY.

ALL DIMENSIONS ARE IN FEET !!!

LENGTH ? 3028

WIDTH ? 1120

77.8549128 ACRES

Problem 3-15 Listing

```
10 PRINT "HOW MANY DOLLARS DO YOU HAVE IN THE"  
20 INPUT "BANK ";M  
30 PRINT  
40 PRINT "WHAT IS THE YEARLY INTEREST RATE "  
50 PRINT "(THIS WILL BE DIVIDED BY 12 TO GIVE "  
60 INPUT "YOU THE MONTHLY RATE) ";I  
70 MR=(I/100)/12  
80 X=1  
90 M=M+(M*MR)  
100 X=X+1  
110 IF X<13 THEN 90  
120 PRINT  
130 PRINT "YOU NOW HAVE";M;"IN THE BANK"  
140 END
```

Problem 3-15 Sample Run

HOW MANY DOLLARS DO YOU HAVE IN THE
BANK ? 100

WHAT IS THE YEARLY INTEREST RATE
(THIS WILL BE DIVIDED BY 12 TO GIVE
YOU THE MONTHLY RATE) ? 8

YOU NOW HAVE 108.299951 IN THE BANK

CHAPTER 4

Problem 4-1 Listing

```
10 INPUT "FIRST NUMBER";A  
20 INPUT "SECOND NUMBER";B  
30 INPUT "THIRD NUMBER";C  
40 IF (A<B) AND (A<C) THEN X=(B*C)/A  
50 IF (B<A) AND (B<C) THEN X=(A*C)/B  
60 IF (C<A) AND (C<B) THEN X=(A*B)/C  
70 PRINT "ANSWER";X  
80 PRINT: GOTO 10
```

Problem 4-1 Sample Run

FIRST NUMBER ? 5
SECOND NUMBER ? 6
THIRD NUMBER ? 2
ANSWER 15

FIRST NUMBER ? 8
SECOND NUMBER ? 3
THIRD NUMBER ? 6
ANSWER 16

Problem 4-3 Listing

```
10 PRINT "HOW MUCH MONEY DO"  
20 INPUT "YOU WANT TO CHANGE";M  
30 IF M<=0 THEN 10  
40 PRINT  
50 Q=0  
60 D=0  
70 N=0  
80 M=M-.25  
90 IF M<0 THEN 120  
100 Q=Q+1  
110 GOTO 80  
120 M=M+.25  
130 M=M-.10  
140 IF M<0 THEN 170  
150 D=D+1  
160 GOTO 130  
170 M=M+.10  
180 M=M-.05  
190 IF M<0 THEN 220  
200 N=N+1  
210 GOTO 180  
220 P=INT((M+.051)*100)  
230 PRINT "QUARTERS:";Q  
240 PRINT "DIMES:";D  
250 PRINT "NICKELS:";N  
260 PRINT "PENNIES:";P  
265 PRINT  
270 GOTO 10
```

Problem 4-3 Sample Run

```
HOW MUCH MONEY DO  
YOU WANT TO CHANGE? 2.39
```

```
QUARTERS: 9  
DIMES: 1  
NICKELS: 0  
PENNIES: 4
```

```
HOW MUCH MONEY DO  
YOU WANT TO CHANGE? 1.47
```

```
QUARTERS: 5  
DIMES: 2  
NICKELS: 0  
PENNIES: 2
```

Problem 4-6 Listing

```
10 A=INT(RND(1)*50)  
20 B=INT(RND(1)*50)  
30 PRINT A;" + ";B;" =";  
40 INPUT Q  
50 IF Q<>A+B THEN 30  
60 GOTO 10
```

Problem 4-6 Sample Run

```
44 + 27 =? 71
6 + 13 =? 19
12 + 10 =? 22
14 + 11 =? 20
14 + 11 =? 24
14 + 11 =? 25
10 + 45 =? 55
15 + 32 =? 47
33 + 48 =
```

