Commodore 128®
Troubleshooting & Repair

John Heilborn

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Trademark Acknowledgments

*This book is dedicated to my wife Sharon,
our daughter Magda, and our son Andrew.*

Contents

Preface

This book has been written as a guide for both experienced and inexperienced users who want to repair their Commodore 128. In it you will find:

- A description of the various subsystems and how they work together
- The use of test equipment and troubleshooting techniques
- Circuit component descriptions and characteristics
- Troubleshooting guides arranged by trouble symptoms
- Preventive maintenance procedures to keep your C128 operating.

Chapter 1 is an overview of the Commodore 128, covering what it does and how it does it. Additionally, it discusses the components used on the circuit board, how they work, and how to identify them.

Chapter 2 is an in-depth discussion of the Commodore 128, covering all of its internal systems and subsystems. In it, you will learn about the basic operation of each part of the computer and how the various parts interact.

Chapter 3 is a guide to basic troubleshooting techniques. It shows you how to isolate subsystems from the computer and how to track down defective components. It also provides a complete description of each of the more commonly used troubleshooting tools, and shows how to use them.

Chapter 4 covers logic devices and their operation. The concepts of AND, OR, NAND, and NOR circuits as well as buffers, inverters, flip flops, RAMs, ROMs, and other devices are described.

Chapters 5 through 8 are the troubleshooting chapters. Here the system is broken down into operating subsystems, each of which is looked at from a troubleshooting standpoint. In these chapters you will find extensive failure mode descriptions and complete troubleshooting guides.

Chapter 9 covers preventive maintenance. In it you will learn how to avoid the more common problems that can shorten the life of the components in your computer. It also covers maintenance and trouble-avoidance techniques for most of the common Commodore 128 peripheral devices such as disk drives and printers.

The appendices include charts and diagrams of the various parts of the Commodore 128. Here you will find system specifications, board layouts, port pinout diagrams, and pinouts of the most common integrated circuits used in the Commodore 128 and its peripherals. A comprehensive glossary completes the book.

JOHN HEILBORN

Introduction:
A New Generation

Years ago, before Silicon Valley had gained its reputation as the "Microcomputer Valley," I had a job working on some of the very first video game machines. In those days, investors for budding electronics firms were hard to find, and as a result, our engineering "laboratories" were actually a corner of a huge dirt-floored cardboard container warehouse.

The lab benches were laid out in a row along one of the walls of the warehouse. And, in the path that separated our tiny domain from the mountainous rows of stacked, flattened, cardboard boxes, rumbled the most enormous fork lifts I had ever seen. Their drive wheels alone towered above the flimsy plywood frames that held our oscilloscopes. Had that time not predated the famous space war films, I might have easily expected a half-mechanical fork-lift driver (possibly named Darth) to step out from a door on the side of one of the fork lifts, walk over, and smash my bench for a lark. But as it turned out, the daily tremors from the passing fork lifts did their share of damage anyway, frequently sending clouds of dirt and occasional boxing staples into our circuits.

One day a number of us were puzzling over how to produce just the right sound for our video "tank." It was supposed to sound like a powerful engine roaring for battle—it actually sounded like a playing card that had been clothespinned to the training wheels of a small bicycle.

Just as we were about to give up for the day, a fork lift spun around roughly five feet from our bench and, hoping, I guess, to make a corner without toppling over (some of the drivers fancied the warehouse was the Indianapolis speedway), lowered its lift arm and became unbalanced. It didn't topple, but it dropped about three tons of boxes no more two feet from our bench, sending boxes, dirt, and one fateful staple right into the first stage amplifier of our circuit.

First there was a "BLAAAAAT" sound, a puff of smoke, the familiar smell of burning semiconductors and then—something none of us expected—our circuit was making a sound like an engine!

Somehow the staple had managed to "zap" one of the transistors in the amplifier just enough to make the circuit produce a wonderful, raspy sound instead of the plain old clicking that it had frustrated us with for weeks. But how had it happened? And could we reproduce it?

For the next few days we spent our time deliberately murdering transistors. In those experiments, we came to understand the nature of transistors more intimately than we had ever imagined. We learned about the stress that a tiny chip of silicon or germanium can handle, and in the process, we learned how to bring life into circuits that had seemingly died. We used our components like artists, carefully sculpting the sounds that our amplifiers produced until they were perfect.

Years later, a friend of mine came to visit me one evening, his computer tucked gently under his arm.

"It's dead, isn't it," he sighed.

"Computers don't die," I told him, as I led him into my lab. In about two hours we had figured out what was wrong and fixed the problem. From that time on, he would frequently stop by evenings with this or that circuit board or clever electronic device that had somehow stopped working. Frankly, I think he'd go to the electronic junk stores just to find the "really broken stuff."

This book is a product of all those evenings with the crazy circuits and the years that preceded them—especially the time in the paper box warehouse. Through those years I learned that to fix a circuit you have really to understand what makes it "tick."

In this book we'll look at the parts of a Commodore 128 and how they work. In the process, we'll examine the things that can go wrong, why they go wrong, and what you can do if you want to set things straight.

1

A Look at the Commodore 128

The Commodore 128 has three unique operating modes: Commodore 64 mode, Commodore 128 mode, and CP/M mode. The reason for the three operating modes can be explained in one word —software. The more software a computer can use, the more useful that computer becomes. Unfortunately, most new computers enter the world with little or no software written for them and, until software becomes available, the computers are of little use. By including two extra operating systems (Commodore 64 and CP/M) in the Commodore 128, Commodore opened up a vast supply of available software for the new computer when it was introduced.

In Commodore 64 mode, the Commodore 128 emulates the Commodore 64, displaying 40 columns of characters in sixteen colors as well as several graphics modes. These include bit-mapped graphics and sprites (moveable, programmable graphic shapes). In this mode, the Commodore 128 can run the vast library of programs written for the Commodore 64.

The Commodore 128 mode is an enhanced Commodore 64 mode which includes all of the features of the Commodore 64 plus an improved BASIC language (with more than 140 commands), a full-color 80-column mode, a built-in machine-language monitor, an extended keyboard, a high speed disk drive capability, and maximum memory expansion of 655,360 bytes (ten times that of the Commodore 64).

CP/M was, until the introduction of MS-DOS, the most popular operating system for microcomputers. As a result, there are literally thousands of programs available that run under CP/M; most of them are business programs.

The CP/M mode utilizes a second microprocessor in the Commodore 128, called a Z80. In CP/M mode the Z80 runs all of the software in the computer and the 8502 (the Commodore 128's main microprocessor) is used to run all of the peripheral devices such as the printer, video display, and so on.

SYSTEM DESIGN

The Commodore 128 is a dual-microprocessor, single-board computer which uses a Z80 and an 8502 microprocessor. It includes 131,072 bytes of RAM memory (128K) which may be expanded to 655,360 bytes (640K).

Unlike is predecessor, the Commodore 64, which had a 66-key keyboard, the Commodore 128 has a full 92-key keyboard which includes an industry standard Qwerty style typewriter keyboard, a full ten-key keypad, eight function keys, and separate Up/Down/Left/Right/ cursor keys.

Along the rear and the right side of the Commodore 128 (Fig. 1-1) are a total of ten connectors and three switches. These include:

1. Controller ports
2. Reset switch
3. Power switch
4. Power connector
5. Cartridge/expansion port
6. Cassette port
7. Serial I/O port
8. Composite video port
9. TV channel (3/4) switch
10. TV video port
11. RGBI video port
12. User port

Controller Ports

The controller ports (labeled 1 in Fig. 1-1A) were originally designed for game use and accepted commands from a joystick or a paddle controller. On the Commodore 128 they are called Control Port 1 and Control Port 2 because, unlike the earlier "game ports", these ports will accept a mouse, light pen, joystick, paddle controller, track ball, or accessory keyboard. In fact, almost any kind of "controlling" device you can imagine can be connected to these parts.

Reset Switch

The Reset switch (2 in Fig. 1-1A) is a " button of last resort". Pressing this switch will halt any program that is running on the Commodore 128 and return the computer to its "power-up" state. You should use this switch only in case of emergency (i.e., if the computer is stuck doing something—or nothing obvious, and will not respond to any normal input such as the keyboard).

Power Switch

The power switch (3 in Fig. 1-1A) turns power on and off to the computer. *Do not* confuse this with the Reset switch. You should never use the power switch to reset the computer unless *nothing else works!* Repeatedly cycling the power to the computer with the power switch will subject the system to undue stress and shorten the life of the electronic circuits.

Power Connector

The square connector on the right side of the computer (4 in Fig. 1-1A) carries all of the power to the system. To avoid accidentally shorting across any of the connector pins on this cable, *never* plug the power supply cable into the wall outlet until the square connector is plugged into the computer. Also, beware: although the connector is keyed to make it difficult to incorrectly insert it into the socket, it can be overcome. *Never force any connectors into their sockets.*

Cartridge/Expansion Port

The cartridge/expansion port (5 in Fig. 1-1B) contains all of the memory and control lines from the computer. It is most often used for either memory expansion or cartridge programs. However, it may be programmed and used for custom applications as well.

Cassette Port

The cassette port (6 in Fig. 1-1B) interfaces the Commodore 128 to a Commodore cassette player. In addition to data lines, the port includes power for both the cassette player and motor control lines.

Serial I/O Port

The serial I/O port (7 in Fig. 1-1B) is used to connect most of the standard Commodore peripheral devices, including the disk drive(s), printers, and plotters, to the Commodore 128. Although it is

(A) Right side view.

(B) Rear view.
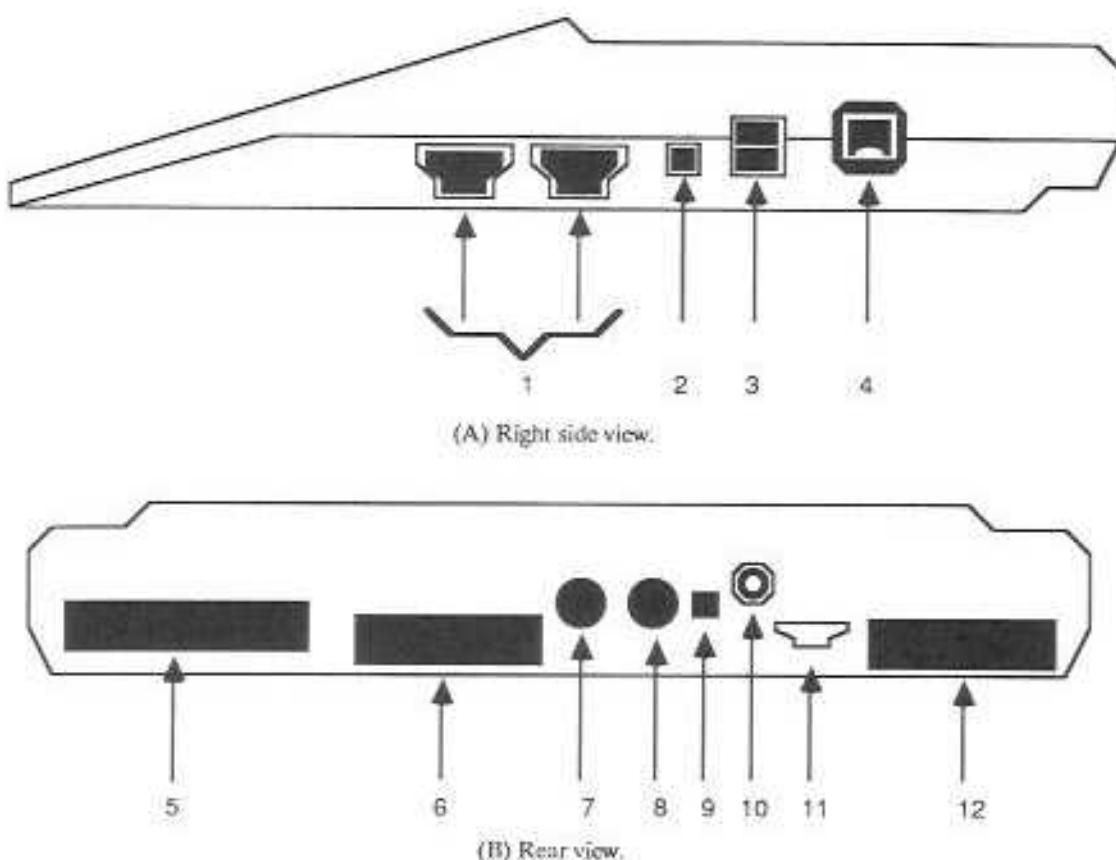
Fig. 1-1. Commodore 128 connector and switch locations.

called a serial port, it is not compatible with the industry standard RS232 serial interface.

Video Ports

The Commodore 128 has three different video ports: the composite video port, the TV video port, and the RGBI port. These are labeled 8, 10, and 11 respectively in Fig. 1-1B.

TV video is RF (radio-frequency) modulated which means it is the same kind of signal that is broadcast over the air. The difference, of course, is that the signal is sent to the television through a wire instead of an antenna. Therefore, the signal from the TV video port and can be viewed through any standard television. Note: This video signal is set up for channel 3 or 4 (depending upon a switch setting).

Composite video is a video signal similar to TV video, but it is not RF modulated and can only be viewed with a video monitor. Do not mistake the composite video port for the serial port which is just to its left.

RGBI (Red-Green-Blue-Intensity) video is quite different from either composite or TV video. Instead of providing a signal which includes all of the video and color information together (composite video), it supplies separate signals which are fed directly to the red, green, and blue electron guns in the video display. In addition, the "I" (intensity) signal tells the monitor how bright to display a given color.

TV Channel Switch

The TV channel (9 in Fig. 1-1B) is labelled L/H. It switches the TV video signal coming from the computer between channels 3(L) to 4(H). You should select the channel that is not used (or weakest) in your area. This will usually produce the clearest image on your screen.

User Port

The user port (12 in Fig. 1-1B) has the necessary logic signals to produce a parallel port or an RS-232 serial port. Be aware, however, that the signals, as they emerge from this connector, are not the correct voltage levels for the standard RS-232. Some of the signal lines have inverted logic (provide a positive signal when a standard device would be looking for a negative signal) and, instead of having a voltage swing of 0 to 12 volts, it provides 0 to 5 volts. If you want to use this port to interface to a standard RS-232 device, you will need to get (or make) a converter, and you will probably need to get or write your own serial driver software routines.

INTRODUCTION TO TROUBLESHOOTING TECHNIQUES

To begin with, you do not need to understand anything about computers to use this book and to repair your computer. The only assumptions made are that you are reasonably handy and that you want to fix your computer. I'll discuss the use of any tools you'll need as we come to them. Also, if you ever "trip" over any of the terms in the book, don't panic! In almost every case I'll describe what things are and/or how they work right on the spot. However, if you find something that isn't explained to your satisfaction, flip to the back of the book and check the glossary.

Indentifying Electronic Components

The components that go into the Commodore 128 and its peripherals can be divided into two categories: mechanical components and electronic components. Mechanical components are usually pretty easy to identify since their functions are typically obvious from their design. For example, a belt might be identified as: " . . . geared belt that goes around the two drive gears on the left side of the paper feed motor on the printer." Unfortunately, electronic components are not always so obvious. An electronic component might be simply identified as "U25" or a "7406." Also, in

some cases, it is difficult to determine which resistor has a value of 220 ohms (assuming that you know which of the devices *is* a resistor).

In this section, we'll take a look at the kinds of components that you may run into, what they look like, and how to determine what their values are . . . if they have any.

Resistors

Figure 1-2 shows three different types of resistors. Although they look different, they serve the same function— they provide electrical resistance in a circuit. The measure of electrical resistance is the ohm which is represented by the symbol "Ω" (the Greek letter omega).

Notice that the resistors in Figs. 1-2A and B look like small, banded cylinders. Every resistor has a resistance value and that value determines its affect on the rest of the circuit. The bands are color-coded with the resistor's resistance value. Table 1-1 shows the standard resistor color codes for carbon composition resistors (the most commonly used type).

Table 1-1. Resistor Color Codes

Color	Bands 1 & 2 Significant Digits	Band 3 Multiplier	Band 4 Tolerance
Black	0	1	20%
Brown	1	10	1%
Red	2	100	2%
Orange	3	1,000	3%
Yellow	4	10,000	4%
Green	5	100,000	-
Blue	6	1,000,000	-
Violet	7	10,000,000	-
Grey	8	-	-
White	9	-	-
Gold	-	0.1	5%
Silver	-	0.01	10%
None	-		20%

To determine the value of a resistor, view it horizontally. Notice that the bands are grouped so they are closer to one end of the resistor than the other in Fig. 1- 3. On some resistors, the bands will be spread out across the entire resistor body, and on others the band labeled "Band D" in Fig.

(A) Carbon composition.

(B) Carbon film resistor.

(C) Ceramic high-current resistor.
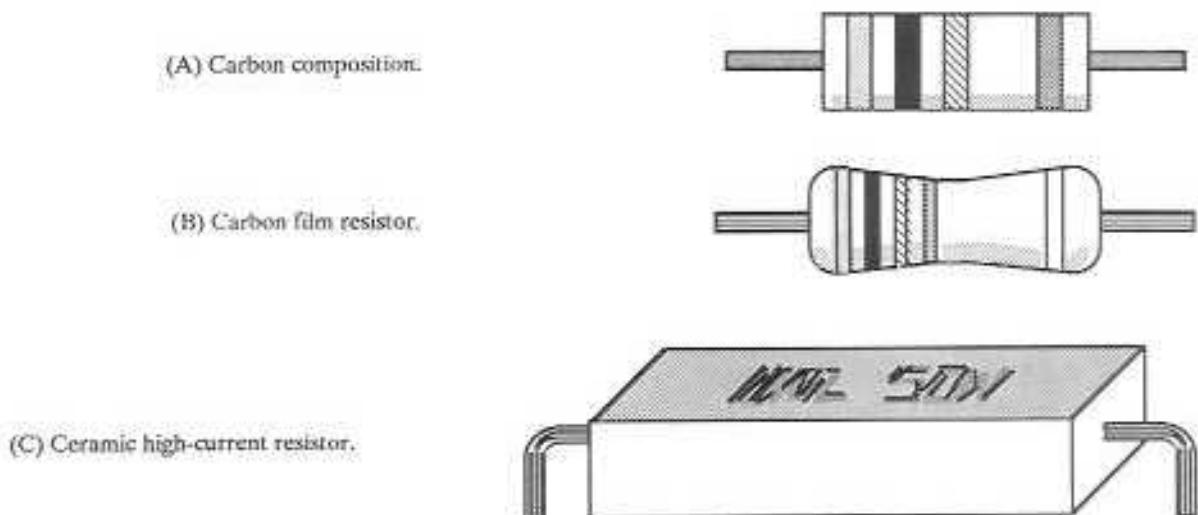
Fig. 1-2. Types of resistors.

1-3 will be moved over next to the other bands. Regardless of the positions, the result is the same. Position the resistor so the bands are nearer to the left end of the resistor. In this position, the band that is furthest left is band 1, the band to the right of 1 is 2, and so on.

To read the resistance, determine the values indicated by the colors of bands 1 and 2 and multiply by the value of band 3. For example, to determine the resistance of a resistor whose bands are yellow (4), violet (7), and brown (10), take the first two digits (47) and multiply that by the third (10). This makes the resistor 470 ohms (47 × 10 = 470).

The Fourth Band

Some of the resistors on the Commodore 128 have a fourth band. This is the tolerance band. A three-band resistor such as the one we just discussed may have an actual resistance that is as much as 20% above or 20% below its coded value. For example, our 470-ohm resistor may actually have a resistance as low as 376 ohms or as high as 564 ohms. If the fourth band is gold, the resistor has a tolerance of 5%, that is, its actual value will be between 446.5 ohms and 493.5 ohms. If the fourth band is silver, the resistor has a tolerance of 10% (its value will be between 423 and 517 ohms).

Band A
Band B
Band C
Band D
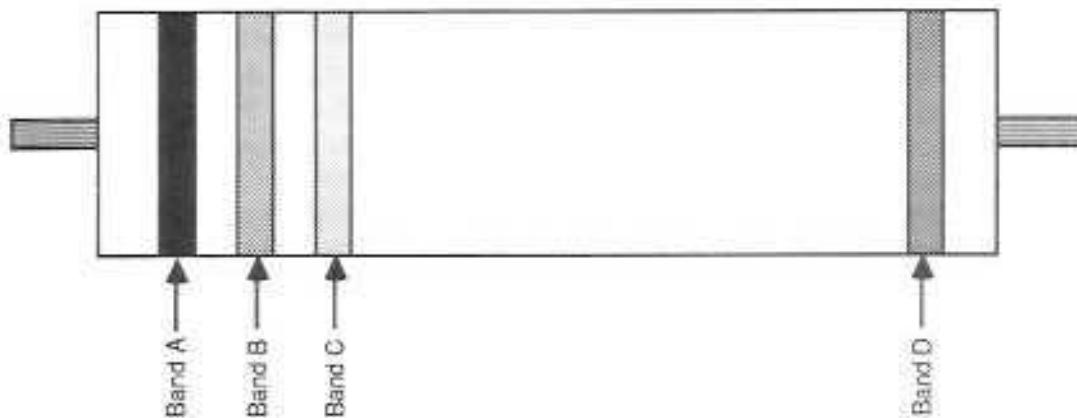
Fig. 1-3. Location of color code bands on carbon composition resistors.

Precision Resistors

Occasionally you will find a resistor whose the fourth band is neither silver or gold. These resistors usually have a closer tolerance (often 1%) and the value is coded to three significant figures. Most resistors of this type look like the one in Fig. 1-2B; however, they can look like Fig. 1-2A. When such coding is used, the first three bands determine the three significant digits of the resistor value. The fourth band then becomes the multiplier. Thus, for a resistor with bands coded red, red, red, and brown, the first three bands translate to 222 and the fourth (multiplier) band is ×10, so the resistance is 2220 ohms. For this type resistor, the tolerance band is usually separated from the others as shown in Figs. 1-2B and 1-3, but it can be adjacent to the other bands.

Numeric Designators

The resistor shown in Fig. 1-2C does not use color coding to indicate its resistance. Instead, it is printed with a numeric designator. One example of a numeric designator is 4.3 kΩ. The letter "k" is an abbreviation of the metric term "kilo" and means thousand. Therefore the number 4.3 kΩ translates into 4300 ohms. Once again, the symbol that follows the number is the Greek letter omega, which is used to represent the word "ohms" which is the unit of measurement for resistance.

Occasionally you may find a resistor with the letter M following a number such as 2.2 MΩ. The letter "M" is an abbreviation of the metric term "Mega" and means million. Therefore 2.2 MΩ means 2,200,000 ohms.