Problem 4-8 Listing

```
10 Q=INT(RND(1)*100)
20 INPUT "YOUR GUESS";G
30 IF G<Q THEN PRINT "TOO LOW"
40 IF G>Q THEN PRINT "TOO HIGH"
50 IF G<>Q THEN 20
60 PRINT "THAT'S RIGHT"
70 GOTO 10
```

Problem 4-8 Sample Run

```
YOUR GUESS ? 50
TOO LOW
YOUR GUESS ? 75
TOO HIGH
YOUR GUESS ? 62
TOO HIGH
YOUR GUESS ? 56
TOO LOW
YOUR GUESS ? 59
TOO LOW
YOUR GUESS ? 61
THAT'S RIGHT
```

```
YOUR GUESS ? 50
TOO LOW
YOUR GUESS ? 75
TOO HIGH
YOUR GUESS ? 62
TOO HIGH
YOUR GUESS ? 56
TOO LOW
YOUR GUESS ? 59
THAT'S RIGHT
```


Problem 4-11 Listing

```
10 INPUT "DAY OF YEAR";N
12 IF N>31 THEN 20
14 PRINT "JANUARY";
16 GOTO 200
20 N=N-31
22 IF N>28 THEN 30
24 PRINT "FEBRUARY";
26 GOTO 200
30 N=N-28
32 IF N>31 THEN 40
34 PRINT "MARCH";
36 GOTO 200
40 N=N-31
42 IF N>30 THEN 50
44 PRINT "APRIL";
46 GOTO 200
50 N=N-30
52 IF N>31 THEN 60
54 PRINT "MAY";
56 GOTO 200
60 N=N-31
62 IF N>30 THEN 70
64 PRINT "JUNE";
66 GOTO 200
70 N=N-30
72 IF N>31 THEN 80
74 PRINT "JULY";
76 GOTO 200
80 N=N-31
82 IF N>31 THEN 90
84 PRINT "AUGUST";
86 GOTO 200
90 N=N-31
92 IF N>30 THEN 100
94 PRINT "SEPTEMBER";
96 GOTO 200
100 N=N-30
102 IF N>31 THEN 110
104 PRINT "OCTOBER";
106 GOTO 200
110 N=N-31
112 IF N>30 THEN 120
114 PRINT "NOVEMBER";
116 GOTO 200
120 N=N-30
124 PRINT "DECEMBER";
200 PRINT N
210 PRINT
220 GOTO 10
```

Problem 4-11 Sample Run

DAY OF YEAR? 1
JANUARY 1

DAY OF YEAR? 15
JANUARY 15

DAY OF YEAR? 100
APRIL 10

DAY OF YEAR? 365
DECEMBER 31

Problem 4-13 Listing

```
10 PRINT "HOW MANY CHECKS DID YOU"  
20 INPUT "WRITE THIS MONTH";NC  
40 PRINT  
50 X=1  
60 TC=0  
70 INPUT "AMOUNT OF CHECK";A  
80 TC=TC+A  
90 X=X+1  
100 IF X<=NC THEN 70  
110 PRINT  
120 PRINT "TOTAL OF CHECKS";TC  
130 PRINT  
140 X=1  
150 TD=0  
160 INPUT "NUMBER OF DEPOSITS";ND  
180 PRINT  
190 INPUT "DEPOSIT AMOUNT";D  
200 TD=TD+D  
210 X=X+1  
220 IF X<=ND THEN 190  
230 PRINT  
240 INPUT "PREVIOUS BALANCE";PB  
250 PRINT "CHECKS";TC  
260 PRINT "DEPOSITS";TD  
270 PRINT "NEW BALANCE";PB+TD-TC  
280 END
```

Problem 4-13 Sample Run

HOW MANY CHECKS DID YOU
WRITE THIS MONTH? 3

AMOUNT OF CHECK? 10
AMOUNT OF CHECK? 20
AMOUNT OF CHECK? 5

TOTAL OF CHECKS 35

NUMBER OF DEPOSITS? 2

DEPOSIT AMOUNT? 35
DEPOSIT AMOUNT? 65

PREVIOUS BALANCE? 100
CHECKS 35
DEPOSITS 100
NEW BALANCE 165

CHAPTER 5

Problem 5-1 Listing

```
100 PRINT "[SHIFT] [CLEAR/HOME]";  
110 FOR I=0 TO 23  
120 PRINT TAB(I) "[SHIFT] [M]"  
130 NEXT  
140 GOTO 140
```

Problem 5-3 Listing

```
10 PRINT "[SHIFT] [CLEAR/HOME]"  
20 PRINT "THIS MESSAGE GETS YOUR ATTENTION"  
30 FOR J=1 TO 200: NEXT J  
40 PRINT "[SHIFT] [CLEAR/HOME]"  
50 FOR J=1 TO 200: NEXT J  
60 GOTO 20
```

Problem 5-5 Listing

```
10 PRINT
20 PRINT "ADD      - 1"
30 PRINT "SUBTRACT - 2"
40 PRINT "MULTIPLY - 3"
50 PRINT "DIVIDE   - 4"
60 PRINT: INPUT "COMMAND ";C
70 C=INT(C)
80 IF (C<1 OR C>4) THEN 60
90 ON C GOSUB 200,300,400,500
95 GOTO 10
100 PRINT: INPUT "NUMBERS ";X,Y
110 RETURN
200 GOSUB 100
210 A=X+Y
220 PRINT "RESULT IS ";A
230 RETURN
300 GOSUB 100
310 A=X-Y
320 GOTO 220
400 GOSUB 100
410 A=X*Y
420 GOTO 220
500 GOSUB 100
510 A=X/Y
520 GOTO 220
```

Problem 5-5 Sample Run

```
ADD      - 1
SUBTRACT - 2
MULTIPLY - 3
DIVIDE   - 4
```

COMMAND ? 1

```
NUMBERS ? 2 , 3
RESULT IS 5
```

```
ADD      - 1
SUBTRACT - 2
MULTIPLY - 3
DIVIDE   - 4
```

COMMAND ? 3

```
NUMBERS ? 6.5 , 7.2
RESULT IS 46.8
```

Problem 5-7 Listing

```
10 FOR I=2 TO 100
20 FOR X=2 TO I
30 IF (I/X)<>(INT(I/X)) THEN 40
35 B=B+1
40 NEXT X
50 IF B=1 THEN PRINT I
60 B=0: NEXT I
70 END
```

Problem 5-7 Sample Run

```
2
3
5
7
11
13
17
19
23
29
31
37
41
43
47
53
59
61
67
71
73
79
83
89
97
```

Problem 5-9 Listing

```
10 DIM T(6)
20 FOR I=1 TO 100
30 X=1+INT(RND(0)*5.999)
40 T(X)=T(X)+1
50 NEXT
60 FOR I=1 TO 6
70 PRINT I;" : ";T(I)
80 NEXT
90 END
```

Problem 5-9 Sample Run

```
1 : 25
2 : 7
3 : 21
4 : 14
5 : 17
6 : 16
```

Problem 5-11 Listing

```
10 DIM C(52)
20 FOR I=0 TO 3
30 FOR J=1 TO 13
40 C(I*13+J)=J
50 NEXT J
60 NEXT I
70 S=INT(RND(1)*3.9999)
80 V=1+INT(RND(1)*12.9999)
90 A=C(S*13+V)
100 IF A=0 THEN 70
110 C(S*13+V)=0
120 ON S+1 GOSUB 200,210,220,230
125 PRINT TAB(10);
130 IF A=1 THEN 170
131 IF A=11 THEN 171
132 IF A=12 THEN 172
133 IF A=13 THEN 173
140 PRINT A
150 GOTO 70
170 PRINT "ACE": GOTO 70
171 PRINT "JACK": GOTO 70
172 PRINT "QUEEN": GOTO 70
173 PRINT "KING": GOTO 70
200 PRINT "SPADES: ";: RETURN
210 PRINT "HEARTS: ";: RETURN
220 PRINT "DIAMONDS: ";: RETURN
230 PRINT "CLUBS: ";: RETURN
```