Variable Resistors

Variable resistors are resistors that can be adjusted to any resistance value within a specified range. This is the kind of control device you'll find inside your paddle controllers. They are also called potentiometers, pots, and rheostats. Sometimes the upper value of a variable resistor is simply printed on its side, back, or face using numeric designators (as we have described). The value printed on the device indicates the highest resistance that can be obtained using that resistor. So for example, a potentiometer with the value of 1 kΩ can be adjusted from 0 to 1000 ohms. Often no value is included on potentiometers—only a part number is stamped on it.

Capacitors

The devices in Fig. 1-4 are capacitors. The unit measure of capacitance is the farad. Actually, the farad is such an enormous amount of capacitance that most capacitors are measured in microfarads, nanofarads, or picofarads—one millionth, one billionth, and one trillionth of a farad, respectively.

There are two major kinds of capacitors —polarized and nonpolarized. Polarized capacitors are labelled + and – and must be inserted into their circuits with the appropriate leads connected to the positive (+) and negative or ground (–) lead respectively. Failure to do this will result in a malfunction of the circuit and can even cause the capacitor to explode!

Figure 1-5 shows a detail of several polarized capacitors. Notice that each of them is labelled with either a (+) or (–) on one or the other of its leads.

Nonpolarized capacitors may be inserted into their circuits in any orientation. In general, the lower-value capacitors are not polarized and the higher-value capacitors are polarized. To be sure, however, always look closely at the capacitor. Polarized capacitors will have a (+) or (–) indicator near one of its leads or terminals.

Capacitor Values

As mentioned earlier, capacitors are usually measured in microfarads or picofarads. The abbreviation for microfarads is μF (occasionally you will also see uF or mfd). The funny looking character in the first example is the Greek letter mu and represents 1/1,000,000. The abbreviation for picofarads is pF. The letter p represents pico which means 1/1,000,000,000,000. Although not as common, you will also see capacitor values expressed in nanofarads (abbreviated nF), which stand for 1/1,000,000,000.

Larger capacitors are almost always labelled with their values; they do not use special codes. In other words, a 100-microfarad capacitor will be labelled 100 μF. Unfortunately, smaller value capacitor labels are often a bit cryptic. (Several color codings and other labels are used.) To determine the capacitor value in these instances, refer to the circuit schematic or parts list.
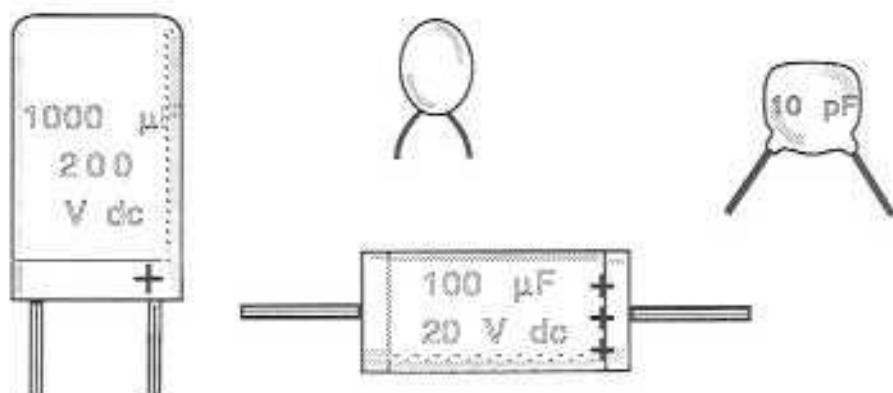
Fig. 1-4. Types of capacitors.
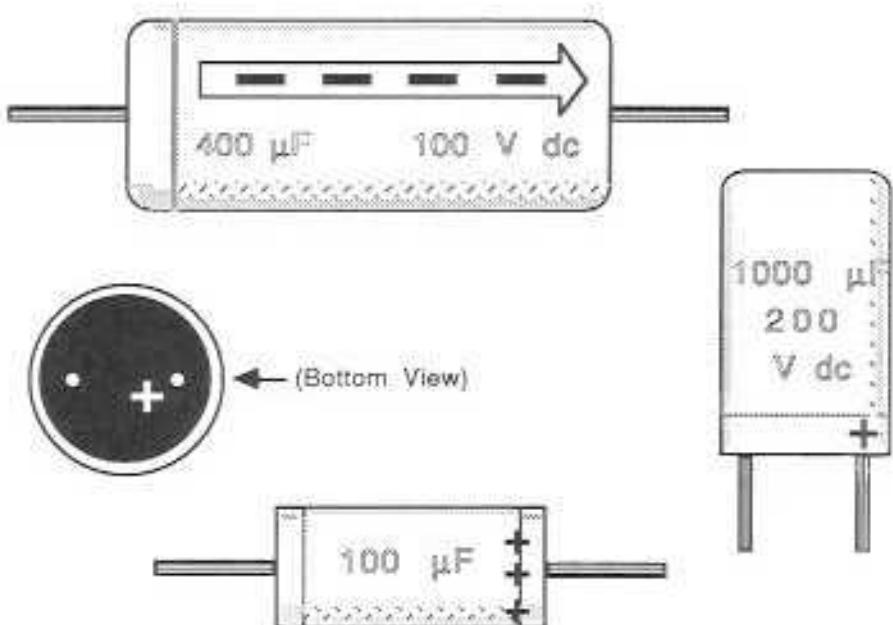
Fig. 1-5. Polarized capacitors.

(Bottom View)

Transistors

Transistors are three-legged devices. On bipolar transistors (the kind most commonly used in computers), the three legs are called the emitter, the collector, and the base (often labelled E, C, and B). Figure 1-6 shows some of these transistors.

Notice that the E, C, and B legs are not always in the same places. To insert a transistor correctly it is important to refer to the circuit diagram and the basing diagram. Make sure that you are inserting the parts into the circuit correctly. Failure to do this can result in damage to your computer.

Integrated Circuits

Integrated circuits, also called ICs are complex circuit subsystems that are used as logical modules in larger circuits. Figure 1-7 shows a number of integrated circuits.

Notice that the integrated circuits pictured at the 1-7 have two rows of leads. These leads are numbered. To determine the lead numbers, look for a crescent-shaped or similar mark on one end of the integrated circuit. Place this to your left and the lower left lead is lead number 1 (Fig. 1-8A). The leads are numbered counterclockwise from number 1, therefore the lower right-hand
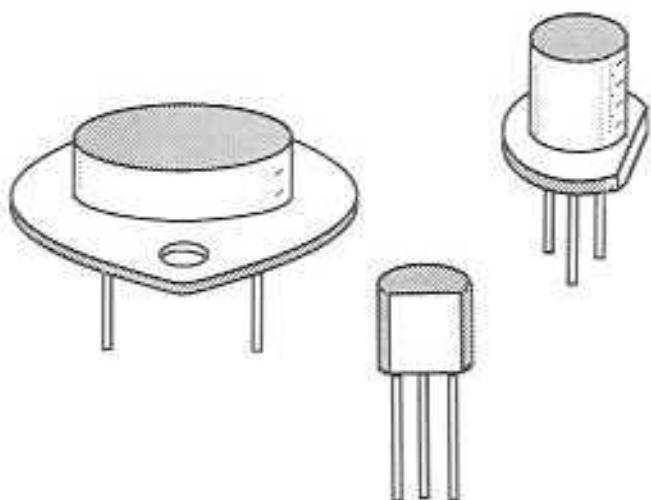
Fig. 1-6. Transistors.

lead is No. 7, the upper right-hand lead is No. 8 and the upper left-hand lead is No. 14. Other similar IC's will have a different number of leads but the same numbering method is used.

Another common method of marking integrated circuits is with a small dot placed near lead number 1 (Fig 1-8B). These integrated circuits are numbered in the same way as those marked with a crescent or similar mark.

Integrated Circuit Part Numbers

Since integrated circuits are not single electronic devices like resistors or transistors, but are actually many components assembled into a small circuit, manufacturers cannot simply place a device value on the part. Also, there is no easy way to determine what integrated circuit you have without proper labeling. Fortunately, most integrated circuits are clearly marked with a part number. Unfortunately, the part numbers can be mistaken for some of the other codes that find their way onto the integrated circuit such as the date code. For example, look at the integrated circuit in Figure 1-9. This device has two sets of numbers on it—the date code (7406) and the part number (7445). If you were to check a product data book, you would find that 7406 and 7445 are both valid part numbers.

To determine which is the part number, look for additional numbers or letters in the code. These usually indicate the part number. For example, the part number in the integrated circuit of Fig. 1-9 has the letters SN in front and an S in back. Therefore, SN7445S is the part number and 7406 is the date code (which means the part was manufactured during the 6th week of 1974).
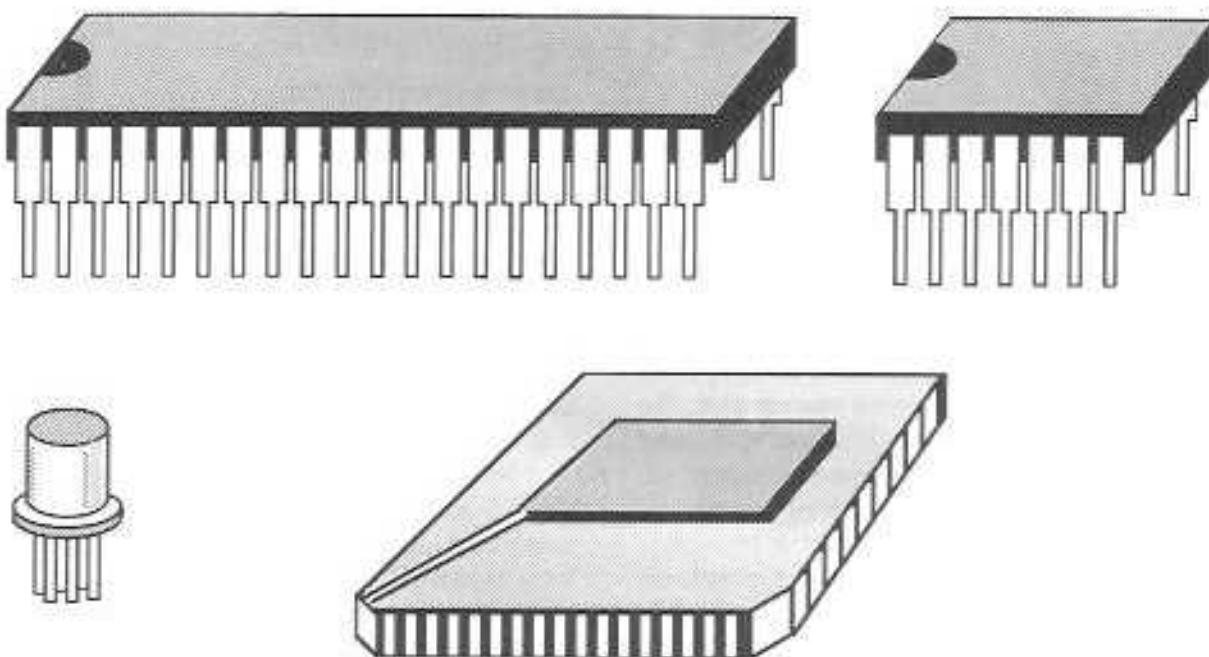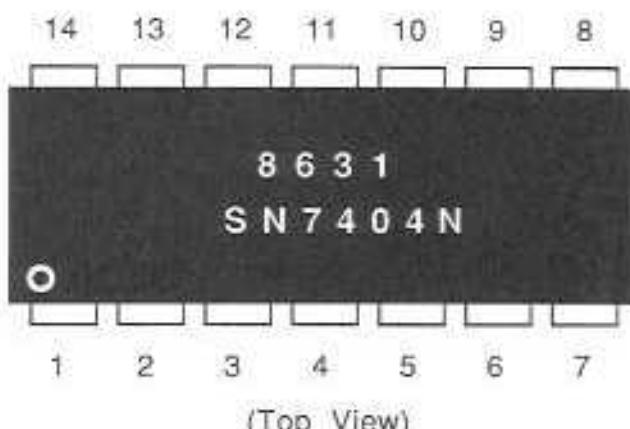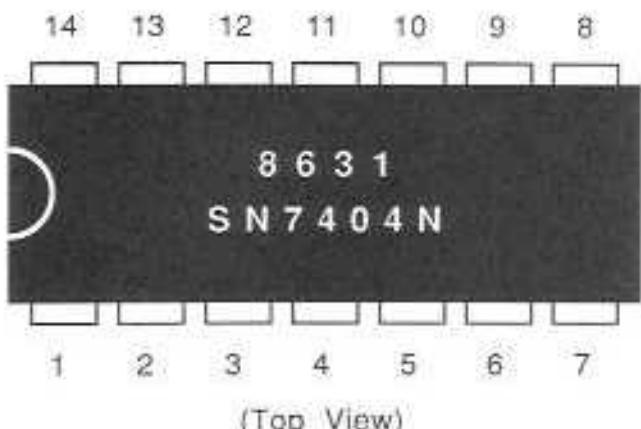
Fig. 1-7. Integrated circuits.

(A) Crescent indicator.

(B) Dot indicator.

Fig. 1-8. Lead numbering on integrated circuits
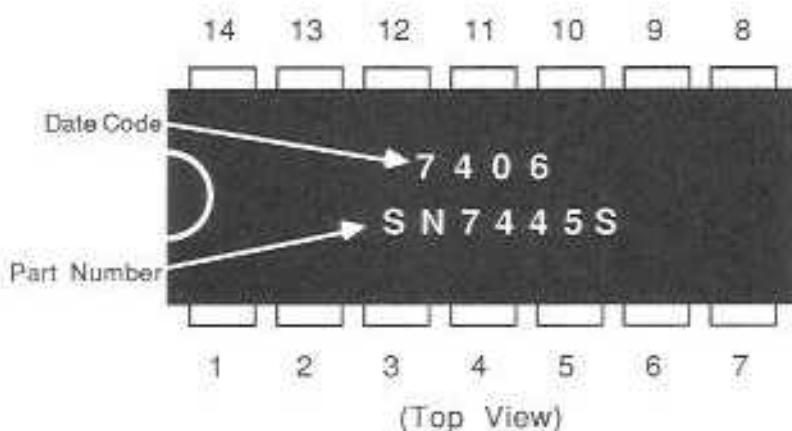
Fig. 1-9. Part number and date code on an integrated circuit.

The Repair Process

Needless to say, you may not remember everything that is covered in this chapter. That's okay, you will be able to use the chapters on troubleshooting and repair without memorizing all this information. As you will see, the repair process is much more like exploring than like taking a test. You can always check the map for directions in case you get lost. This chapter is part of the map.

2

Commodore 128
Systems and Subsystems
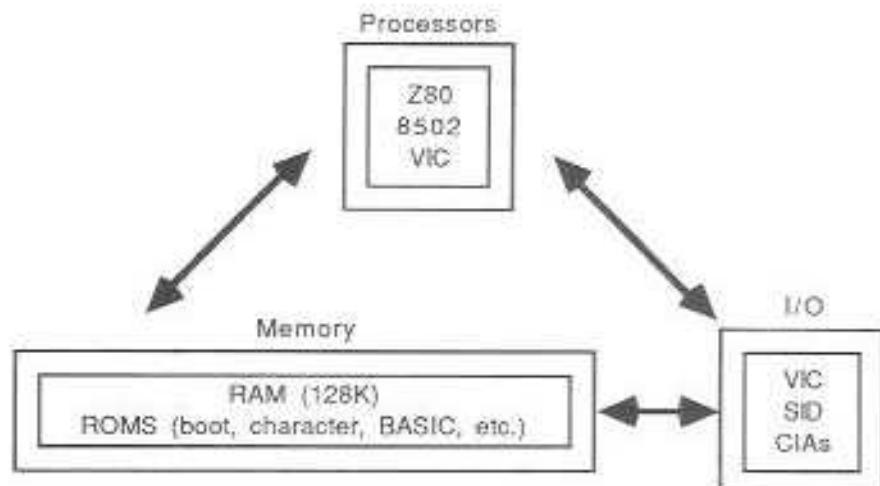
Functionally, the Commodore 128 can be broken down into three main sections: the microprocessor/controller circuits, the memory circuits, and the I/O (input/output) circuits. Additionally, each of these sections may be broken down into several subsections. In this chapter, we'll look at each of these three main sections and the subsections that make them up.

Figure 2-1 is a simplified block diagram of the Commodore 128. As you can see, each of the

three primary systems (microprocessor, memory, and I/O) contains several subsystems. The process of troubleshooting consists of examining each failure from a functional standpoint, isolating it first at the system level and then tracing it to smaller and smaller subsections until we have found the defective component.

Figure 2-2 shows the layout of the Commodore 128 processor board. In it, each of the major components is labeled and shown in its proper po-

Fig. 2-1. Main sections and subsections of the Commodore 128.

Processors

Z80
8502
VIC

Memory

RAM (128K)
ROMS (boot, character, BASIC, etc.)

I/O

VIC
SID
CIAs
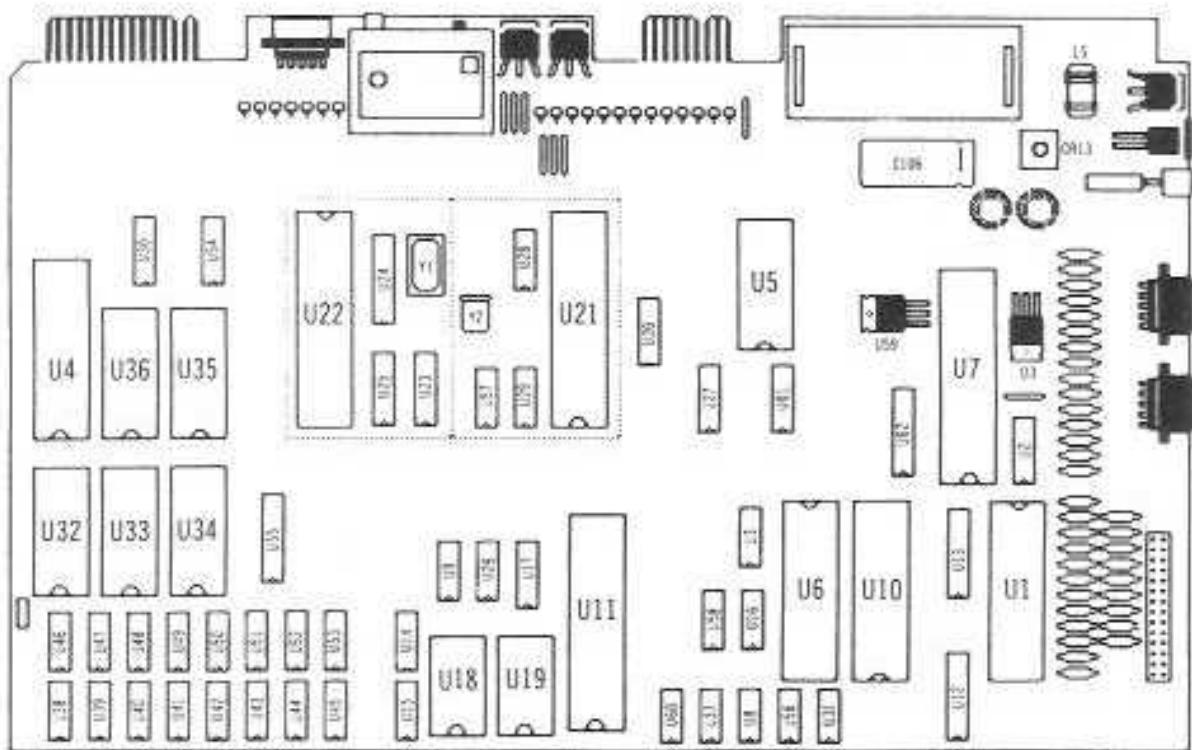
Fig. 2-2. Layout of the Commodore 128 processor board.

sition. This diagram will serve as a guide to locating each of the sections and subsections of the Commodore 128 throughout this book.

Unlike the arrangement on many printed circuit (PC) boards, on the Commodore 128 PC board, many of the integrated circuits are placed upside down (with pin 1 down instead of up). This is done to provide the shortest data path between devices. Therefore, you should be sure to look at the position of any components that you remove before you actually take them out of the circuit board. Failing to install circuits correctly can damage the new component and/or the entire circuit board.

THE MICROPROCESSORS

The Commodore 128 has two microprocessors: an 8502 and a Z80. The 8502 is the upgraded version of the 6502 and related microprocessors (which we'll refer to collectively as the 65xx family) that Commodore used in its earlier computers such as the PET series, the VIC 20, and the Commodore 64.

Although the 8502 has a few added features, its greatest improvement over the 65xx microprocessors is in speed. The 8502 can run at twice the speed of the 65xx-series processors.

How Fast Is Fast?

Microprocessors are timing-dependant devices. To operate, they need one or more special electronic signals called clocks to synchronize their activities. Naturally, the faster the clock runs, the faster the microprocessor will run. You cannot, however, simply keep increasing the clock speed of a computer system and hope to improve its performance. Microprocessors have definite limitations and, when run beyond these limits, they will malfunction. The 6502, for example, can operate at clock speeds up to 1 MHz (one million cycles per second). The 8502, on the other hand, can operate as high as 2 MHz—twice as fast.

Although it is not actually a good way to gauge performance, the speed of a microprocessor is often measured by its maximum clock speed. To get a better idea of how this works, let's take a look at what clocks are and how they work in a computer system such as the Commodore 128.

Most electronic components are asynchronous devices. This means that they do whatever they are going to do as soon as they have the proper inputs. For example, a logic circuit that is properly powered and receives logical data at its input lines will produce some kind of logical output immediately. Microprocessors, however, are designed to control whole systems and must, therefore, synchronize many different events. To do this, most microprocessors are designed so that every logical event is timed according to some signal which is common to the entire system. This signal is the clock.

The clock is actually nothing more than a train of constant electronic pulses which are fed into the microprocessor and its supplementary circuits. In most cases, the clock is generated by a crystal and counter circuit in much the same way digital watches are controlled. This way the system will operate at a very precise speed. A precise speed is necessary because, in most cases, the microprocessors and support circuits run so quickly that one or two improperly spaced clock pulses could cause the system to make errors or even come to a complete halt. Figure 2-3 shows the type of waveform that is produced by a crystal oscillator.
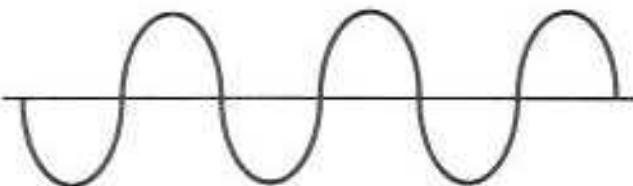

Fig. 2-3. A crystal oscillator output.

As you can see, the signal rises and falls in a waveform that resembles a sine wave. As it turns out however, digital circuits prefer square-wave signals. As a result, the clock circuits need to modify the crystal output to make it the correct size and shape (Fig. 2-4.)
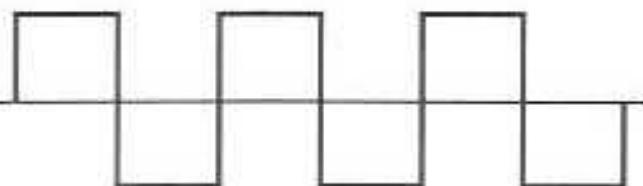

Fig. 2-4. Square-wave output from a crystal oscillator.