Problem 5-11 Sample Run

SPADES: 10
CLUBS: 6
HEARTS: KING
SPADES: 9
SPADES: 2
DIAMONDS: 3
CLUBS: ACE
DIAMONDS: 7
CLUBS: 4
CLUBS: 5
CLUBS: KING
CLUBS: 2
CLUBS: JACK
HEARTS: ACE
HEARTS: QUEEN
SPADES: QUEEN
DIAMONDS: 10
CLUBS: 7
HEARTS: 6
HEARTS: 4
DIAMONDS: ACE
DIAMONDS: JACK
CLUBS: QUEEN
SPADES: JACK
HEARTS: 9
CLUBS: 8
HEARTS: 3
HEARTS: 5
DIAMONDS: QUEEN
CLUBS: 9
DIAMONDS: 2
HEARTS: 8
CLUBS: 3
DIAMONDS: 4
CLUBS: 10
DIAMONDS: 9
SPADES: 4
HEARTS: JACK
SPADES: 3
SPADES: ACE
HEARTS: 2
HEARTS: 7
HEARTS: 10
SPADES: 7
DIAMONDS: 6
DIAMONDS: 5
DIAMONDS: 8
SPADES: 8
SPADES: KING
SPADES: 6
DIAMONDS: KING
SPADES: 5

CHAPTER 6

Problem 6-2 Listing

```
10 PRINT: INPUT "STRING TO SPLIT";A$
20 L=LEN(A$)
30 H=INT(L/2)
40 PRINT MID$(A$,1,H)
50 PRINT MID$(A$,H+1,L-H)
60 GOTO 10
```

Problem 6-2 Sample Run

```
STRING TO SPLIT? MICROCOMPUTER
MICROC
OMPUTER
```

```
STRING TO SPLIT? SPLIT THIS STRING !
SPLIT THI
S STRING !
```

Problem 6-3 Listing

```
10 DIM N$(5), A$(5)
20 FOR X = 1 TO 5
30 PRINT
40 INPUT "NAME"; N$(X)
50 INPUT "AGE"; A$(X)
60 NEXT X
70 PRINT: INPUT "NAME OR AGE"; B$
80 K = 1
90 IF B$ = N$(K) THEN PRINT "AGE IS "; A$(K): GOTO 70
100 IF B$ = A$(K) THEN PRINT "NAME IS "; N$(K): GOTO 70
110 K = K + 1: IF K<6 THEN 90
120 PRINT "NO SUCH PERSON!": GOTO 70
```


Problem 6-3 Sample Run

NAME? WENDY
AGE? 19

NAME? BILL
AGE? 34

NAME? LOIS
AGE? 33

NAME? HENRY
AGE? 23

NAME? MARGARET
AGE? 36

NAME OR AGE? WENDY
AGE IS 19

NAME OR AGE? 23
NAME IS HENRY

NAME OR AGE? JIM
NO SUCH PERSON!

NAME OR AGE? 45
NO SUCH PERSON!

Problem 6-5 Listing

```
5 DIM S$(50)
10 PRINT: PRINT: PRINT "STRING TO": INPUT "SCRAMBLE";W$
20 L=LEN(W$)
30 FOR I=1 TO L
40 S$(I)=MID$(W$,I,1)
50 NEXT
60 FOR I=1 TO L
70 Z=INT(RND(1)*(L+.999))
80 IF S$(Z)="" THEN 70
90 PRINT S$(Z);: S$(Z)=""
100 NEXT
110 B$="": PRINT: PRINT "? ";
120 FOR I=1 TO L
130 GET A$: IF A$="" THEN 130
140 PRINT A$;: B$=B$+A$
150 NEXT
160 IF B$=W$ THEN 10
170 PRINT: PRINT "TRY AGAIN": GOTO 110
```

Problem 6-6 Listing

```
100 L=(40-LEN(A$))/2
110 PRINT TAB(L) A$
120 RETURN
```

Problem 6-7 Listing

```
10 INPUT "STRING TO USE";A$
20 PRINT
30 FOR K=1 TO LEN(A$)
40 PRINT MID$(A$,1,K)
50 NEXT
60 PRINT: GOTO 10
```

Problem 6-7 Sample Run

STRING TO USE? ORANGE

```
O
OR
ORA
ORAN
ORANG
ORANGE
```

STRING TO USE? MICROCOMPUTER

```
M
MI
MIC
MICR
MICRO
MICROC
MICROCO
MICROCOM
MICROCOMP
MICROCOMPU
MICROCOMPUT
MICROCOMPUTE
MICROCOMPUTER
```

Problem 6-9 Listing

```
10 DIM S$(5)
20 FOR I=1 TO 5
30 PRINT "STRING";I;: INPUT S$(I)
40 NEXT
50 FOR I=1 TO 5
60 T$="ZZZZZ"
70 FOR J=1 TO 5
80 IF S$(J)<T$ THEN T$=S$(J)
90 NEXT
100 FOR G=1 TO 5
110 IF S$(G)=T$ THEN S$(G)="ZZZZZ"
120 NEXT
130 PRINT T$
150 NEXT
160 END
```

Problem 6-9 Sample Run

```
STRING 1 ?HOUSE  
STRING 2 ?DOORMAT  
STRING 3 ?KITCHEN  
STRING 4 ?HALLWAY  
STRING 5 ?WINDOW  
DOORMAT  
HALLWAY  
HOUSE  
KITCHEN  
WINDOW
```

Problem 6-10 Listing

```
10 DATA "JANUARY",31  
20 DATA "FEBRUARY",28  
30 DATA "MARCH",31  
40 DATA "APRIL",30  
50 DATA "MAY",31  
60 DATA "JUNE",30  
70 DATA "JULY",31  
80 DATA "AUGUST",31  
90 DATA "SEPTEMBER",30  
100 DATA "OCTOBER",31  
110 DATA "NOVEMBER",30  
120 DATA "DECEMBER",31  
130 INPUT "DAY";D  
140 READ M$,A  
150 IF D>A THEN D=D-A: GOTO 140  
160 PRINT M$;D: RESTORE: GOTO 130
```

Problem 6-11 Listing

```
10 PRINT: INPUT "INPUT A NUMBER";N  
20 N$=STR$(N)  
30 L=LEN(N$)-1  
40 B$=""  
50 K=0  
60 B$=MID$(N$,L+1,1)+B$  
70 L=L-1: IF L=0 THEN 110  
80 K=K+1: IF K<3 THEN 60  
90 B$=","+B$  
100 GOTO 50  
110 PRINT B$: GOTO 10
```

Problem 6-11 Sample Run

```
INPUT A NUMBER? 1
1

INPUT A NUMBER? 12
12

INPUT A NUMBER? 123
123

INPUT A NUMBER? 1234
1,234

INPUT A NUMBER? 12345
12,345

INPUT A NUMBER? 123456
123,456

INPUT A NUMBER? 1234567
1,234,567
```

Problem 6-13 Listing

```
10 INPUT "MESSAGE";M$
20 L=LEN(M$)
30 M$=M$+" [4 SPACES] "+M$
40 PRINT "[SHIFT] [CLEAR/HOME]";
50 I=1
60 PRINT MID$(M$,I,39)
70 FOR K=1 TO 300: NEXT
80 PRINT "[SHIFT] [CLEAR/HOME]";
90 I=I+1: IF I=L+5 THEN 40
100 GOTO 60
```

Problem 6-14 Listing

```
10 PRINT: PRINT "HOW MANY TIME DELAYS"
20 INPUT "WOULD YOU LIKE";N
30 DIM A$(N)
40 FOR I=1 TO N
50 PRINT "DELAY ";I;: INPUT B$
60 A$(I)=RIGHT$("000000"+B$,6)
70 NEXT
80 FOR I=1 TO N
90 TI$="000000"
100 IF TI$<A$(I) THEN 100
110 PRINT "TIME";I;"HAS ELAPSED"
120 NEXT
130 END
```