Like other mechanical devices, crystals are subject to changes from their environment such as temperature. As computers operate, they get warmer. As the temperature increases, the speed of the crystal will change. To help minimize these changes, the oscillator signal (also called the clock) is divided down by a counter circuit. That way, minor fluctuations in the main oscillator are minimized at the actual clock speed. For example, the main oscillator for the Commodore 128 is run by a 16-MHz crystal. However, the system only requires a 2-MHz clock. So the main oscillator is divided down to 2 MHz using logic circuits.

To get an idea of how this works, let's say that the 16-MHz crystal drifted upwards to 16.16 MHz (an increase of 160,000 Hz). This is a 1% change in speed and will speed up the actual clock rate to 2.02 MHz—not a major problem. However, if the crystal was running at only 2 MHz and it increased by 160,000 Hz it would be nearly a 8% increase in speed and could cause some major operational problems since the system speed would then exceed the maximum ratings of the processor and memory circuits.

Figure 2-5 shows the logic structure of the 8502. It is quite similar to the structure used in the earlier 65xx. The idea with the design of 8502 was to produce a part that was similar enough to the older parts to be able to run the same software while increasing the performance of the system.

The Z80 is an upgrade of the earlier 8085 microprocessor which was at one time the most popular microprocessor in the industry. Although the primary function of the Z80 in the Commodore 128 is to run CP/M, because of some of its initialization characteristics, it is also used to boot up the Commodore 128. Once it has initialized the system, the Z80 will generally pass control over to the 8502. Figure 2-6 shows the logic structure of the Z80.

Figure 2-7 shows the location of the 8502 and the Z80 on the Commodore 128 processor board. Notice that the 8502's chip index is upward while the Z80's is downward. This was done because of the pinout arrangements of the two processors (see Fig. 2-8). By reversing the Z80, both sets of data and address lines were brought to the space between the chips.

Although I have referred to the Commodore 128 as a two-processor system, in fact it has a third processor on board. This is the video
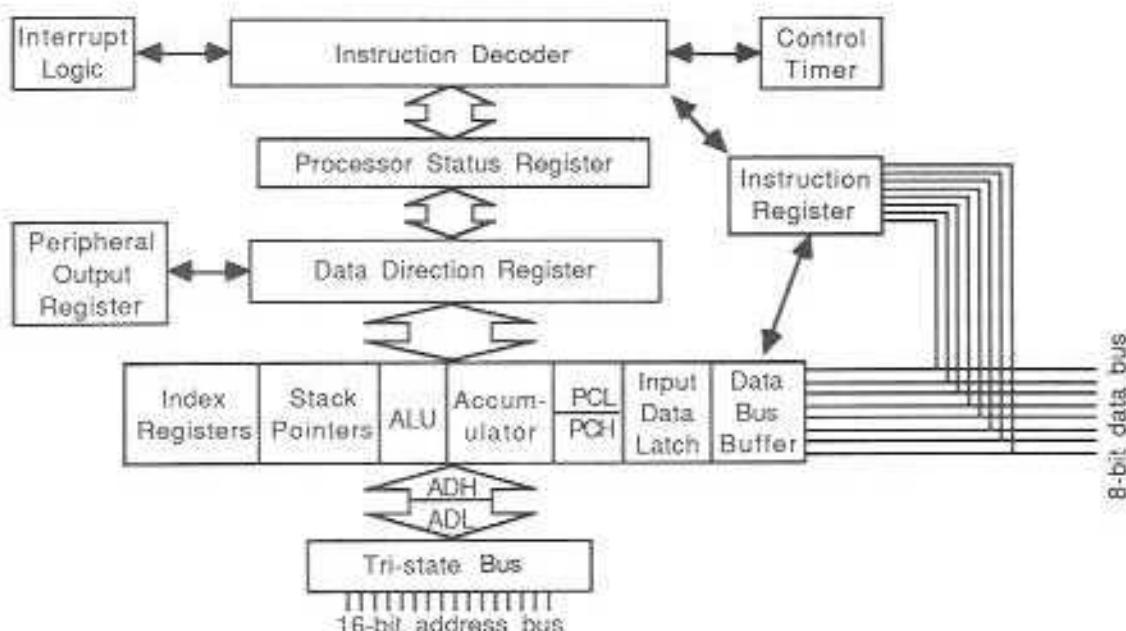
Fig. 2-5. The internal architecture of the 8502.

processor: the 8564 VIC chip. The VIC chip used in the Commodore 128 is an upgrade of the 6567 VIC chip used in the earlier C64. In addition to its video display responsibilities, the VIC chip scans the keyboard and performs the memory refresh function. Additionally, unlike its predecessors, the 8564 is able to operate in both 1-MHz and 2-MHz mode. In 2-MHz mode, however, the chip cannot display data on the screen.

Coprocessing

The most difficult part of understanding the processor portion of the Commodore 128 is coprocessing. Within the Commodore 128 both the Z80 and the 8502 processors (as well as the video display processors) need to have access to one or more of the devices on the control, data, and/or address lines at one time or another. The problem is that only one of the processors can have control
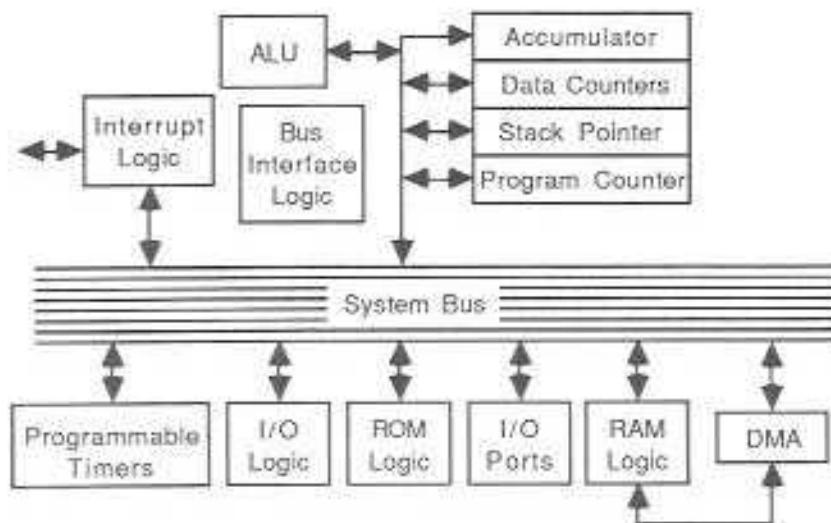
Fig. 2-6. The internal architecture of the Z80.
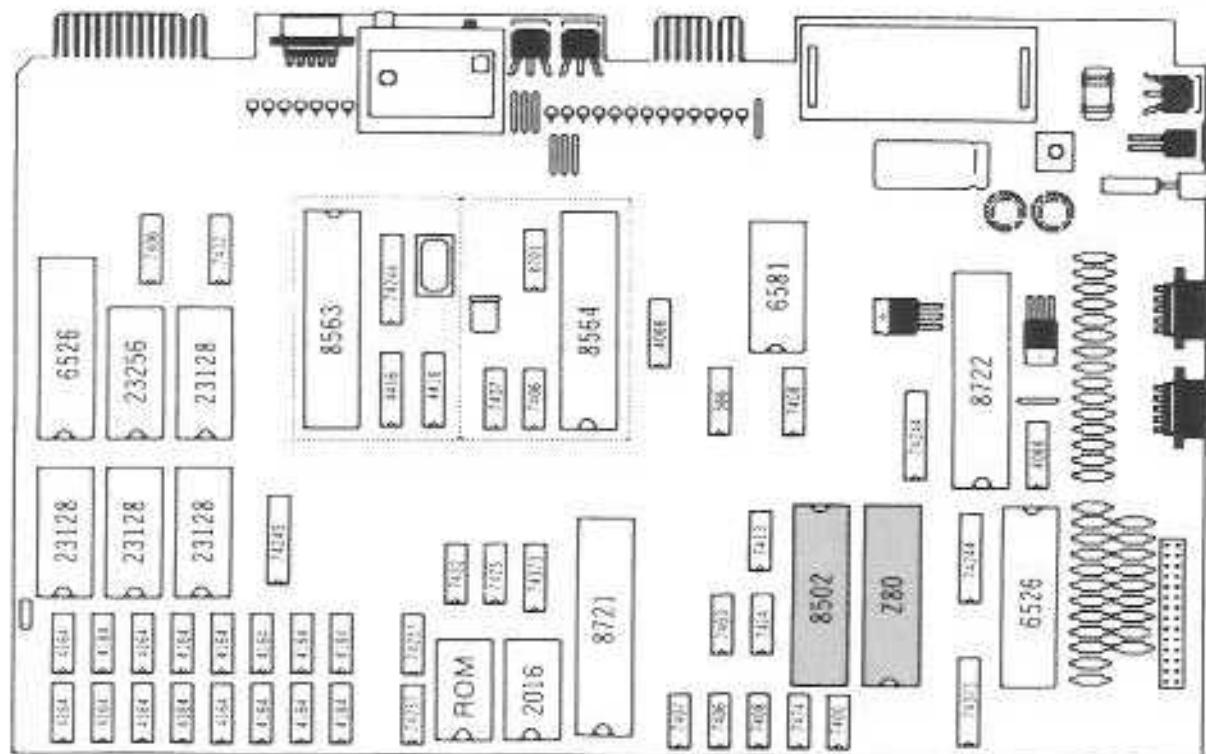
Fig. 2-7. Location of the 8205 and the Z80 microprocessors on the Commodore 128 processor board.

(A) Z80.

(B) 8502.

Fig. 2-8. 8502 and Z80 pinout diagram.

at a time; the Commodore 128 is not designed for parallel or multiprocessing, it cannot have more than one controller in charge at a time.

Data Lines, Address Lines

Before we can cover how the Commodore 128 manages its internal controls, it is important to understand what it is actually controlling. As we discussed earlier, in essence, the computer consists of three main sections: the microprocessor, the memory (RAM, ROM, video display memory, etc.), and the I/O ports. In every case, the devices are connected together by a series of conductors called the data bus (Fig. 2-9).

To control which device uses the data on the data lines, the Commodore 128 has a second set of
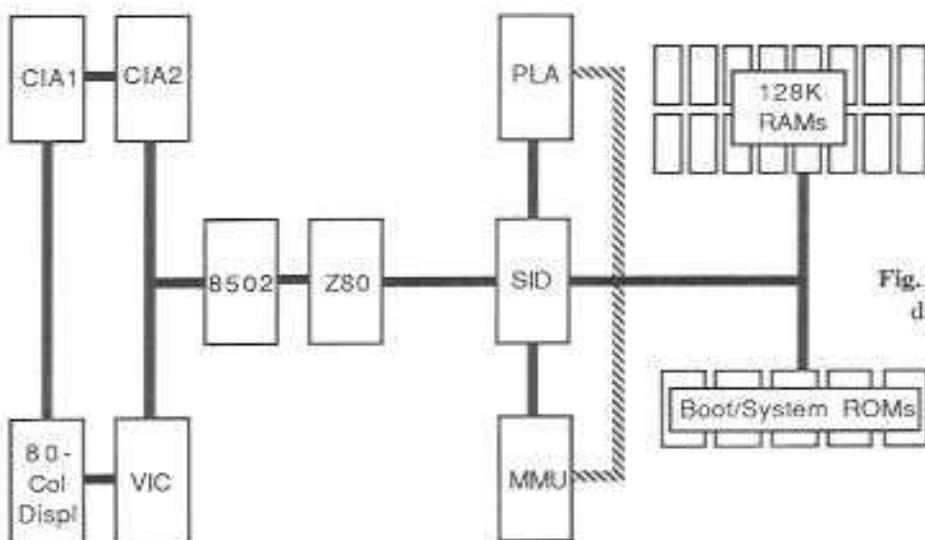
Fig. 2-9. Commodore 128 block diagram, showing the data bus connections.
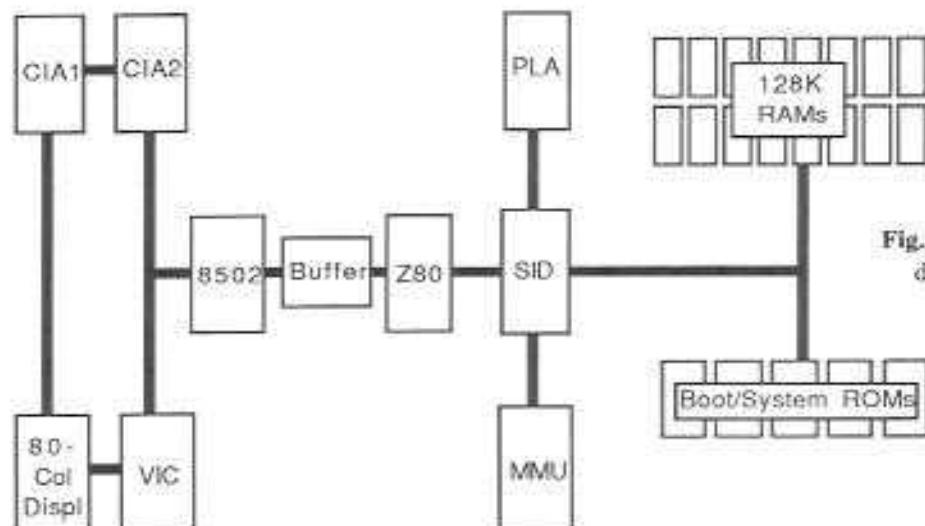
Fig. 2-10. Commodore 128 block diagram, showing the address bus connections.

lines called the address bus (Fig. 2-10). Every major device in the system has its own unique address, just as every memory location and I/O port has a unique address. When the computer is operating, devices will only respond to the data present on the data bus if their address has been selected.

In the Commodore 128, the data bus contains eight lines while the address bus contains sixteen. For all of its applications, the Commodore only requires 256 different kinds of data (2^8 = 256).

On the other hand, it must address up to 65,536 different memory locations at once and has therefore sixteen address lines (2^{16} = 65,536). This allows the Commodore 128 to access any of 65,536 memory locations and/or devices at any one time. We'll examine how the Commodore 128 is able to access the additional 64K of memory and all of the I/O devices and internal devices within the (apparently) same 64K of memory in the next section.
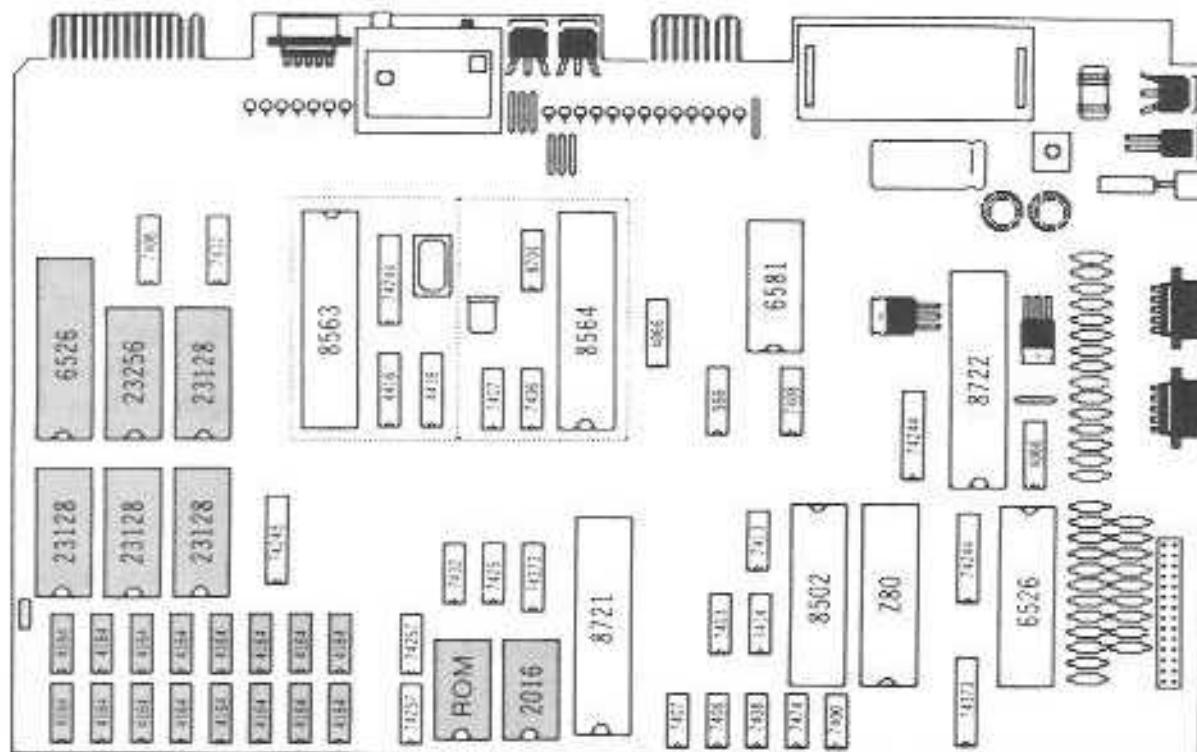
Fig. 2-11. Location of memory devices on the processor board.

Taking Control

In order to take control of the address/data lines the Commodore 128 uses a control signal called the AEC (address enable control). This signal is produced by the VIC chip and determines which processor may be active (generating addresses and reading/writing data on the buses).

One question that may arise at this point is: "How can all these devices be on the same address and data lines at the same time?" Most logical devices can be either at a logical 1 (hi) or logical 0 (low) and, if all of the processors are on the same bus, then the signals that are on the bus will conflict at least some of the time.

In fact, with ordinary logic devices this would be true, however, both the Z80 and the 8502 have I/O lines that can be in any of three conditions: high, low, or "tri-state". Tri-state mode is a kind of "floating" condition in which the processor has no control of the data or address lines. When the processor(s) are inactive their I/O lines are "tri-stated."

MEMORY

Figure 2-11 shows the various memory devices on the Commodore 128 processor board. These include the 128K of RAM (Random Access Memory) and all of the systems ROMs (Read Only Memories) which covers the kernal (boot up programs), BASIC programming language, the character set, and so on. In addition to these, the Commodore 128 has a separate RAM chip which is used to store all of the color data for the video display.

RAMs

There are three different kinds of semiconductor memory chips in the Commodore 128, they are:

Dynamic RAMs

Static RAMs

ROMs

ROMs are preprogrammed at the factory and contain data that is essential to the operation of

the computer. Without the correct ROM data the computer will almost certainly malfunction. ROMs can only be read. Attempts to write to ROMs are ineffective; however, because of the organization of memory in the Commodore 128, parts of the ROMs may be copied into RAM and then modified as desired. This can be useful for certain diagnostic operations as you will see later in the section on advanced troubleshooting techniques. The Commodore 128 has two different kinds of ROMs: 23128 and 23256. Fig. 2-12 shows the pinouts and signal names for these two ROM types.

electronically) periodically or they will lose their data. In the Commodore 128, the color memory (U19) is a 2016 static RAM. The main memory consists of sixteen 4164 chips which are each configured as 65,536 × 1 bits of memory. To produce the 128K of RAM for the Commodore 128, the 4164 chips are arranged as two banks of eight, each containing 65,536 8-bit bytes of memory. The 80-column video display RAM is made of two 4416 RAMS which are dynamic memories configured as 16K × 4 bits. Fig. 2-13 shows the pinouts and signal names for these RAM chips.

Bank Switching

Since the Commodore 128 uses eight-bit microprocessors, it can never actually address more than 64K (65,536) bytes of data at one time. How-

(A) 23128.

(B) 23256.

Fig. 2-12. Commodore 128 ROM pinouts and signal names.

(A) 2016 Static RAM.

(B) 4164 Dynamic RAM.

(C) 4416 Dynamic RAM.
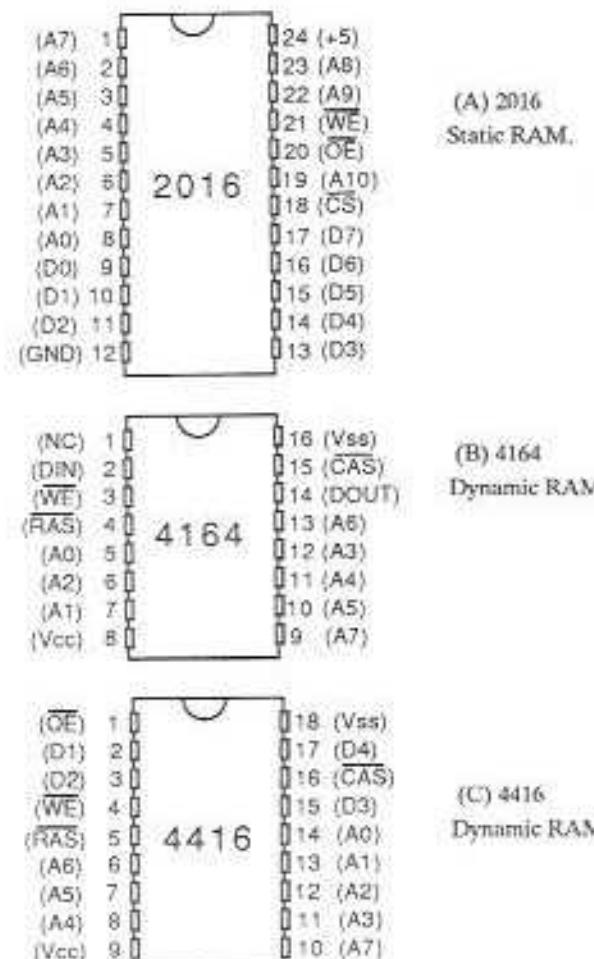
Fig. 2-13. Commodore 128 RAM pinouts and signal names.

There are two kinds of RAMs in the Commodore 128: static RAMs and dynamic RAMs. Static RAMs are devices that will retain their data as long as power is supplied to them. Dynamic RAMs must be "refreshed" (polled
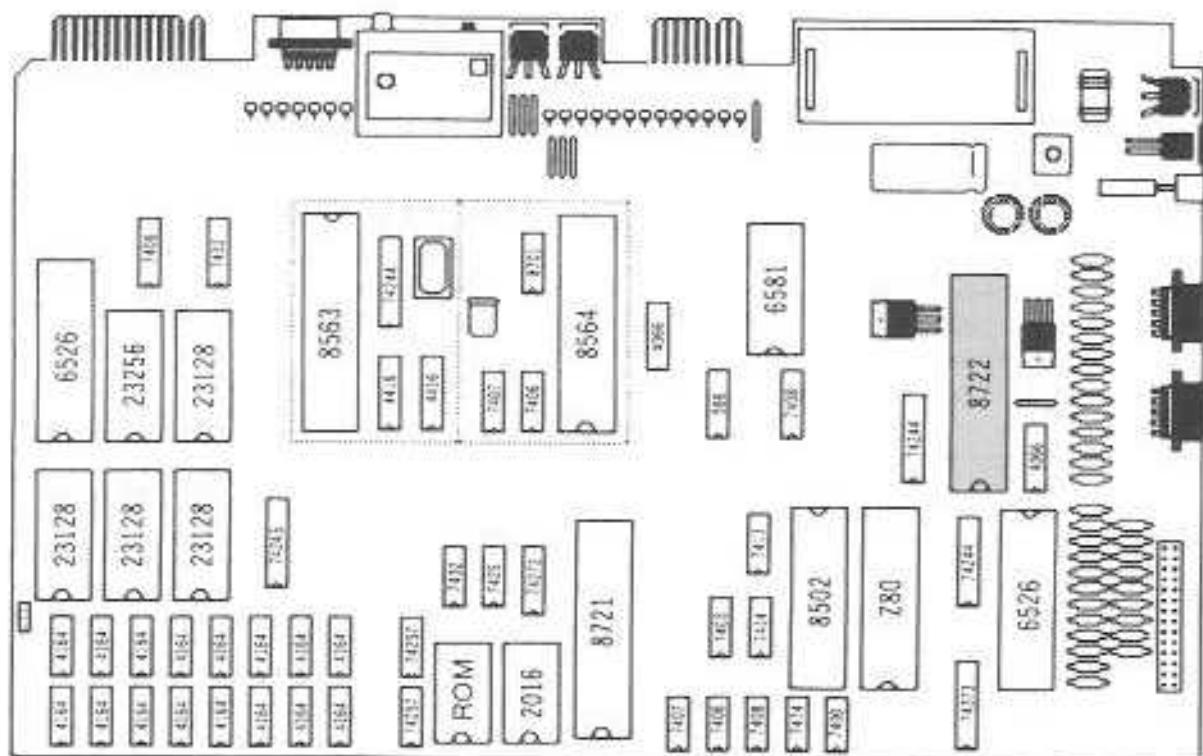
Fig. 2-14. Location of the MMU on the Commodore 128 processor board.

ever, if you add up all of the memory space and add to that the I/O and device port addresses you'll find that the Commodore 128 actually addressing far more than this limit. In fact, its main memory alone is double the 64K limit. In order to give the Commodore 128 the ability to address more than its upper limit of 64K memory, it has been designed to perform bank switching.

Every memory chip has address lines, data lines, and enable lines. By selecting a specific address and enabling one of several different "enable" lines, the Commodore 128 is able to read and write to different memory and device locations that actually have the same address! This (at least theoretically) gives the Commodore 128 unlimited memory space. In fact, Commodore supports up to 640K of memory expansion for the Commodore 128. Bank switching is handled by the MMU (memory manager unit) The location of the 8722 (MMU) on the processor board is shown in Fig. 2-14.

In addition to performing the bank-switching functions for the computer, the MMU also produces the Z80, 8502, and VIC processor select signals, controls the external RAM and ROM,

Fig. 2-15. PLA pinout and signal names.

switches between fast and slow disk I/O modes, and selects the 40/80 column display mode.

Although the MMU actually selects which bank of memory is accessed, the signals from the
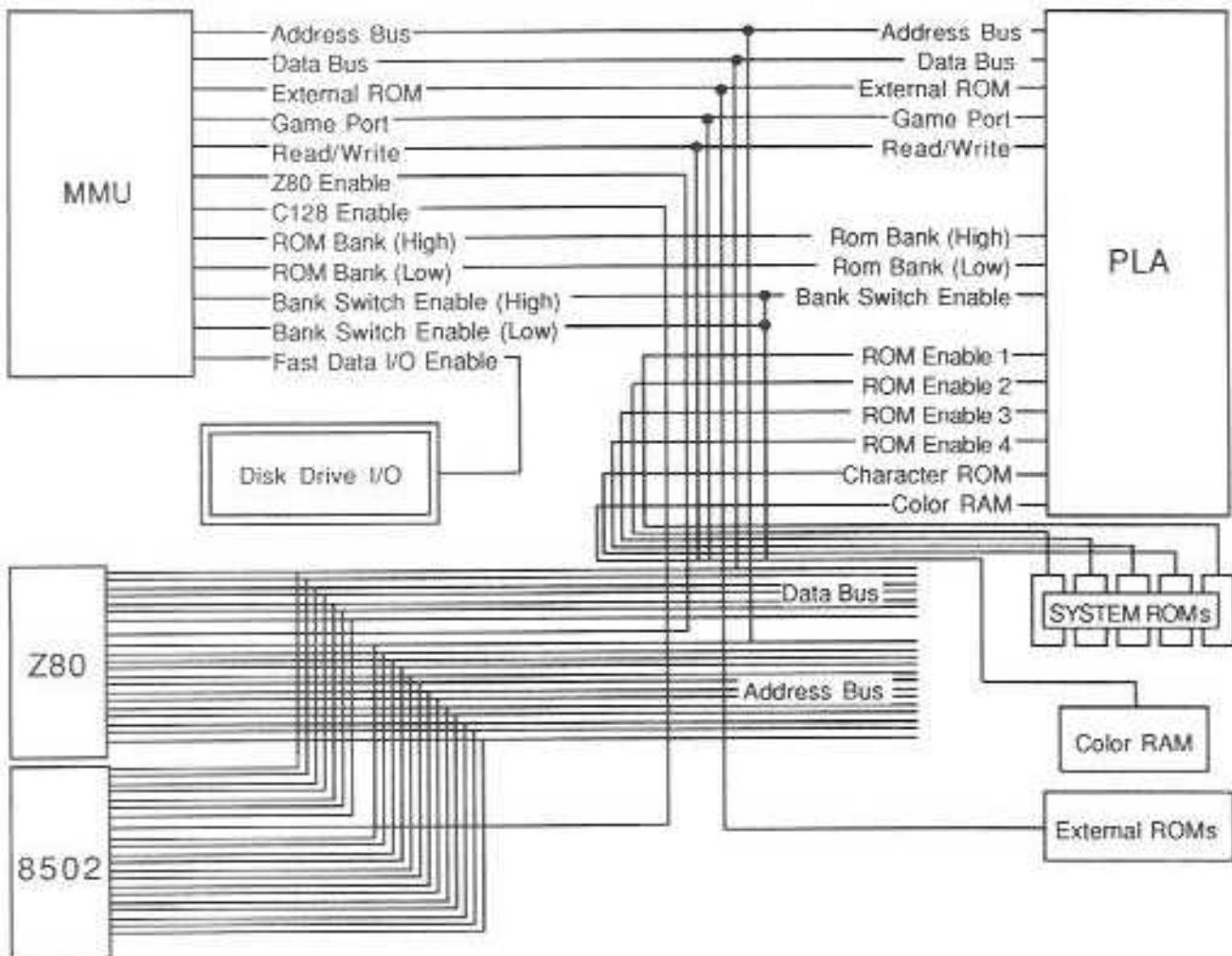
Fig. 2-16. Memory control signals from the MMU and PLA.

MMU do not control the memory devices directly. This is because there are a number of "rules" which the Commodore 128 makes for itself regarding how and when memory shall be switched. For example, some sections of memory are never switched. To make sure that the proper signals are switched at the proper time, the memory "bank" commands from the MMU are handled by a PLA (Programmed Logic Array). Programmed logic arrays are special devices (similar to ROMs) that contain groups of logic cells. The cells accept input signals and produce an output based upon the inputs and their own preprogrammed logic structure. The PLA in the Commodore 128 (Fig. 2-15) performs a large number of (in some cases) seemingly unrelated tasks including accepting commands from the MMU and sending the actual bank-switch signals to main RAM and the ROMs.

Figure 2-16 is a block diagram showing the way the MMU, PLA, and memory signals interact.

INPUT/OUTPUT

I/O (Input/Output) functions on the Commodore 128 can be split into two categories: internal I/O and external I/O. Internal I/O functions are those functions that are always a part of the system. They include reading and writing to the keyboard, writing to the video display, and the sound output device (typically a speaker inside the video display).
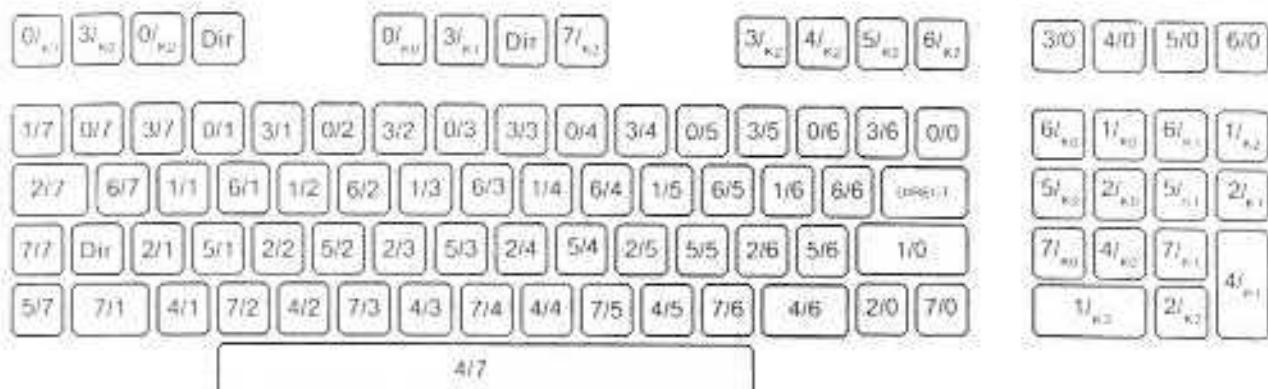
Fig. 2-17. Commodore 128 row and column keyboard addresses.

The external I/O functions control the game ports, the user port, the serial port, and the cassette port. Internal I/O functions must always be operational for the Commodore 128 to function while the external I/O are not required. In this section we'll look at the I/O operations of the Commodore 128, how they work, and how they are connected to the computer.

The Keyboard

The Commodore 128 keyboard consists of a matrix of 88 keys arranged as eight rows and eleven columns of switches. It also includes four keys that are not a part of the matrix. They are: Shift Lock, Restore, 40/80 Column Display, and Caps Lock. Figure 2-17 shows the arrangement of the

	C0	C1	C2	C3	C4	C5	C6	C7	K0	K1	K2
R0	INST DEL	# 3	% 5	' 7	(9	+	1b	£ 1	HELP	ESC	ALT
R1	RETURN	W	R	Y	I	P	*	←	8	+	0
R2	↑↓	A	D	G	J	L	! :	CONTROL	5	–	.
R3	F8 F7	$ 4	& 6	< 8	0	–	CLR HOME	" 2	TAB	LINE FEED	↑
R4	F2 F1	Z	C	B	M	> .	RIGHT SHIFT	SPACE BAR	2	ENTER	↓
R5	F4 F3	S	F	H	K	! :	=		4	5	←
R6	F6 F5	E	T	U	O	@	# ^	Q	7	9	→
R7	←→	LEFT SHIFT	X	U	N	< ,	? /	RUN STOP	1	3	NO SCROLL
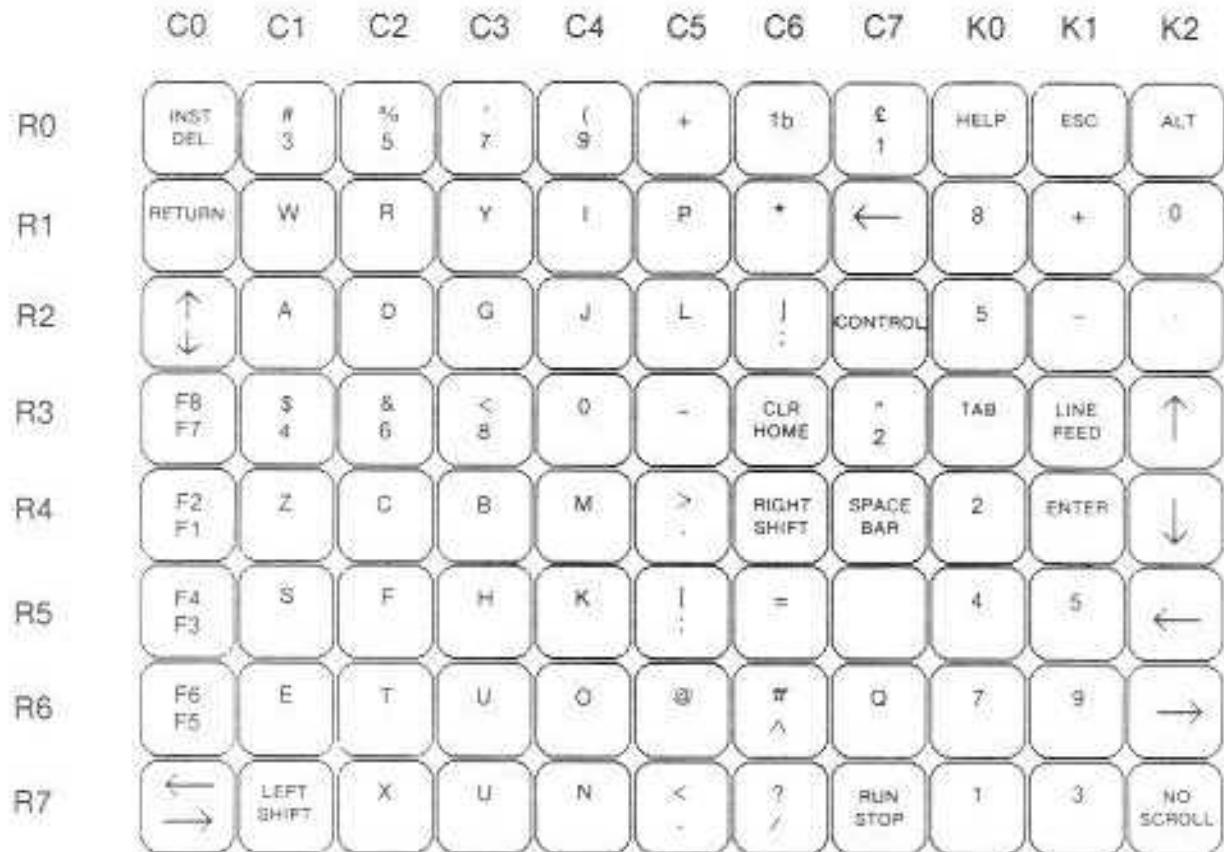
Fig. 2-18. Keyboard matrix.
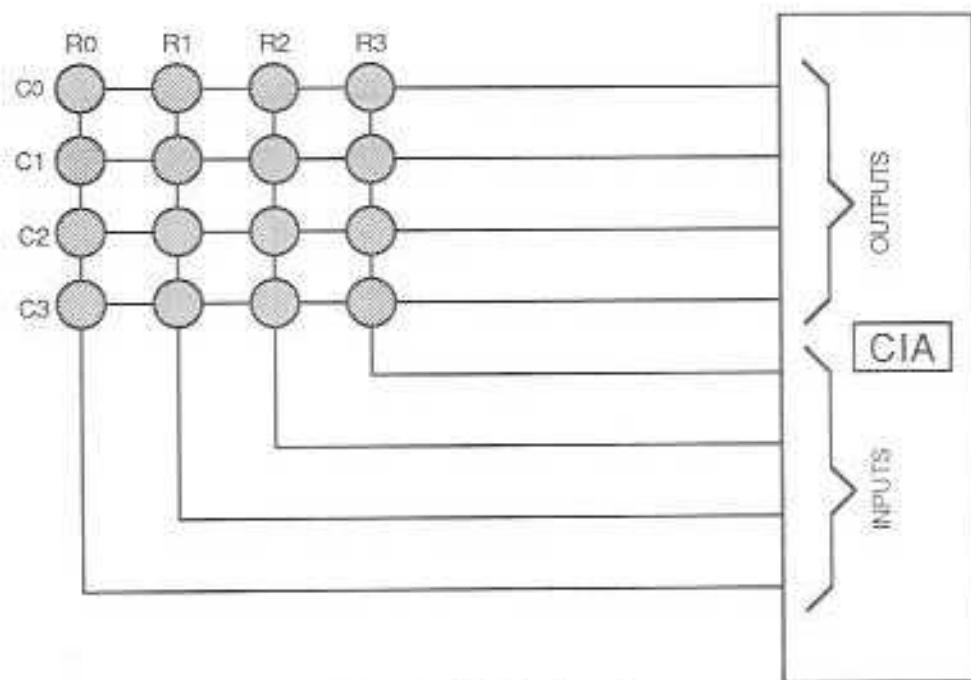
Fig. 2-19. A simplified keyboard scanner.

keys on the keyboard with their actual row and column designations while Fig. 2-18 shows the rows and columns as they are arranged logically.

Keyboard Scanner

In theory, the best way to determine if a key has been pressed is for the processor to look at every key position all of the time. The trouble with this is that the processor would then have no time for any other functions. Instead, the processor uses a technique called "scanning." Scanning consists of putting a signal on each of the keyboard matrix columns one-at-a-time. Depressing a key closes a switch connecting the column line to
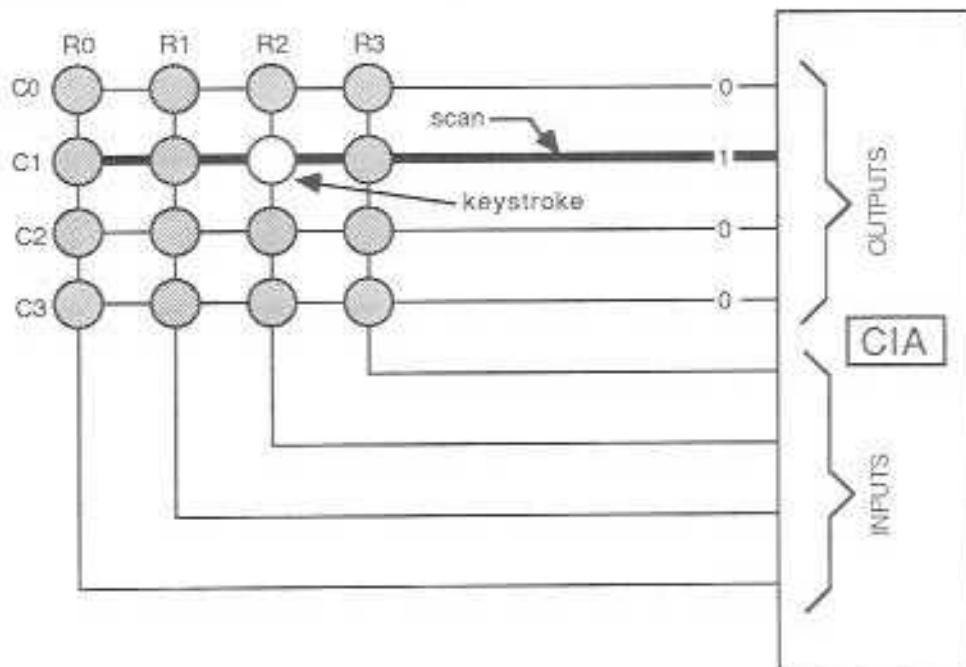
Fig. 2-20. Scanning the simplified keyboard.
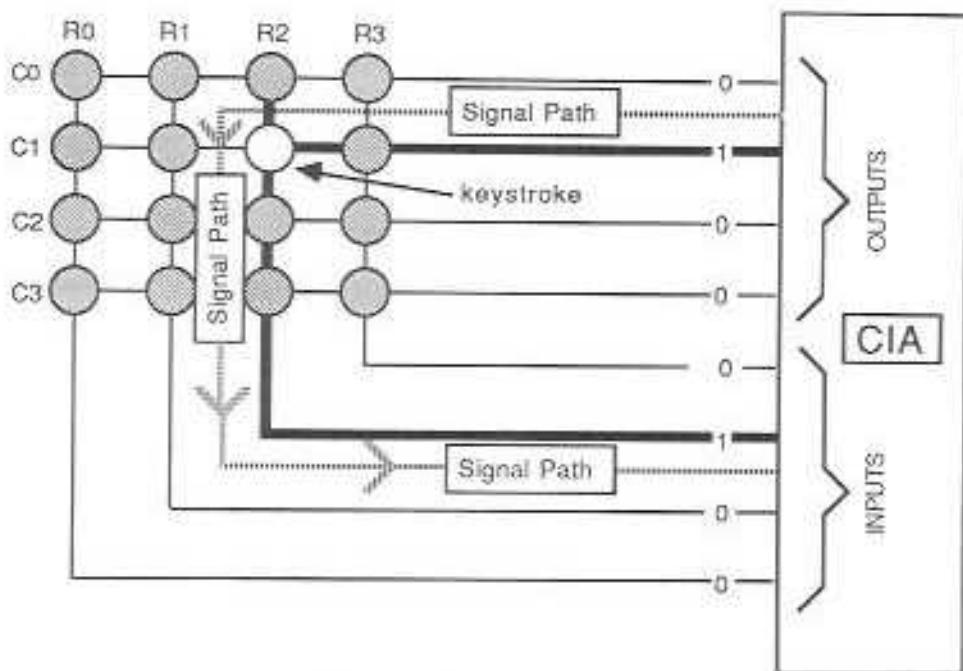
Fig. 2-21. Detecting a keystroke.

to the row line. Thus, the rows are then scanned to see if the signal has been passed to one of them.

To get a better idea of how this works, take a look at Fig. 2-19. It shows a simplified matrix with only four rows labeled R0–R3 and four columns labeled C0–C3. In Fig. 2-19, each of the row and column lines from the keyboard matrix is connected to one of each of the eight I/O lines of

lines of the complex interface adapter (CIA). To scan this keyboard, the CIA simply writes a pattern of data to the four column lines and looks at the four row lines to see if any data passed through. If, for example, the CIA writes the pattern "0100" it will place a low signal on lines 0, 2, and 3, a high signal on column 1 (Fig. 2-20).
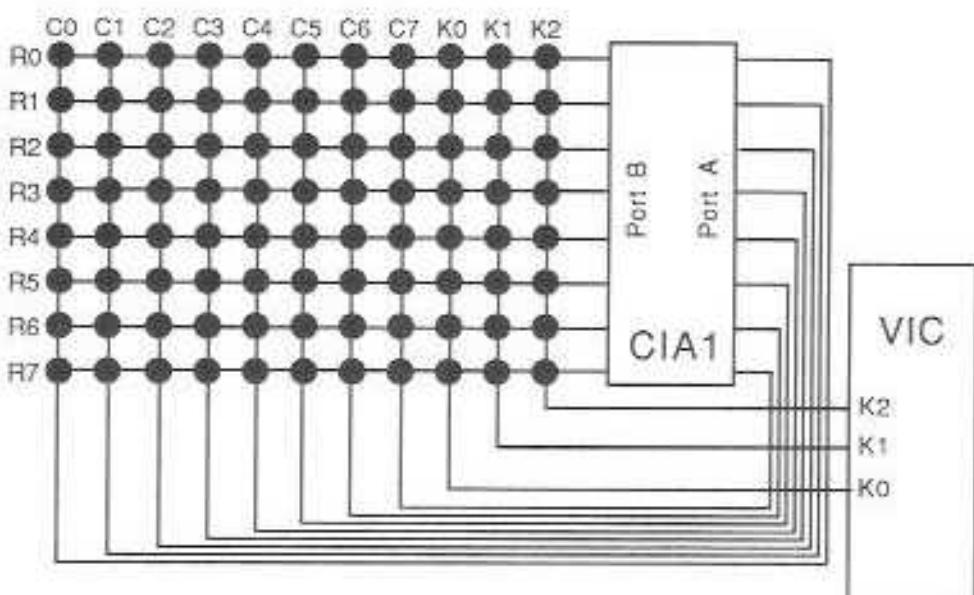
Fig. 2-22. The keyboard scanning circuit.