CHAPTER 7

Problem 7-3 Listing

```
300 PRINT "ANGLE
305 FOR I=0 TO 350 STEP 10
310 A=(I/360)*2*3.14159
320 PRINT I,SIN(A)
330 NEXT
340 END
```

SIN"

Problem 7-3 Sample Run

ANGLE	SIN
0	0
10	.173648033
20	.342019866
30	.499999598
40	.642787158
50	.766043969
60	.866024962
70	.939692268
80	.984807548
90	1
100	.984808009
110	.939693175
120	.866026288
130	.766045674
140	.64278919
150	.500001915
160	.342022359
170	.173650645
180	2.65227048E-06
190	-.17364542
200	-.342017373
210	-.49999732
220	-.642785126
230	-.766042265
240	-.866023636
250	-.93969136
260	-.984807088
270	-1
280	-.984808469
290	-.939694083
300	-.866027614
310	-.76604738
320	-.642791222
330	-.500004212
340	-.342024853
350	-.173653257

Problem 7-5 Listing

```
2000 PRINT "ANGLE          TAN          SIN/COS"
2010 INPUT A
2020 PRINT A,
2030 A=(A/360)*2*3.14159
2040 PRINT TAN(A), SIN(A)/COS(A)
2050 GOTO 2010
```

Problem 7-5 Sample Run

ANGLE	TAN	SIN/COS
10	.176326829	.176326829
60	1.73204727	1.73204727
130	-1.19175823	-1.19175823
190	.176324093	.176324093
230	1.19174539	1.19174539
305	-1.42816167	-1.42816166
355	-.0874939371	-.0874939371

CHAPTER 8

Problem 8-1 Listing

```
10 POKE 53281,5
```

Problem 8-3 Listing

```
10 X=20: PRINT "[SHIFT] [CLEAR/HOME]"
20 D=1-INT(RND(1)*2.9999)
30 POKE 1024+X,32: REM WIPE OUT PREVIOUS DIAMOND
40 X=D+X : REM CALCULATE NEW POSITION
45 REM MAKE SURE THAT WE DON'T EXCEED THE SCREEN LIMITS
50 IF X<0 THEN X=0
60 IF X>39 THEN X=39
65 REM POKE THE CHARACTER THEN THE COLOR
70 POKE 1024+X,90: POKE 55296+X,0
80 FOR J=1 TO 100: NEXT
90 GOTO 20
```

Problem 8-6 Listing

```
10 PRINT "[SHIFT] [CLEAR/HOME]"
20 X=0: Y=0
30 FOR X=0 TO 38.5
40 GOSUB 300
50 NEXT
60 FOR Y=0 TO 23.5
70 GOSUB 300
80 NEXT
90 FOR X=39 TO 0.5 STEP -1
100 GOSUB 300
110 NEXT
120 FOR Y=24 TO 0.5 STEP -1
130 GOSUB 300
140 NEXT
150 GOTO 10
300 S=1024+X+(Y*40)
310 C=55296+X+(Y*40)
320 POKE S,42
330 POKE C,2
340 FOR J=1 TO 20: NEXT
350 POKE S,32
360 RETURN
```

Problem 8-9 Listing

```
10 X=20: Y=12
20 INPUT A$
30 A=ASC(A$)-64
35 PRINT "[SHIFT] [CLEAR/HOME]";
40 P=X+Y*40
50 S=1024: C=55296
60 POKE S+P,A: POKE C+P,0
70 GET A$: IF A$="" THEN 70
80 B=ASC(A$)
90 IF B=17 THEN Y=Y+1
100 IF B=29 THEN X=X+1
110 IF B=145 THEN Y=Y-1
120 IF B=157 THEN X=X-1
130 IF X<0 THEN X=0
140 IF X>39 THEN X=39
150 IF Y<0 THEN Y=0
160 IF Y>24 THEN Y=24
170 POKE S+P,32
180 GOTO 40
```