If no keys are pressed in that column while it is high (being scanned), the CIA will read all 0s (low) on the row lines. On the other hand, if one of the keys has been pressed then it will receive a pattern that corresponds to the key that is down, since the key switch will conduct the signal from the column line (Fig. 2-21).

The actual keyboard has eight rows and eleven columns. To scan the keyboard, the CIA writes patterns to eight column lines and reads eight row lines (it has only sixteen I/O lines available). The three extra keyboard lines are connected to the VIC chip, which scans them just as the CIA scans the other lines.

Incidentally, scanning the lines is exactly the same as reading and writing data to any memory location. The column lines are at memory location 56320; the eight row lines are at 56321 and the three extra lines that go to the VIC chip are at memory location 53295 (see Fig. 2-22).

Video Display

The Commodore 128 has two video display chips—the 8564 VIC chip and the 8563 column display chip. In the 40-column text and graphics modes, the 8564 VIC chip controls the video display. In the 80-column text mode, the 8563 display chip takes over.

To get an idea of how these display circuits work, let's take a look at the way the video monitor produces images. Figure 2-23 shows a very simplified cutaway video display tube. The neck of the display tube contains an electron gun which is at a slightly negative voltage. The inside front surface of the display tube is charged to a high positive voltage. Therefore, electrons from the
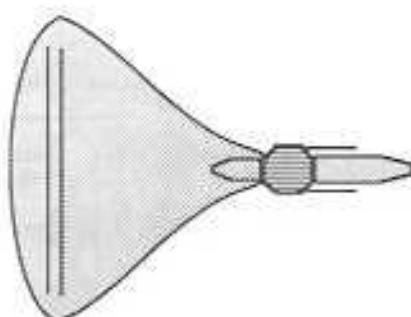
Fig. 2-23 Cutaway view of a video display tube.

electron "jump" across the space between the electron gun and the front of the display. Wherever the electron beam strikes the phosphorus-coated inner surface of the tube, it produces a glowing dot.

Without any additional controlling circuitry or devices, all this simplified display would show is a single dot in the center of the screen. To produce a full-screen picture, the beam must be caused to move back and forth and up and down the screen. This scanning of the width and height of the display tube is called producing a "raster".

To produce a raster, the picture tube uses a set of four electromagnetic coils. As these coils are energized, they deflect the electron beam (Fig. 2-24). With application of the proper voltages to the deflection coils, the electron beam scans the entire surface of the screen (Fig. 2-25).

When the video display is operating properly, it produces a raster that runs at a constant speed. To produce light and dark dots on the screen, the display turns the electron gun on and off as it scans. When the gun is off, the screen is dark. When the beam is fully on, it produces a bright
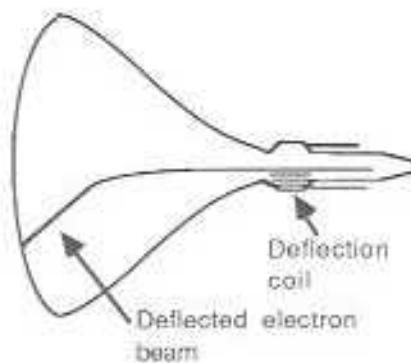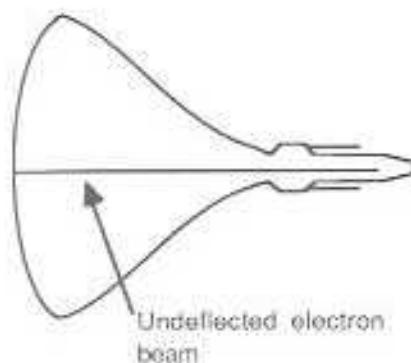
Fig. 2-24. Electron beam being deflected by magnetic coil.
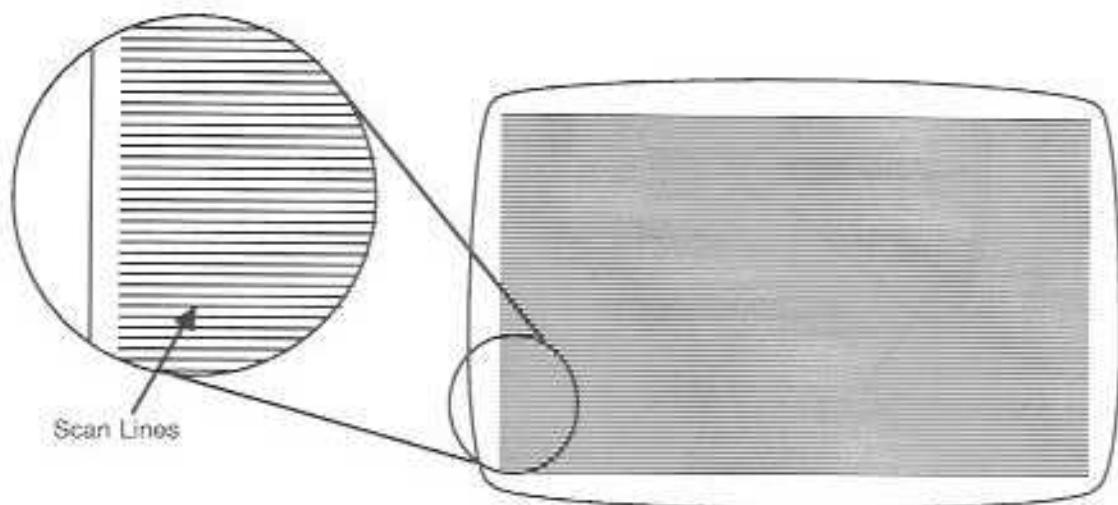
Fig. 2-25. Video raster.

dot. Reducing the intensity of the beam produces a lighter dot. The more quickly the gun is turned on and off, the smaller the dots will be and the closer together they will be positioned (Fig. 2-26).

Color Displays

The display in the previous example was for a monochrome (one color) display. Thus, whether the monitor produces a white, green, or amber
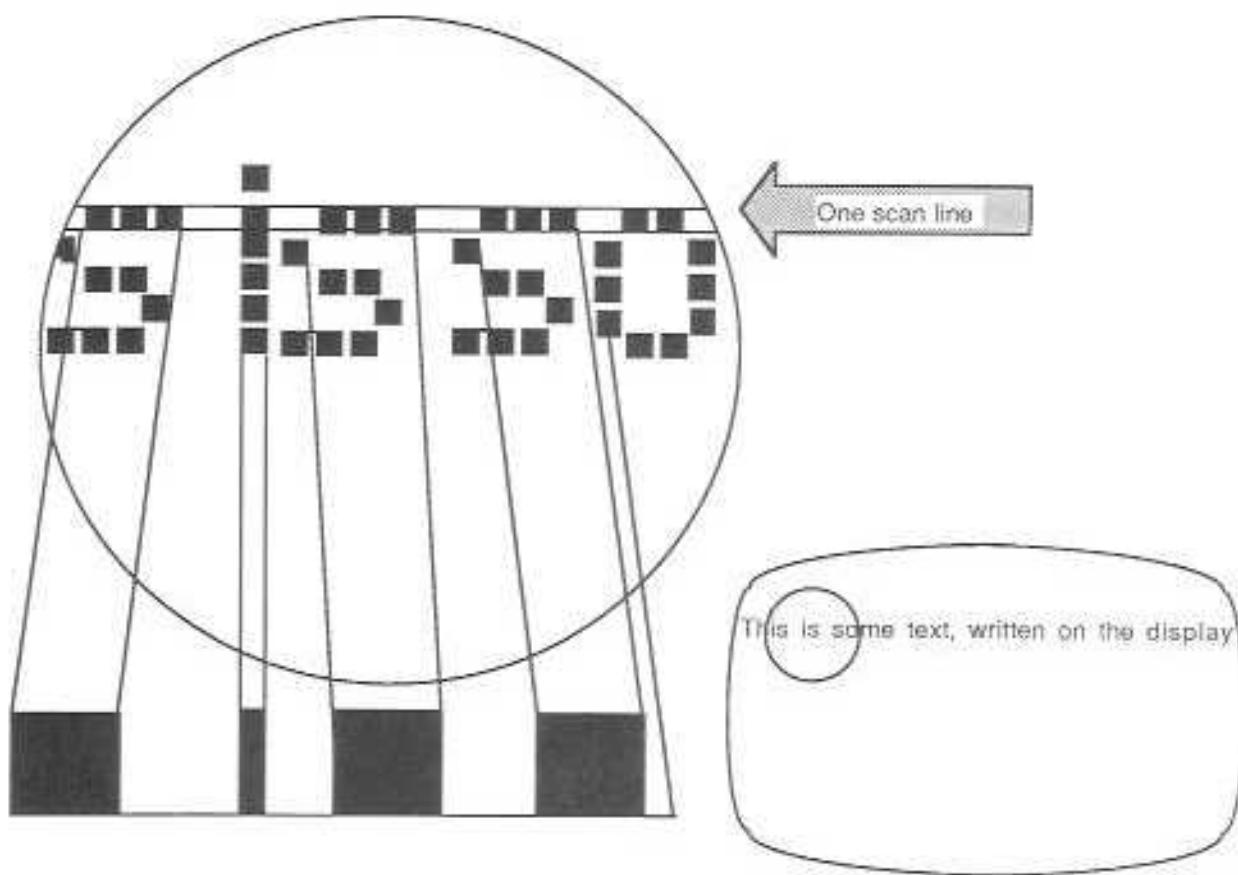
Fig. 2-26. Dot patterns used to produce a video display.
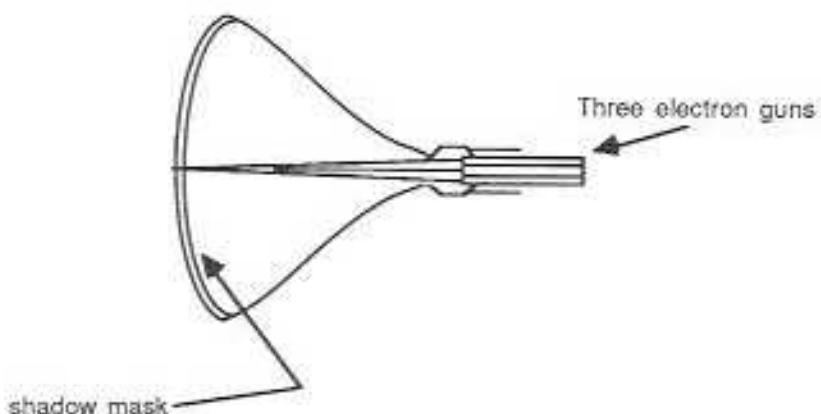
Fig. 2-27. Color display
tube (cutaway).

pattern, this principle applies. Although producing a color display is quite similar, there are a few differences that arise. Instead of a solid, phosphorus coating on the front of the screen, color displays have a pattern of three different kinds of phosphor dots "painted" onto the inside of the screen. These phosphor dots will glow in either red, green, or blue when the electron beam strikes them.

The color display tube (Fig. 2-27) has three separate electron guns (red, green, and blue). These guns are adjusted so that each beam will strike the center of its respective color dot.

Additionally there is a perforated metal sheet, called the shadow mask in front of the patterned coating to insure the beams strike the proper phosphor dots.

The beams produced by the three electron beams are turned on and off and varied in intensity to produce a wide range of colors since the glow produced by the three dots mix with each other just as any other pallet of colors will mix. For example, to produce a white dot, all three electron beams are turned on and off, with equal intensity. For black, all three beams are turned off. The combination of red and green produces yellow, red and blue produces magenta, and blue and green produces cyan. Other combinations and intensities can be used to produce all colors of the rainbow.

The Video Display Chips
As we discussed previously, producing dots on the video display is a process of turning the electron
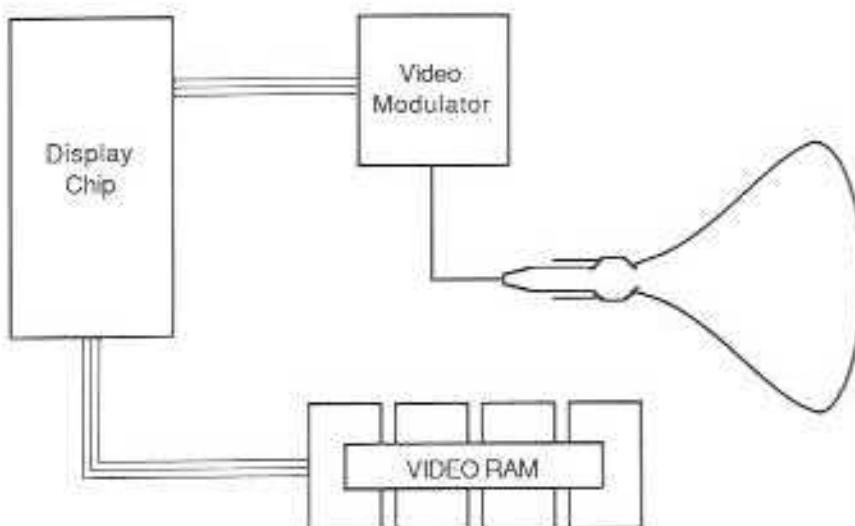
Fig. 2-28. Reading the video
RAM and painting the dot
pattern on the screen.

beam in the display on and off at the proper time(s). To time the dots properly, both the 8564 40-column VIC chip and the 8463 80-column text chip use clock circuits that synchronize their output to the video display.

To produce a particular pattern of dots, the display chips put the desired pattern into a block of memory and then read it out at the same speed as they output on/off signals to the display (1s correspond to a dot and 0s correspond to no dot). This is illustrated in Figure 2-28.

In text mode, the display chips read a block of memory that contains the Commodore ASCII character codes for the text—not the actual dot patterns of the display. To produce characters, the display chip must "look up" the actual character patterns from the character ROM (or other specified memory location(s)) and place those dot patterns into its display RAM before it can paint the images onto the screen (Fig. 2-29).

To control the VIC chip, the Commodore 128 uses a set of memory registers which are directly connected to the VIC's control lines.

Sound

All of the sounds produced by the Commodore 128 are created by the 6581 Sound Interface De-

(CAP 1A)	1	28 (Vdd)
(CAP 1B)	2	27 (AUDIO OUT)
(CAP 2A)	3	26 (EXT IN)
(CAP 2B)	4	25 (Vcc)
($\overline{RES}$)	5	24 (POTX)
($\varnothing$2)	6	23 (POTY)
(R/$\overline{W}$)	7	22 (D7)
($\overline{CS}$)	8	21 (D6)
(A0)	9	20 (D5)
(A1)	10	19 (D4)
(A2)	11	18 (D3)
(A3)	12	17 (D2)
(A4)	13	16 (D1)
(GND)	14	15 (D0)

SID (6581)
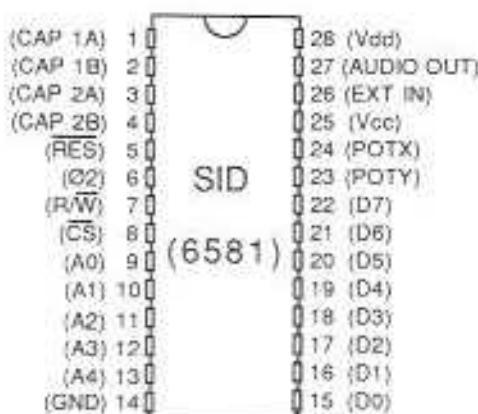
Fig. 2-30. The 6581 SID chip pinouts.

vice (SID). The SID chip (Fig. 2-30) has three voices, four waveforms, and three amplitude modulators. It can also produce programmable sound envelopes.

In most cases, the SID is used to produce sound through the audio output of the video display. It can, however, also source high fidelity sound to an external audio sound system. Additionally, it can synchronize its output to an external sound source.

To produce sounds, the SID chip is connected to a range of memory locations in much the same way as the VIC chip.
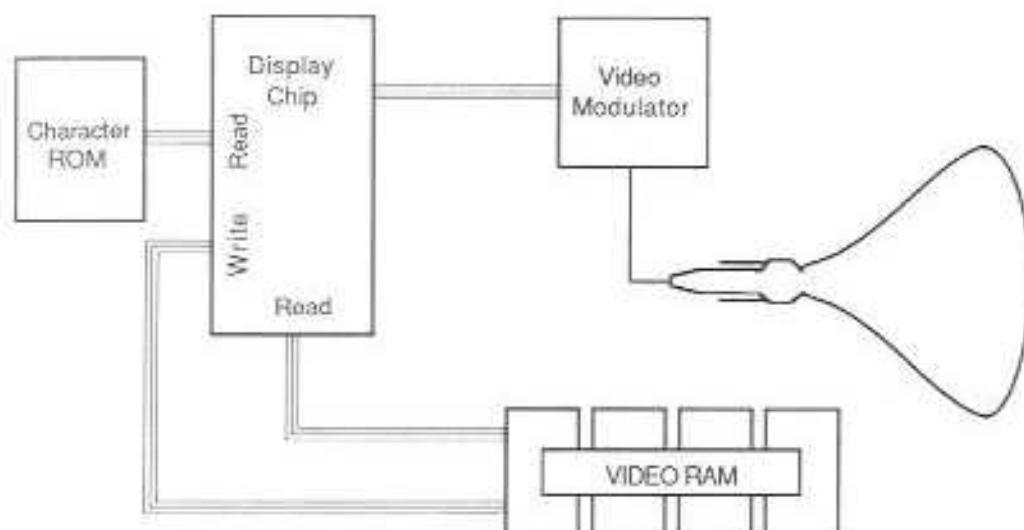
Fig. 2-29. Looking up the character patterns, building video RAM, and displaying the text on screen.
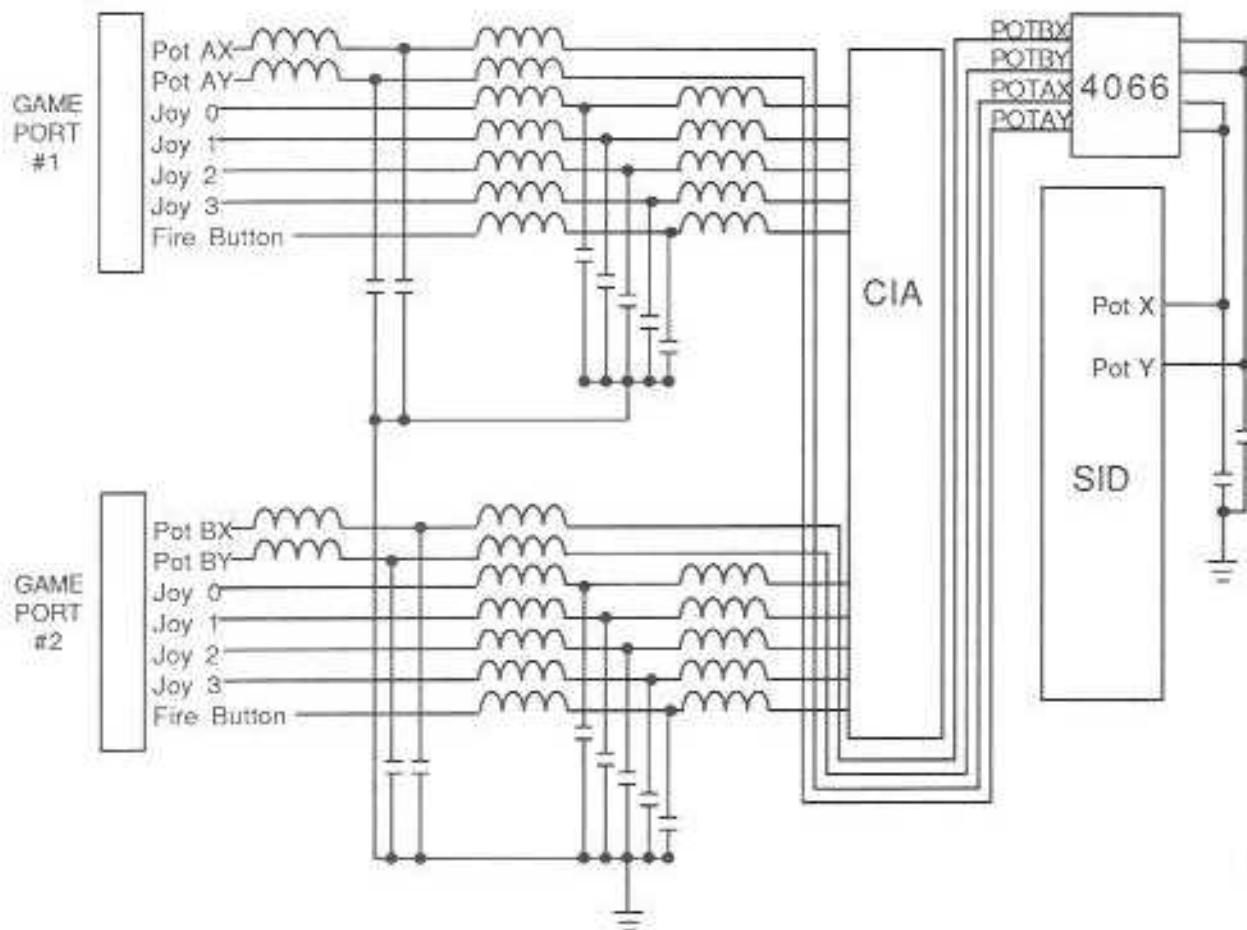
Fig. 2-31. The game port circuits.
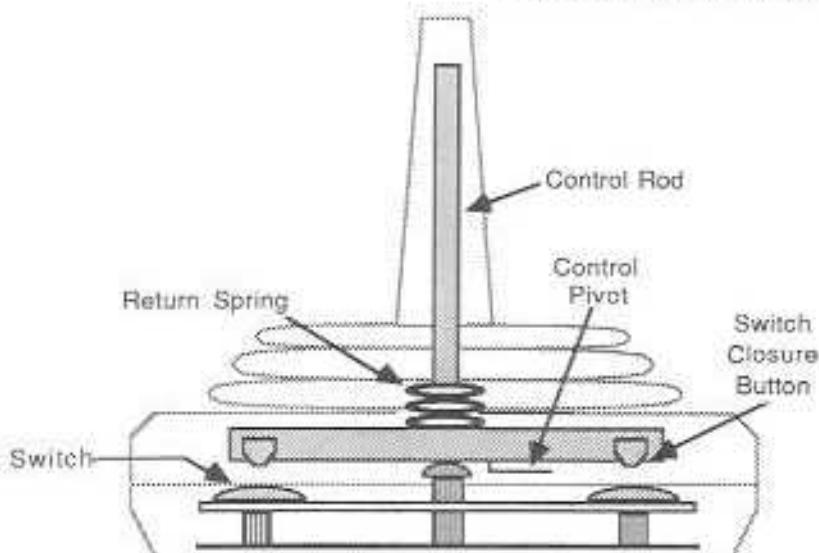
Fig. 2-32. Cutaway view of a joystick.

Game Ports

There are two ports located on the side of the Commodore 128. These multipurpose I/O ports are more versatile than any of the other ports on the computer. They can read switch-controlled devices such as joysticks, timing-dependent devices such as light pens, and resistive controllers

such as paddle controllers. They accomplish this by having more than one input controller. In fact, they are read and controlled by three separate devices: the CIA, the VIC chip, and the SID chip (Fig. 2-31).

To get an idea of the kinds of input received by the game ports, and why they require so many input devices, let's take a moment to look at some of the input devices they can read.

Joysticks

Fig. 2-32 shows a cutaway view of a typical joystick. Although you can only see two of the switches from this view, it contains five internal switches: four to detect up to eight directions and one to detect the "Fire" button. There are eight positions on the joystick which produce the following closure patterns:

Switch 1 only
Switches 1 & 2
Switch 2 only
Switches 2 & 3
Switch 3 only
Switches 3 & 4
Switch 4 only
Switches 1 & 4

To detect the position of the joystick handle when it is pushed to one of its eight positions, closing one or two of the contact switches inside, a

digital code is produced at the input lines of the joystick port (Fig. 2-33). This code is then captured by the CIA chip and the value is transmitted to the computer. The code can then be used by a program to determine which direction the stick was pushed. Interestingly, the memory locations that correspond to the joysticks are the same locations on the CIA chip that read the keyboard (56320 and 56321); however, when the CIA is reading one of the joysticks, only the first five bits of the I/O port are used.

The Commodore 1350 Mouse is read in exactly the same way as a joystick. It contains all of the circuitry internally to convert mouse movement into direction-switch closures.
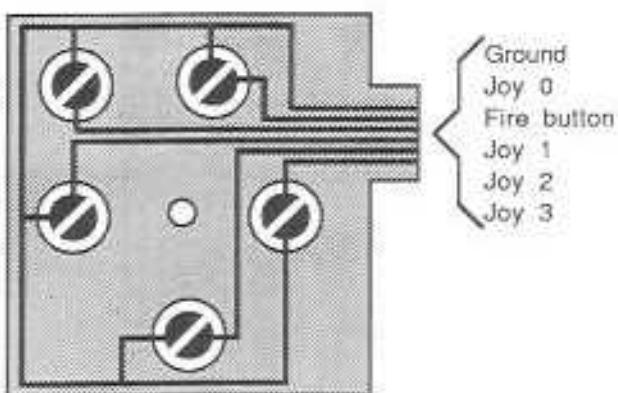
Paddle Controllers

The paddle controllers are actually variable resistors with a "Fire" button (Fig. 2-34). Since they are not switch-closure devices, they cannot be read by the CIA chips, so instead, the information from the paddles is transmitted through the analog switch (4066) to the SID chip which can read non-digital data.
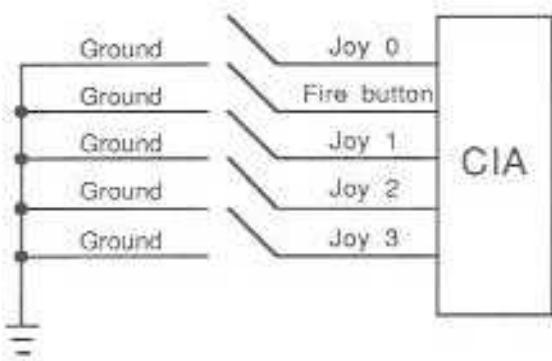
At the SID chip, the actual resistive values of the paddle is converted (via an A/D converter) to a numeric value which is stored in memory locations 54297 and 54298.

Light Pen

The light pen is a device that detects a pulse of light from the video display. In so doing, it allows the computer to determine the actual position of

(A) Board layout.   (B) Equivalent circuit.

Fig. 2-33. Joystick PC boards.

Control shaft

Potentiometer

Pot A

+5

Pot B

+5

(A) Cutaway view.
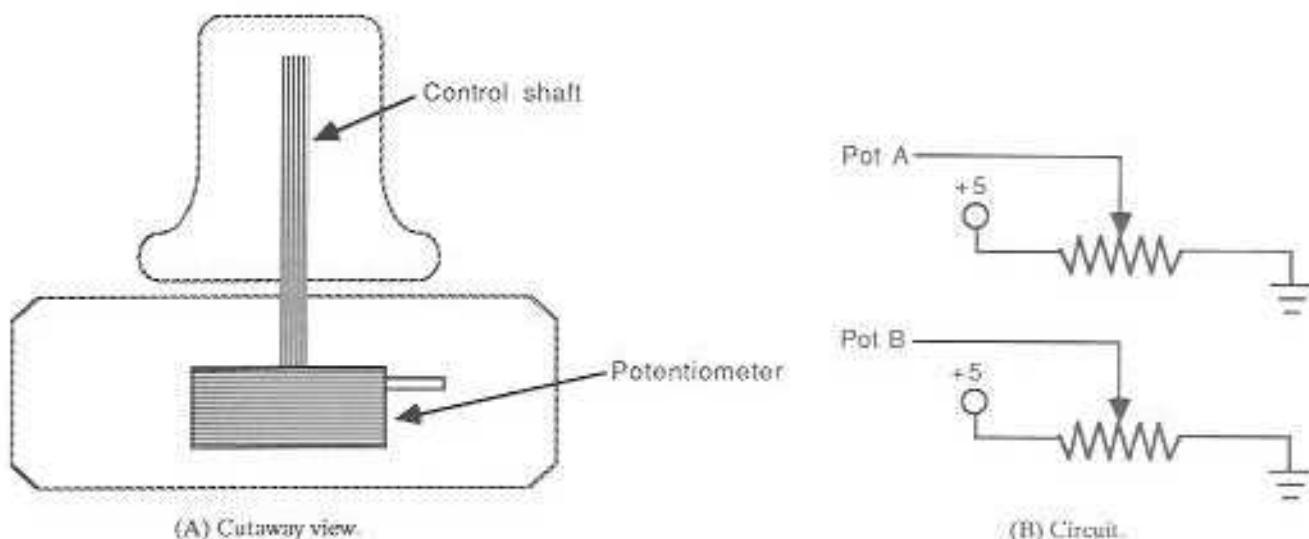
(B) Circuit.

Fig. 2-34. Cutaway view and circuitry of a paddle controller.

the pen on the screen, based upon timing calculations produced by the VIC chip.

To understand this process, you'll need to remember the discussion we had earlier about the video raster. The VIC chip is synchronized to the raster and has a clock pulse that corresponds to every dot (also called pixel) position on the display. While the VIC chip is reading out its video RAM it is keeping track of its position in memory numerically; after all, every dot in memory has to have a unique location for the VIC to find it.
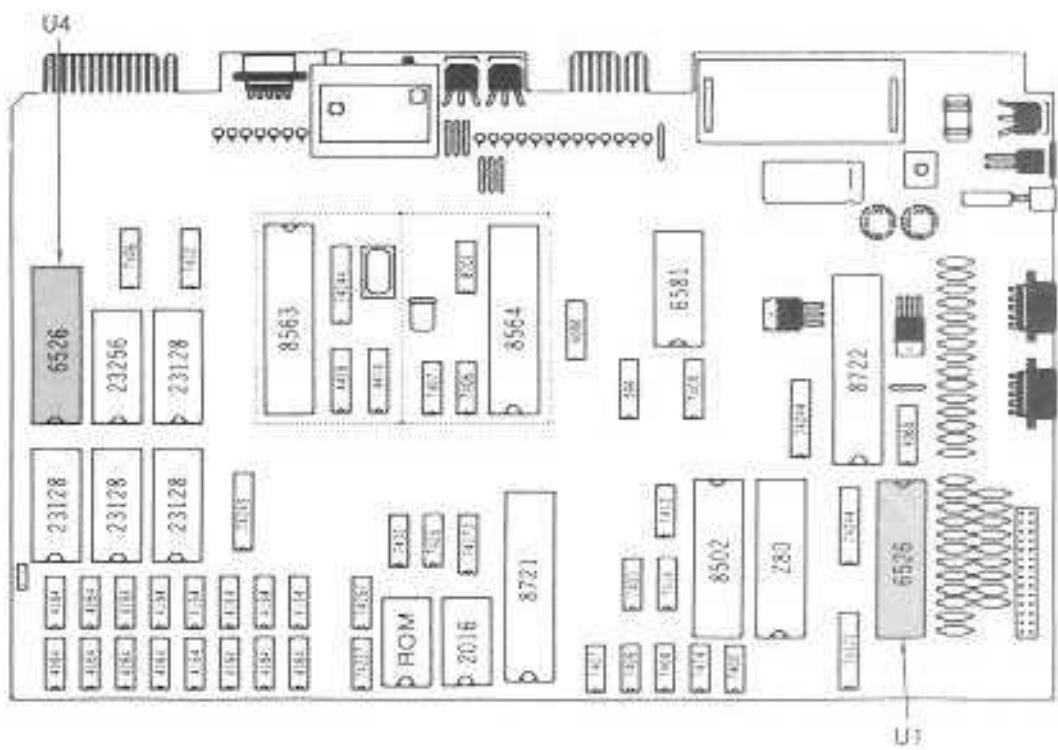
Fig. 2-35. Location of the 6526 CIA chips on the Commodore 128 processor board.

If, during the video scan, the VIC detects a light pen pulse (caused by the pen detecting the electron beam passing beneath it), the numeric value of that current pixel location is stored in two memory locations corresponding to the X (horizontal) and Y (vertical) positions of the light pen. They are 53267 (for the X position) and 53268 (for the Y position).

User Port and Serial Port

The user port and the serial port are both controlled by the second 6526 CIA chip called CIA2 at location U4 (Fig. 2-35).

The major difference between these two ports and the other ports that we have examined thus far is that they are bidirectional. This means that they are both input and output devices. The fact is, the user port is actually a parallel port, which is quite different from the serial port. What makes this interesting is that the CIA ports to which they are connected are essentially identical.

The way that the CIA accomplishes this small miracle is by making all of its I/O lines fully programmable. In other words, every line of both ports may (at any time) be either an input or an output. This switching is controlled through a pair of special registers in the CIA called the data direction ports, labeled DDRA and DDRB. The

control registers for this port are connected to memory locations 56576 through 56591.

Cassette Port

Unlike the other ports in the Commodore 128, the cassette port is controlled more or less directly by the 8502 microprocessor. The control lines for the cassette port are CASS SENSE (Cassette Sense), CASS WRT (Cassette Write), and CASS MTR (Cassette Motor). The first two lines contain strictly digital signals that are produced by the Commodore Datasette. However, the CASS MTR line is actually a power control line. If the microprocessor tried to control this line directly, it would burn up.

SUMMARY

In this chapter we looked at all of the major sections of the Commodore 128 processor board. At the same time, we examined how the computer operates and how the various parts interact. We saw how the various large circuits actually perform many more functions than their primary tasks and we saw how all of the I/O ports are polled.

In the next chapter, we'll take a look at basic troubleshooting techniques and examine the tools necessary for the job.

3

Troubleshooting Techniques

In general, the hardest part of fixing anything is figuring out what's wrong. The best way to determine where a failure has occurred is to be able to ask yourself (and effectively, the computer) the right questions. In this chapter, we'll examine the kinds of questions you should be asking and we'll learn how to use those answers to hunt down the problems.

IDENTIFYING PROBLEM AREAS

As you saw in Chapter 1, the Commodore 128 is not so much a collection of components as it is a collection of subsystems. Additionally many of the subsystems themselves consist of subsystems. For example the microprocessor is not a single component, but instead consists of two processors (the Z80 and the 8502) and an assortment of support circuitry.

The easiest way to troubleshoot anything is to find the defective subsystem or peripheral device (if the failure is not on the processor board) and simply replace it. This chapter centers in on how to identify defective subsystems, and how (and if) to replace them.

Components versus Subsystems

A component is a nonrepairable device. If it breaks or becomes defective it must be replaced. This is because it has no replaceable parts. Subsystems are collections of components that can (at least in theory) be disassembled and repaired. A transistor, for example is a component. If it becomes defective you cannot repair it. On the other hand, the video modulator is a subsystem. It has quite a number of individual components that can be replaced.

Isolating the Problem

The first thing that you need to do when you are looking for trouble (i.e., trying to figure out what is wrong with your Commodore 128) is to examine the symptoms. For example, if you have no video display, the first place you should look is the television or monitor. In other words, begin with what you can see. That way you'll have a place to start.

Confirming Connections

The first thing you need to do when you begin troubleshooting your Commodore 128 is to make

sure that it is properly connected. This includes the obvious, "is power connected?", "is the video display cable connected to the computer?" . . . . If you are not sure about the Commodore 128 connections, check the computer manual.

Once you have confirmed that the connections are correct, check for more subtle interconnection problems such as the printer and or disk drive configuration. Most peripheral devices require configuration. For example, the disk drives may be configured as device 8 or 9. Additionally, you may try removing any connected peripherals just to see if the computer will work properly all by itself. The configurations are a series of options that tell the software what kinds of devices are connected, to which I/O ports they are connected, and other essential information. If this information is left out or is incorrect, the Commodore 128 will either not work at all or may produce some very strange symptoms.

Looking for Symptoms

If you have test equipment such as voltmeters, logic probes, or oscilloscopes, good, but don't get them out yet. These are all excellent tools, but they will not find the problems by themselves. The most important tool is you. Test equipment is like a magnifying glass, it helps you to see things that are normally unclear or invisible. But all they do is make them visible. Your eye must still see them and you must analyze what you see.

Most repairs can be made without any test equipment, and often test equipment can become a distraction and inhibit clear observation and evaluation.

THE SINGLE-PATH METHOD

There are, of course, a great many different approaches that you can take in repairing your equipment. The trouble is that many approaches are either very time consuming or they are quite expensive. The best approach is one that will find the repair quickly and will not require the removal and replacement of any nondefective parts. The method that I use is the single-path method.

The single-path method is designed to repair only one defective component. This means that at any given time, we shall assume that there is only one device causing any specific failure. While this may not always be the case, you can never really identify and replace more than one defective device at a time anyway and, as you will see, following a single path will help to keep your thinking organized.

The steps to making a single-path repair are as follows:

1. Trust your senses.
2. Identify suspected failure area.
3. Remove or bypass the suspected device.
4. Retest system.
5. Replace defective component.
6. Retest system.
7. Repeat, if necessary.

Now that you know what the steps are, let's examine each of them in detail so you can actually use them in your repairs.

Trust Your Senses

The first tool(s) you should be using are your senses. Remember, electronic and other test equipment merely extend your senses. They are not a substitute for careful observation.

Smell
When electronic devices fail, they almost always get hot—very hot—and when they get hot they smell terrible. Use your nose to determine if a component has had a heat failure. With experience, a good technician can actually determine what kind of component has failed by its smell alone. Resistors, capacitors, and semiconductors each produce unique odors.

Sight
Look for obvious failures such as smoke emitting from a component. Devices can actually burn if they become hot enough. Look for bent parts, shorted leads, parts that have fallen off, and so on.

Sound

Listen for unusual sounds. Is there a whistling sound coming from the monitor that seems out of place while the Commodore 128 is running? Is the power supply humming loudly? Do you hear the sizzle of burning components?

Touch

Here you must be cautious. If you see or smell smoke, or if you hear a part sizzling, you may still not be able to identify it by simply looking at the Commodore 128. Sometimes you must touch the components to determine which one is hot. Be careful! Hot components can be hot enough to raise a blister.

Identify Suspected Failure Area

If you are unable to determine which component is defective from simple observation, your next step is to look at the Commodore 128 in terms of its major subsystems. For example, if the Commodore 128 is not working at all, you should check the power supply. Is the power light on? Do you have a picture at all? Is the Commodore 128 plugged in? Is the fuse blown (Note: The fuse is inside the power supply)?

If you are faced with a blown fuse, *do not simply replace it!* Fuses do not normally blow for no reason at all. They are designed to protect circuits and to prevent fires. If the fuse has blown you may be looking for a short in the wiring (such as a paper clip on the circuit board or a loose wire). In any event, approach fuse replacement with caution. Also, be sure to replace the fuse with an *exact replacement.* A fuse that is rated too low will generally cause the circuit to fail unnecessarily and a fuse that is too large may cause serious damage to the circuit(s) it was supposed to protect or may even cause a fire. Remember, the fuse is designed to protect a circuit from drawing too much current and becoming too hot.

Remove or Bypass the Suspected Device

Once you have a suspected component in hand, bypass it if you can, before you replace it.
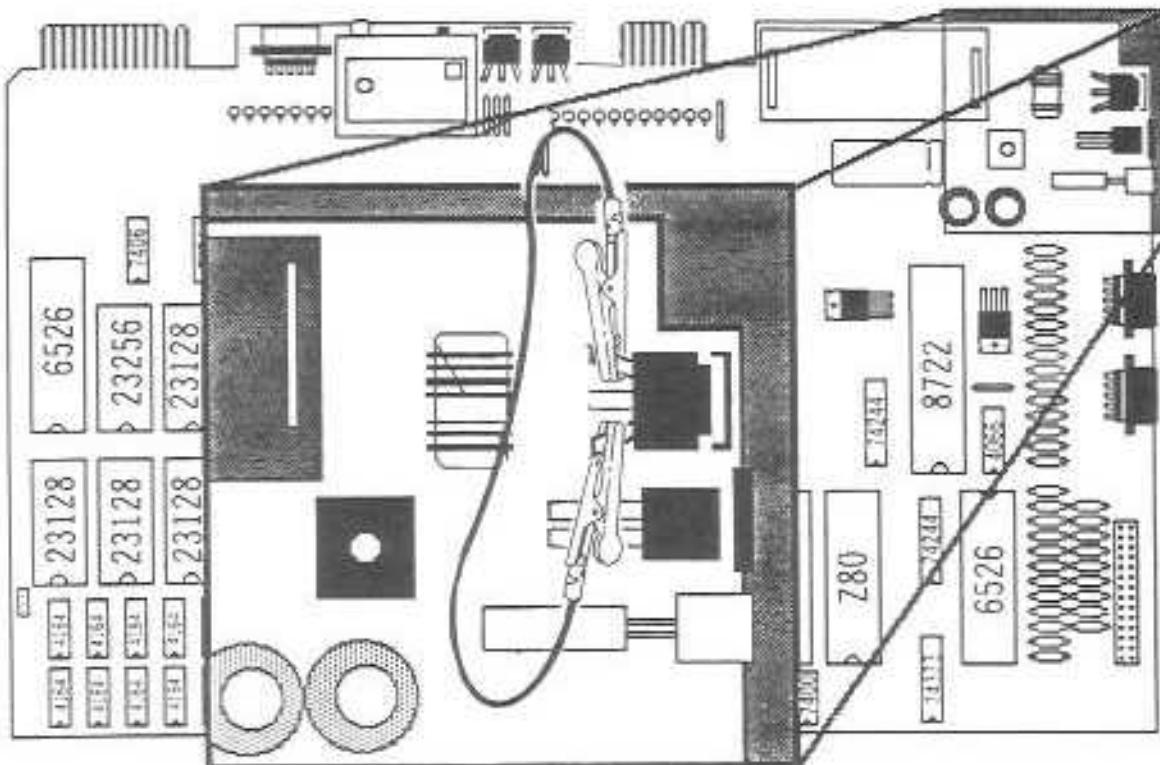

Fig. 3-1. Bypassing the power switch.

For example, suppose that you believe that the power switch is defective. Normally the power switch is in the "on" position when the computer is running. Try using jumper wires to bypass the switch if you cannot get power to the computer (Fig. 3-1). By doing this you will be able to determine whether a part is defective or not without having to replace it. Note: when bypassing the power switch, take care to avoid shorting other circuits that are near your clip leads.

Retest System
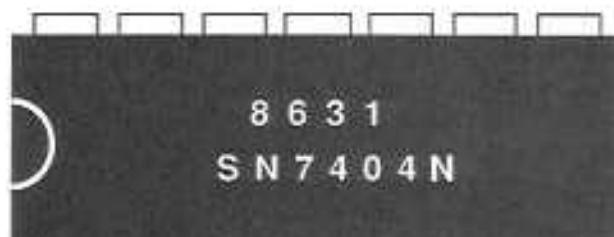
Whenever you make a diagnosis, retest the system one more time before you make your repair using this very specific process. First, turn off power to all devices (i.e., Commodore 128, and other peripheral devices). Then power up the system as you would normally. Finally, retest the system.

The reason that you should power down and then up again is because sometimes, during a test procedure, it is possible to set up electrical conditions that would not be present during normal operation. By powering down and then up again you can validate your test results more accurately.

Replace Defective Component

Once you have determined which device is defective, look at the old part carefully before you actually remove it. Be sure you understand how it is connected. Look for identifying marks that might indicate a special orientation in the Commodore 128 such as the pin 1 notch in an integrated circuit (Fig. 3-2).

Finally, once you have looked at the old part carefully (and made a sketch of it and its orientation if necessary), remove the old part and carefully put it in a safe place. Do your best to not damage the part when you remove it. You may find that you replaced the wrong part and if you have not damaged the old one, you may be able to use it again some other time. Before you insert, attach, or connect the new part, look at it carefully. Does it match the old part perfectly? If it does not, is it an acceptable replacement? Check with the manufacturer if you are not sure. Sometimes subtle differences can make quite a difference in

Fig. 3-2. Identifying pin 1 on an integrated circuit.

performance. For example a 74LS123 is not the same as a 74123 or a 74C123.

Retest

Finally, retest the Commodore 128. No repair is complete until you have confirmed your repair by testing the Commodore 128. Test the Commodore 128 in each mode it normally operates such as 40- and 80-column mode as well as CP/M. Make this a comprehensive test. It is possible to repair one part of a Commodore 128 and cause a failure in another part.

Repeat, If Necessary

Last, if you do find another problem (or the old one again) start over at step 1 and *do not be discouraged*. Repairs are often multipass processes. The important thing is to remain calm and stay organized. If you become frustrated, stand up, walk around, and try again later. The most destructive force to any piece of equipment is a defective repair technician.