Problem 8-11 Listing

```
10 X=20:S=0: PRINT "[SHIFT] [CLEAR/HOME]"
20 POKE 1984+X,30: POKE 56256+X,0
30 GET A$: IF A$<>" " THEN 90
40 IF S=0 THEN 30
50 POKE D+P,32
60 D=D-40: DC=DC-40
70 IF D<1024 THEN S=0: GOTO 30
80 POKE D+P,42: POKE DC+P,1: GOTO 30
90 IF A$<>"V" THEN 120
100 POKE 1984+X,32: X=X-1: IF X<0 THEN X=0
110 GOTO 140
120 IF A$<>"N" THEN 150
130 POKE 1984+X,32: X=X+1: IF X>39 THEN X=39
140 POKE 1984+X,30: POKE 56256+X,0: GOTO 40
150 IF S=1 THEN 30
160 P=X: S=1: D=1944: DC=56216: GOTO 50
```

Problem 8-13 Listing

```
10 PRINT "[SHIFT] [CLEAR/HOME]"; X=0
20 Y=INT(RND(1)*23) :REM GET RANDOM Y POSITION
30 FOR X=0 TO 39 :REM X POSITION
40 POKE 1024+X-1+(Y*40),32 :REM CLEAR PREVIOUS ASTERISK
50 POKE 1024+X+(Y*40),42 :REM POKE THE ASTERISK
60 POKE 55296+X+(Y*40),0 :REM POKE THE COLOR (BLACK)
70 FOR J=1 TO 10: NEXT J :REM WAIT A LITTLE
80 NEXT :REM GENERATE A NEW X POSITION
90 GOTO 10 :REM DO ANOTHER LINE
```

CHAPTER 9

Problem 9-1 Listing

```
10 FOR AD = 54272 TO 54296: POKE AD,0: NEXT
20 GET A$: IF A$ = " " THEN 20
30 A = VAL(A$) + 1
40 FOR J = 1 TO A: READ H, L: NEXT
50 POKE 54296, 15 :REM HIGHEST VOLUME
60 POKE 54273, H: POKE 54272, L: REM HI/LO VALUES
70 POKE 54278, 240 : REM SUSTAIN VALUE
80 POKE 54276, 17 : REM TRIANGLE
90 RESTORE: GOTO 20
100 DATA 30, 141, 32, 94, 34, 75, 36, 85, 38, 126
110 DATA 40, 200, 43, 52, 45, 198, 48, 127, 51, 97
```


Problem 9-3 Listing

```
10 DIM A(50): K=0
20 FOR AD=54272 TO 54296: POKE AD,0: NEXT
30 INPUT "NOTE VALUE";X
40 IF X=0 THEN 60
50 A(K)=X: K=K+1: GOTO 30
60 FOR J=0 TO K
70 H=INT(A(J)/256): L=INT(A(J)-H*256)
80 POKE 54296,15: REM VOLUME AT HIGHEST LEVEL
90 POKE 54273,H: POKE 54272,L: REM HIGH AND LOW FREQUENCY
100 POKE 54278,240: REM SUSTAIN VALUE
110 POKE 54276,17: REM TRIANGLE
120 FOR G=1 TO 200: NEXT
130 NEXT
140 GOTO 60
```

Problem 9-6 Listing

```
10 FOR AD=54272 TO 54296: POKE AD,0: NEXT
20 X=INT(RND(1)*65535)
30 H=INT(X/256): L=INT(X-(H*256))
40 POKE 54296,15: REM VOLUME AT HIGHEST LEVEL
50 POKE 54273,H: POKE 54272,L: REM HIGH AND LOW FREQUENCY
60 POKE 54278,240: REM SUSTAIN VALUE
70 POKE 54276,17: REM TRIANGLE
80 A=RND(1)*1000
90 FOR G=0 TO A: NEXT
100 GOTO 20
```

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