TOOLS AND TEST EQUIPMENT

Just as a telescope allows us to see some stars and planets that would be beyond the capabilities of our normal sight, electronic test equipment allows us to "see" electronic signals that are invisible to our eyes. In this section, we'll take a look at the tools that you might want to have in your toolbox and how they work.

Mechanical Tools

Mechanical tools are at least as important to making electronic repairs as are the electronic tools. After all, electronic tools are used only for diagnosis and there are (as you read before) many approaches to diagnosis. On the other hand, you will *need* mechanical tools to make the repairs. (If you don't believe this, try loosening a tight screw with your fingers sometime.)

Although you won't always need all of these tools, the following list is a good guide.

> Flat-blade screwdrivers
> Phillips screwdrivers
> Tweezers
> Forceps
> Soldering iron
> Solder vacuum tool
> IC removal tool
> IC insertion tool

One thing that is certain to lead to frustration is finding the problem in your Commodore 128 and not being able to fix to it because of a missing tool. To avoid this, look at the screws, nuts, and bolts on the Commodore 128 carefully when you begin the repair, and get the tools you'll need before you start. It is all too easy to strip out the head of a screw by using the wrong size or type screwdriver.

Soldering Irons

Soldering irons are not all alike. They can be purchased with different tips (Fig 3-3) and in different heat ranges. The ideal iron should have a small chisel tip, or a small round tip, and be within the range of 20 to 35 watts (preferably 25 watts). The wattage will determine the heat of most soldering irons.
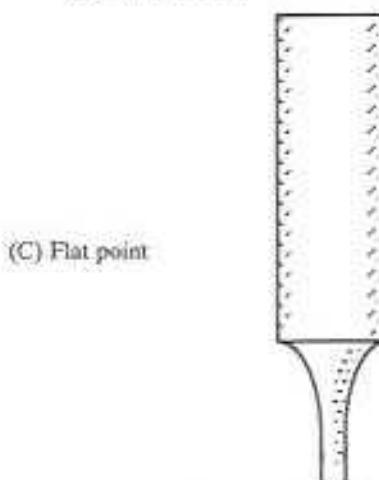
Avoid "soldering guns" for working on computers. These are generally too hot and are difficult to control in delicate electronic circuits.

(A) Chisel point. (B) Round point.

(C) Flat point

Fig. 3-3. Soldering irons.

Special Tools

In addition to the more common kinds of tools such as screwdrivers, pliers, and so on, there are many special tools that can make repairs much easier. Some of these are given in the following:

Solder Vacuum Tool
The solder vacuum tool (Fig. 3-4) is a device that actually "sucks" the solder out of a connection after you have softened it with the soldering iron.

Fig. 3-4. Solder vacuum tool.

IC Removal Tool

The IC removal tool (Fig. 3-5) is used to pry integrated circuits that have been desoldered or are socketed out of the circuit board.
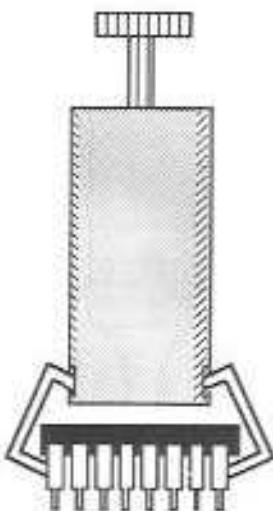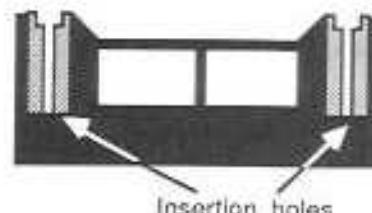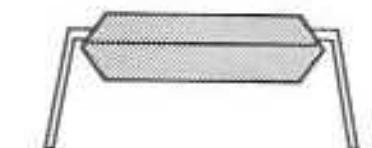
Fig. 3-5. Integrated circuit removal tool.
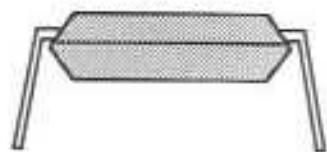
IC Insertion Tool

Most integrated circuits have legs that are slightly splayed (bent outwards). This makes them sit more firmly in their sockets after they have been inserted (Fig. 3-6). Unfortunately, this also makes them a bit more difficult to insert since the insertion holes in circuit boards and sockets are parallel.

To insert the IC by hand, you need to first insert one row of pins into the socket and then,

Insertion holes

(A) Socket alignment.

Insertion holes

(B) Circuit board alignment.
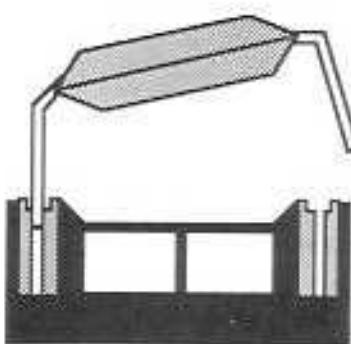
Fig. 3-6. Angle of IC legs versus angle of socket and circuit board holes.

using even pressure, align the second row of pins with their associated holes as shown in Fig. 3-7.
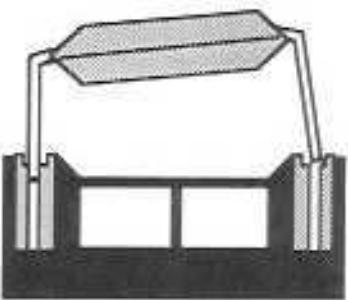
To insert the IC with the insertion tool, simply insert the IC into the tool and press the IC into place in the socket or the circuit board as shown in Fig. 3-8.

Electronic Tools

In addition to the mechanical tools mentioned in the foregoing, there are a number of electronic tools that you may find useful in your repairs. Some of these are:

(A) Aligning the first row of pins.

(B) Aligning the second row of pins.

Fig. 3-7. Inserting an IC.
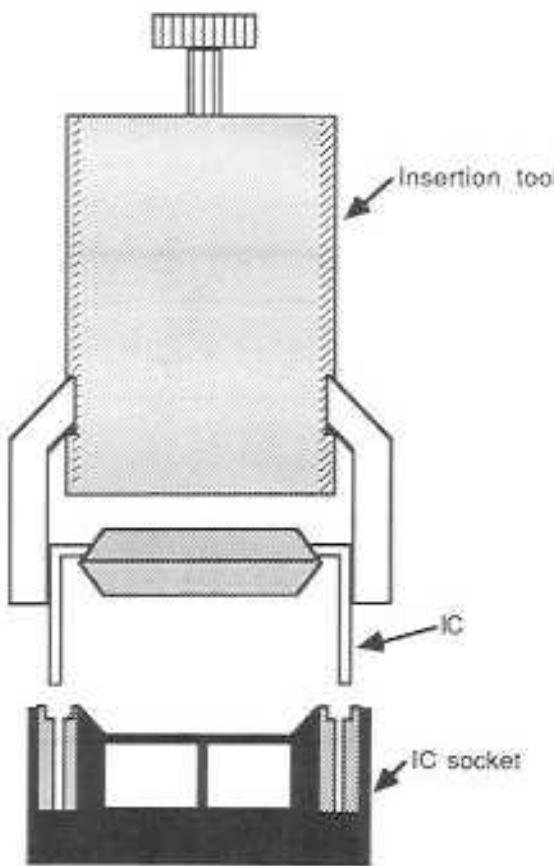
Fig. 3-8. Inserting an IC with an insertion tool.

1. Logic probe
2. Voltmeter
3. Oscilloscope

In this section, we'll take a look at what each of these tools does and how it works.

Logic Probe

Logic probes (Fig. 3-9) are digital devices. This means that they examine the logical states of your circuit. Most Commodore 128s use logic circuits to operate and the logic probe, properly
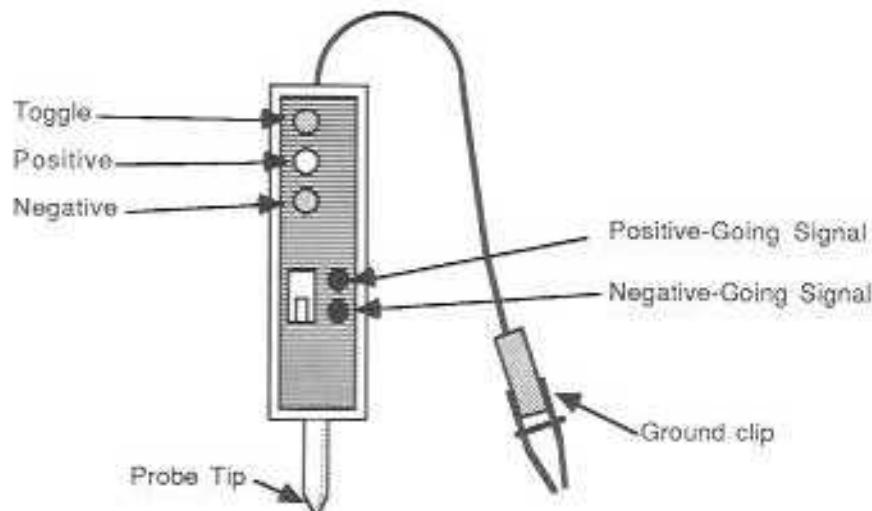
Fig. 3-9. Typical logic probe.
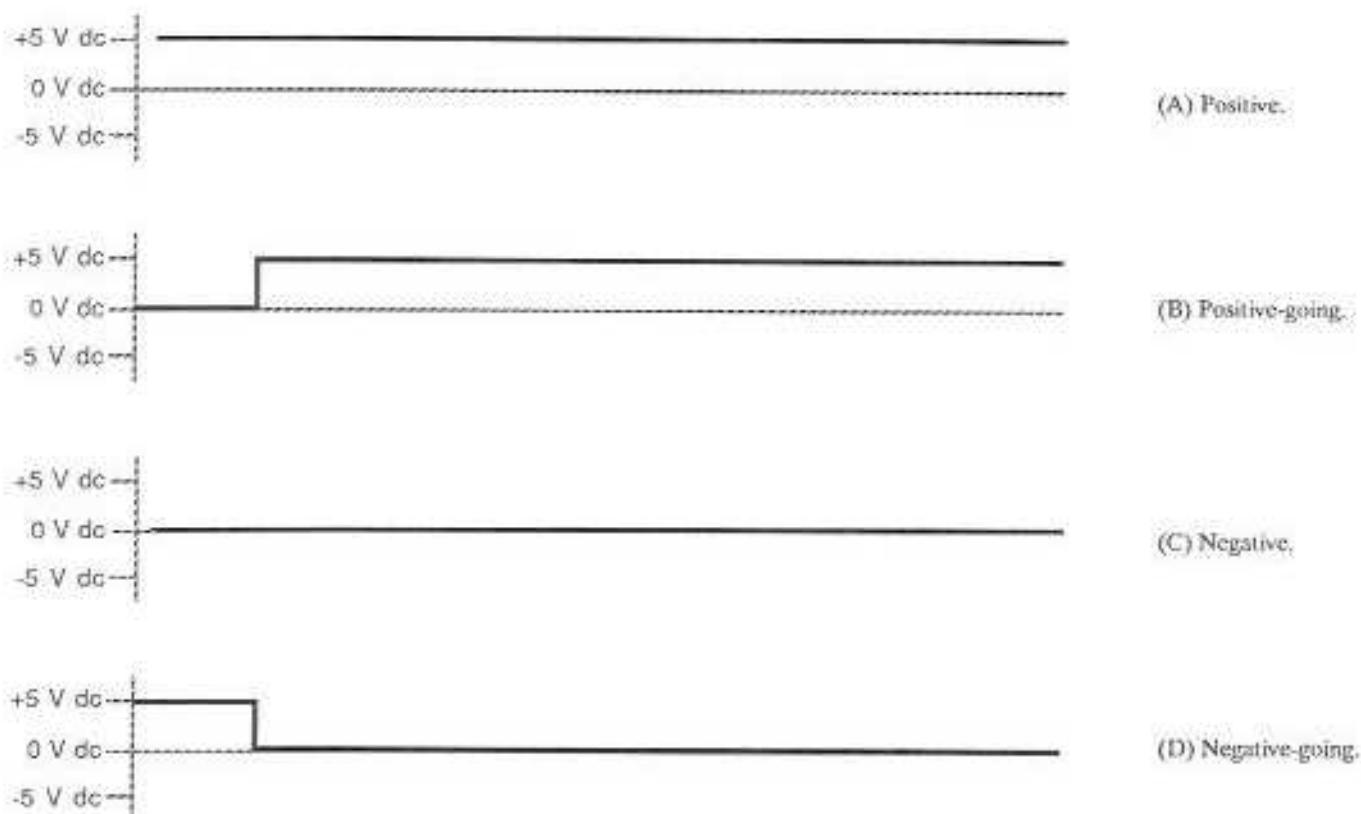
Fig. 3-10. Logical signals.

used, can help to identify logical problems in the circuit.

The indicators on logic probes usually consist of one, two, or three lights. These may be incandescent bulbs or light emitting diodes (LEDs). The lights indicate a positive signal, negative signal, or a toggle (also called a clock) signal.

Logic probe controls are usually quite simple They include a trigger which determines what type of signal will make the probe light (positive, positive-going, negative, negative-going, or toggle) and an on/off switch. A positive signal is one that is at a steady-state, logical high level. A negative signal is one that is at a steady-state, logical low level.
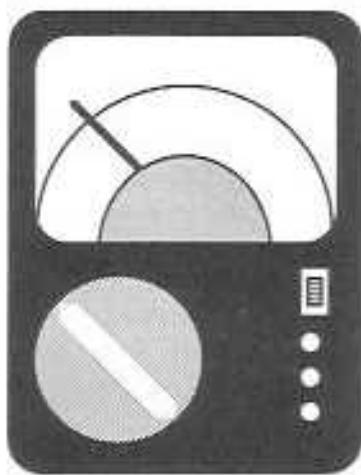
Positive-going and negative-going signals are in transition. They are changing from high to low (negative-going) or from low to high (positive-going). Figure 3-10 shows how these signals might look to a logic probe.

Multimeter
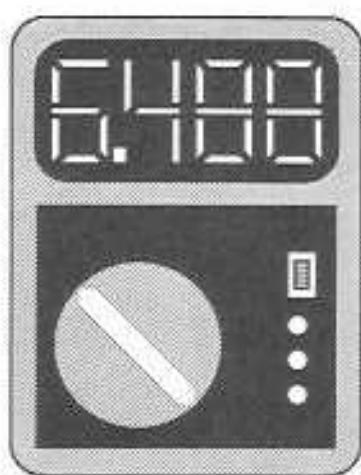
Multimeters are available in two varieties: analog and digital (Fig. 3-11). Both of these kinds of meters are similar in function but an analog multimeter has a mechanical indicator consisting of a scale and moving-arm while a digital multimeter uses a digital display. Do not be misled by the fact that digital meters provide numeric displays, they are *not* inherently more accurate than analog meters although they are easier to read for small differences. To determine the accuracy of a meter you must read its specifications.

Multimeters are designed to measure voltages, electrical resistance, current, and (sometimes) frequency and decibels although you will not need the frequency and decibel functions to repair most Commodore 128s.

If you must measure current, check the amperage rating of your meter. Current measurements are made with the meter *in* the circuit and you can destroy your meter if the current you measure exceeds the meter rating.

(A) Analog.

(B) Digital.

Fig. 3-11. Multimeters.

Oscilloscope

Oscilloscopes are the most sophisticated piece of test equipment that you will ever need in troubleshooting a Commodore 128. Oscilloscopes are not, however, as difficult to use as they might appear to be at first glance. Essentially, all they do is convert electrical signals into a visual representation on a video display.

Under most circumstances, electronic signals change at a predictable rate. The oscilloscope produces a "trace" which is actually a dot that moves horizontally across the screen at a specific rate which you may adjust. The electrical signal is then used to deflect the dot up or down, depending on the input voltage at that instance. The screen continues to glow for a long enough period that the entire trace (Fig. 3-12) can be viewed on the screen.

There are many more functions that can be done with an oscilloscope; however, each is simply a derivation of simple trace deflection.

REPAIRS: GUIDELINES AND CAUTIONS

The most important part of making a repair is being able to put the Commodore 128 back the way it was. This means that you'll need to stay organized, make notes as you go, and keep track of which screw went where. On one occasion (in
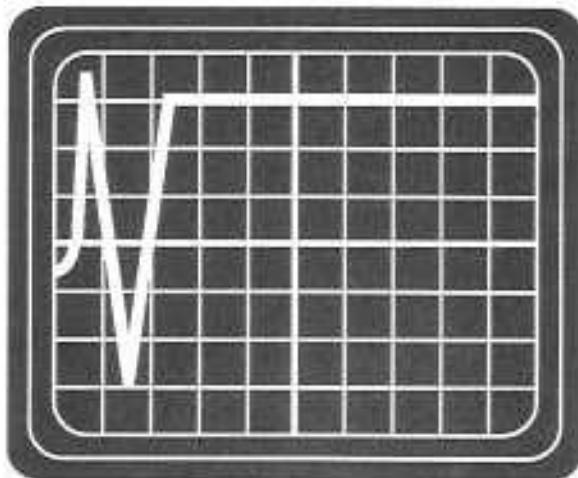
Fig. 3-12. Oscilloscope display.

which I was rushing to make a "simple" repair) I accidentally mixed up some of the hardware attaching a circuit board to the frame of a Commodore 128 and wound up driving a screw through the circuit board, and on through the case of the Commodore 128. Needless to say, I am reminded of my error every time I use my computer.

The best way to keep track of screws is to simply insert them back partially into the holes from which they came (Fig. 3-13) as you remove them. If this is impractical, use an egg carton to store individual components that you remove and label the individual egg troughs carefully (Fig. 3-14).

(A) Assembled.

(B) Disassembled.
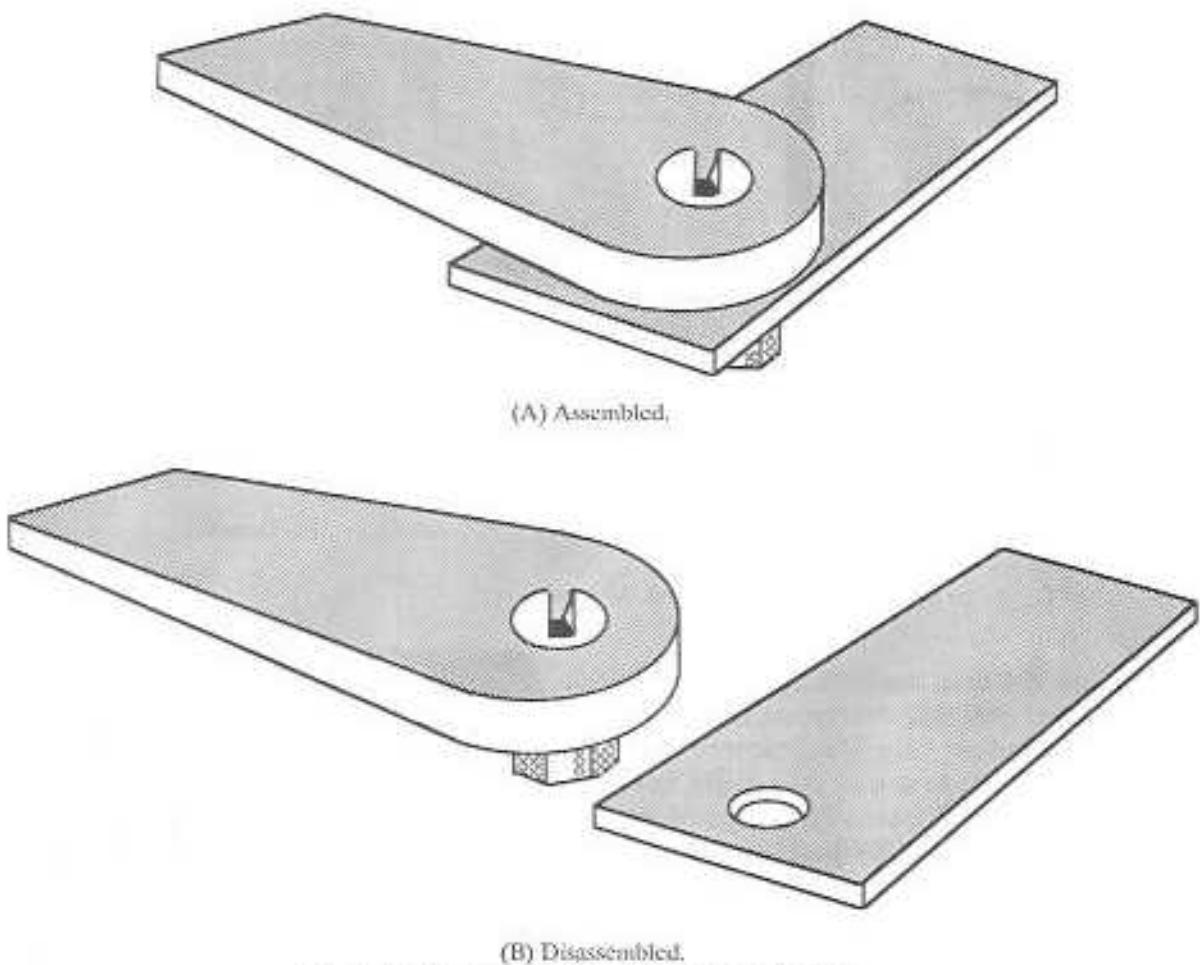
Fig. 3-13. Storing screws in their original locations.
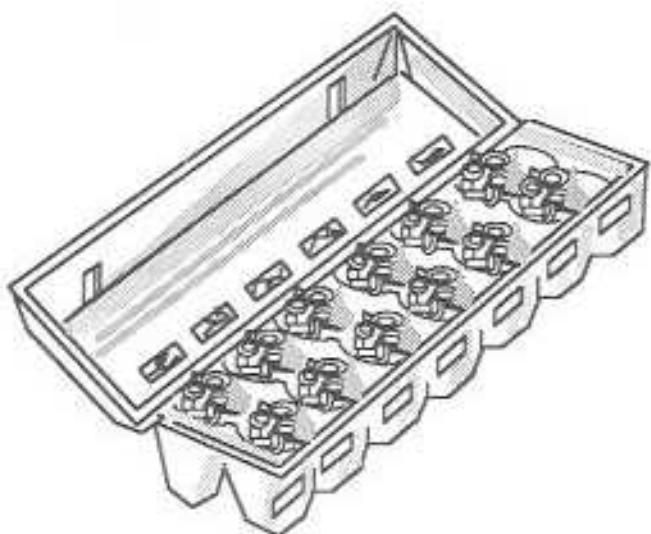
Fig. 3-14. Egg carton storage system.

Caution! High Voltage

Although the power supply that is connected to the Commodore 128 produces low voltages such as 5 volts and 9 volts, the other end of the power supply is connected to the 117-volt house current. Although most of us have come to look at house current as a safe commodity (which it is if contained in closed appliances) it can produce potentially lethal shocks if mishandled. Whenever you are working on an open appliance especially the power supply but also within the Commodore 128 with its covers off, you are exposing yourself to some level of danger—even 5 volts can burn you if you short it out. Keep your hands and tools away from the power supply and never short any connections while the power is on.
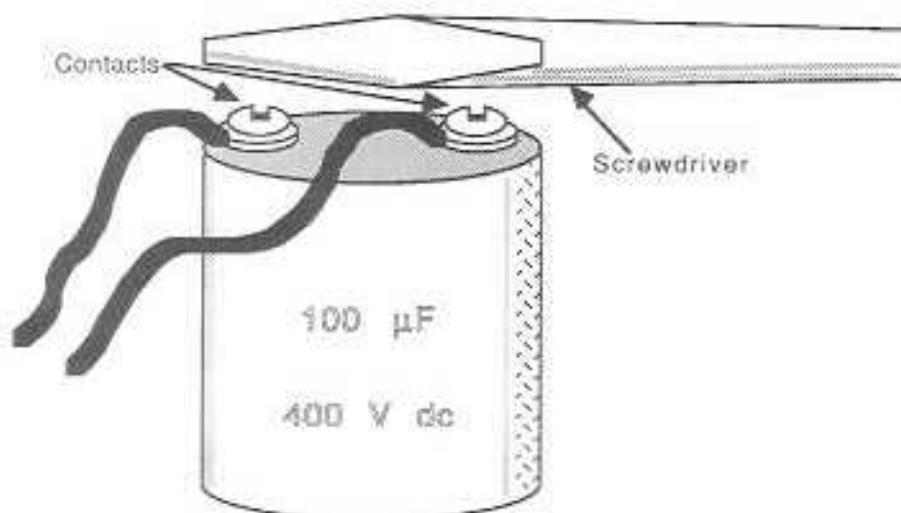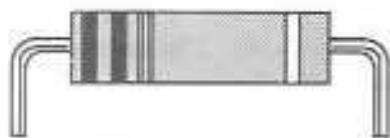
Fig. 3-15. Discharging a capacitor.

Capacitors
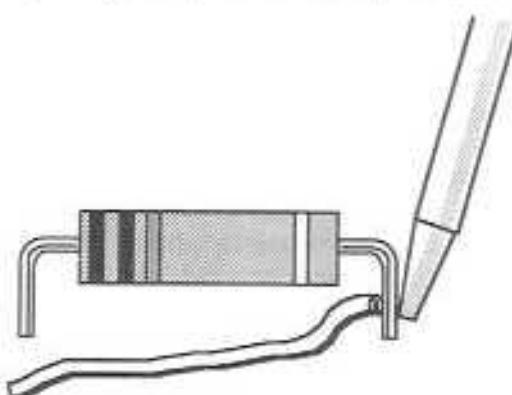
Capacitors are devices that are designed to hold a charge. Some of the larger ones can hold a charge for several days, even if the power has been disconnected. Always approach large capacitors with caution. If you are in doubt whether a capacitor has a charge or not, discharge it by shorting both terminals together with a large metal tool like a screwdriver as shown in Fig. 3-15.

SOLDERING TECHNIQUES
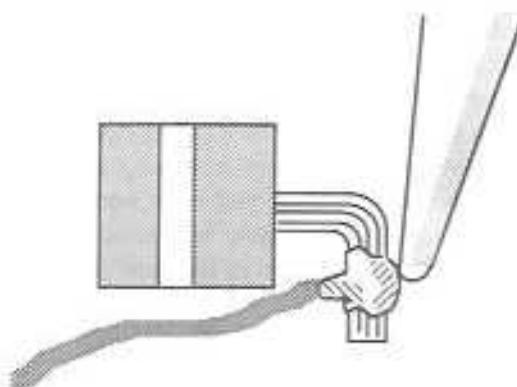
One of the most important skills you need to have before you begin any electronic repair is soldering.
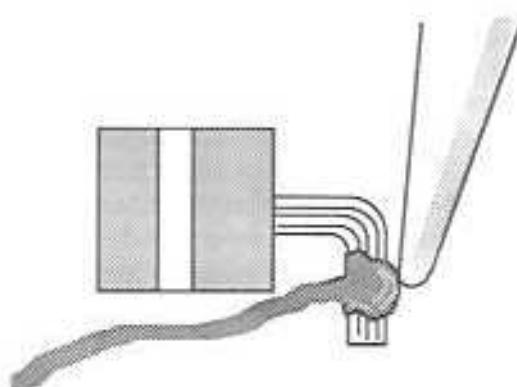
(A) Component leads.

(B) Applying heat and solder.

(C) Rosin cleaning and coating surface.

(D) Solder bonding with metal contact.

Fig. 3-16. The soldering process.
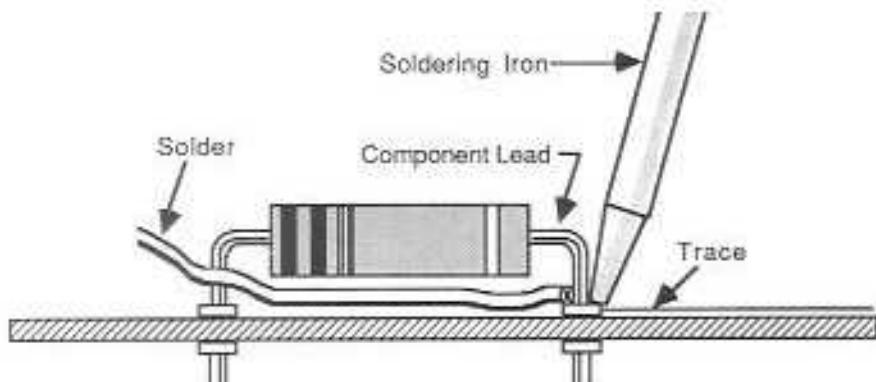
Fig. 3-17. Soldering a component to a circuit board.

Soldering is more than simply making a connection hot and either adding or removing solder from the connection. Circuit boards and electronic components are sensitive to heat, mechanical force, and static discharges.

Soldering a Component Into a Circuit

Since soldering a component into a circuit is easier than desoldering and removing a component, we'll look at how to insert a component first.

To begin with, let's look at the physics behind soldering. Most electronic components have either gold, copper, or solder-plated copper leads. This is because copper and gold are excellent conductors and solder (which consists primarily of the metals lead and tin) adheres well to both of them. When the solder is melted and brought into close contact with the gold or copper leads, it forms an intermolecular bond and produces an excellent electrical and mechanical connection.

In order for the solder and the component leads to make this connection, however, the contact surface must be perfectly clean. Unfortunately metals like copper oxidize naturally as a function of being exposed to air. To clean off the oxides and other contaminants, most electronic solders include a rosin core which, when heated, cleans off the metallic surfaces and forms an airtight seal until the solder flows in (Fig. 3-16).

Since most soldering is done for the purpose of attaching a component to a circuit board, the best approach in soldering is to heat the component lead, the circuit board trace, and the solder at one time as shown in Fig. 3-17.

By following this process, all of the components of the soldering process are at the same temperature and the solder joint will be made in the least amount of time. This results in the least amount of excess heating and mechanical stress.

Removing Components

Component removal is similar to inserting components with one, small exception. When you are inserting a component, it is normally going into a nice, clean hole. When you are removing a component it is usually attached to that hole by some very stubborn solder. To remove the component, you must first remove "all" of the solder and then break the lead free with a small pair of needle-nose pliers (Fig. 3-18). The component may then be withdrawn from the circuit.

Adding Sockets

Naturally, the more leads a component has, the more difficult it is to remove the component. ICs are the most difficult devices to remove from circuit boards because of their many leads. In fact, once you have removed an IC, it is better to solder a socket into that location and plug the new part into the socket. Then, if you ever need to replace the same part again, all you will need to do is pry out the old part and press in the new one.

Static Sensitivity

Although most electronic components are protected against static discharge, they are almost all

(A) Heating the joint.

Soldering Iron

Solder Vacuum Tool

Soldering Iron

(B) Sucking out the solder.

Needle-Nose Pliers

(C) Breaking the solder contacts.
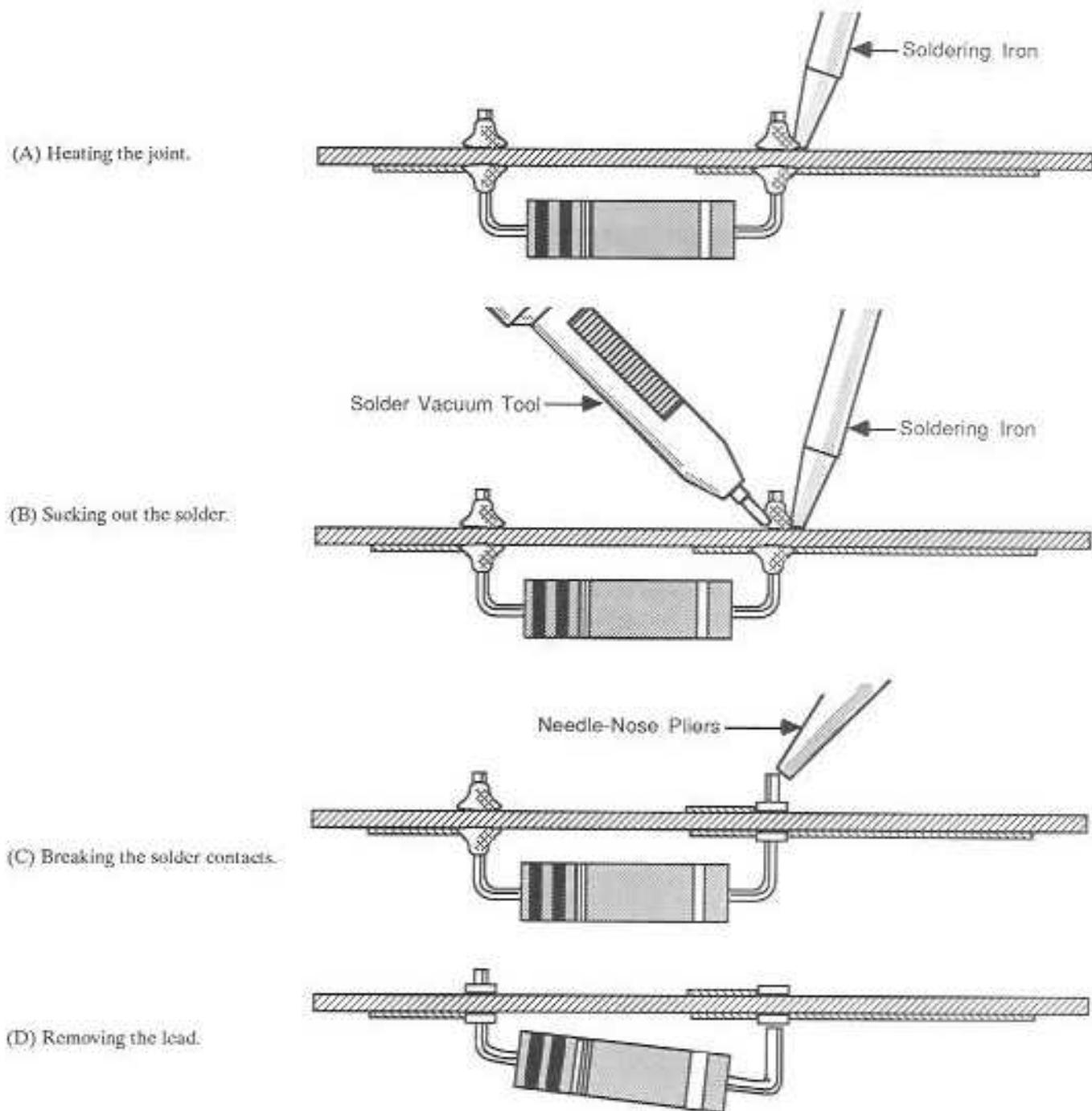
(D) Removing the lead.

Fig. 3-18. Removing an electronic component from a circuit board.

somewhat sensitive; especially the large ICs and memory chips. The least sensitive of the integrated circuits are the components that have part numbers beginning with 74 such as 7400, 7404, and so on. The more sensitive components are the CMOS and NMOS microprocessor-type circuits. In any event, you will want to make sure that you do not touch the leads of an IC while it is out of its circuit board. This precaution will protect you from destroying valuable ICs when you insert them. Figure 3-19 shows the best way to handle ICs when you are inserting them into a socket or a circuit board.
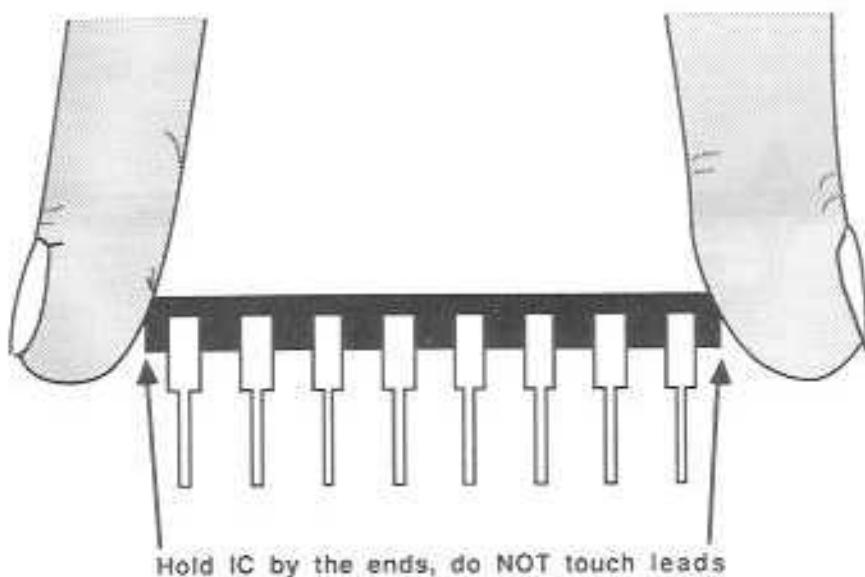
Fig. 3-19. Avoiding static discharges while handling ICs.

Hold IC by the ends, do NOT touch leads

FINISHING UP

There are any number of problems that can occur at the end of a repair that may cause you grief. The first of these is running out of parts before you are finished putting the Commodore 128 back together. If you keep track of all parts as you take the Commodore 128 apart, you should not have to face this problem.

The converse is also true, you should not have extra parts when you are done putting the Com-

modore 128 back together. The best rule is: stay organized.

Finally, never modify the Commodore 128 design. Many new technicians occasionally leave parts out because they are hard to put in and "... it won't make a difference anyway". Remember, manufacturers do not normally want to spend money adding unnecessary parts to their products. If the part was there when the Commodore 128 was built, there must be a reason for it ... put it back in.

Digital Logic Circuits

The majority of the Commodore 128 consists of logic circuits. Before covering specific trouble-shooting approaches an understanding of digital logic circuits is necessary. In this chapter we'll look at how digital logic circuits work (and fail).

All digital logic circuits, whether they are simple or complex, are based upon the operation of tiny, transistorized switches. In fact, electronic switches perform logically in much the same way that light switches do—that is, they turn circuits on and off.

Since light switches and digital logic switches work similarly, let's take a look at a light switch and examine how it works . . . logically.

LOGIC GATES

AND

Figure 4-1 shows a light circuit which includes a switch, a light bulb, an ac power source (117-volts ac in this case) and the wiring to connect them. In this example, when the light switch is down (on) the electrical current is able to reach the bulb. Of course, when the switch is up (off) it cannot. If the bulb is good, *and* the switch is on then the bulb will light. This is a logical AND circuit. Both the switch on and the bulb good factors must be present for the bulb to light. If either is not true (if for example we had a burned out bulb) then the bulb will not light.

Although this was a very simple example, really digital logic is not more difficult than this. The only tough part is remembering all of the different devices and how they interact. For example, Fig. 4-2A shows the symbol that is used to represent an AND device. This can be any logical device that accepts two or more inputs and produces an output that follows the rules set out in the AND truth table (shown in Fig. 4-2B).

In the example of Fig. 4-1, it's a little difficult to test the circuit logically because one of the elements—the light bulb—is normally always good and as a result, the light switch almost always is the only controlling device. If we used two light switches instead and wired them up like the circuit in Fig. 4-3, we could use the switches as the inputs and the light bulb as the output. Now, if switch A is on *and* switch B is on the light will light. If you use any other combination of switch settings, the light will be off. Thus the circuit in Fig. 4-3 is an AND circuit.
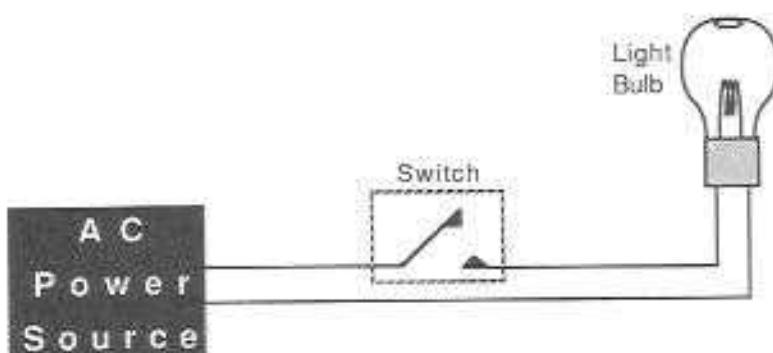
Light
Bulb

Switch

Fig. 4-1. Light
switch circuit.

A C
P o w e r
S o u r c e

'AND'
Truth   Table

A	B	C
T	T	T
T	F	F
F	T	F
F	F	F

(A) Truth table.

A ———
         C   (B) Symbol.
B ———
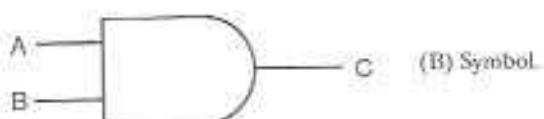
Fig. 4-2. The AND symbol and truth table.

OR

The OR is almost the opposite of AND Figure 4-4 shows a light-switch arrangement that demonstrates the OR function. As you can see, in Fig. 4-4, if either switch A *or* switch B is on then the bulb will light. A quick look at the truth table for the OR function shows that, unlike the AND function which has three false conditions and only one true condition, the OR has three true conditions and only one false condition.

As you can see from the preceding examples, every logic function that we've looked at is a combination of the simple on/off switch. In fact, every logic function is also some combination of on/off

functions. To make the electronic design process a bit simpler (and faster) the companies that manufacture logic devices have combined numerous logic devices (which they call logic gates) into single electronic components called integrated circuits (also called ICs). Each integrated circuit may have from one or two to thousands of logic gates in them. In this section, we'll take a look at the more common logic gates and how they can be combined to form more complex devices.

Other Logic Gates

Figure 4-5 shows the symbols and truth tables for most of the commonly used logic gates. Notice that some of them are very similar except that they have small circles at their outputs. This small circle indicates an inverted output device. They are identical to their noninverted counterparts except they produce a false output for the conditions when the noninverted device produces a true output (and vise-versa). For example, the AND gate looks very much like the NAND gate. In fact, AND and NAND are exact opposites, as are OR and NOR.

Now look at the small, triangular gate called an *inverter*. Inverters are used to switch the output of a gate from true to false or from false to true.

The counterpart to the inverter is called a *buffer*. Although buffers do not produce any logical changes in a circuit, they do perform electrical and timing functions that allow logic circuits to perform tasks that they would otherwise be unable to do. We'll take a look at the kinds of things that buffers do, and how they are used later.

Fig. 4-3. Two-switch AND circuit.
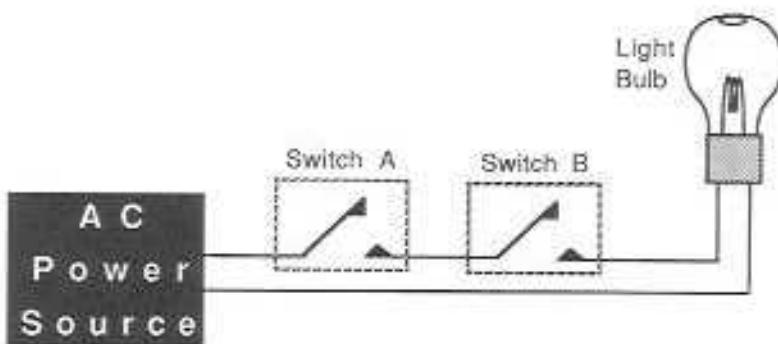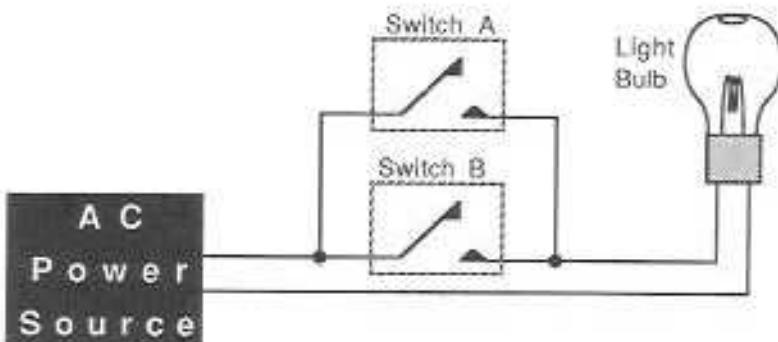
Fig. 4-4. The OR light switch circuit.

COMBINING LOGIC FUNCTIONS

As individual components, the logic devices that we've looked at so far are fairly powerful, however, there are few real tasks that any one gate can perform alone. Under normal circumstances, logic gates are combined to produce complex logic functions specifically designed to perform certain tasks. To get a better idea of how this works, let's take another look at the light circuits discussed earlier. Suppose you had a long hallway with a light bulb in the middle and you wanted to be able to turn the light on or off from a switch at either end of the hall (Fig. 4-6). This is clearly more complex than a simple AND or OR function. It can, however, be solved by combining several gates. Before we design the actual wiring diagram, let's look at the way that the logic devices might be connected to accomplish this function.

One way to produce this circuit (and I am sure you can find others if you try) is to make the light turn on when both switches are in the same position (i.e., both on or both off). So we'll need

one gate which will look at the switches and become True if both are on (Fig. 4-7).
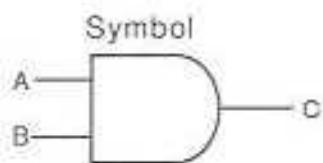
Second, we'll need a gate that is connected to the same switches and becomes True when both switches are off (Fig. 4-8).

Incidentally, an easy way to determine the kind of gate that you need for a particular application is to look at the function (in Fig. 4-8A an AND), and determine the kinds of signals that will be needed to make the gate True (in this case, both off). Drawing an AND gate with two negative inputs (small circles at the inputs) will produce the desired results (Fig. 4-8A). By creating a Truth Table for this nonstandard device and comparing it to the standard devices, we find that this device has the same Truth Table as the standard NOR gate in Fig. 4-8B (see Fig. 4-5).
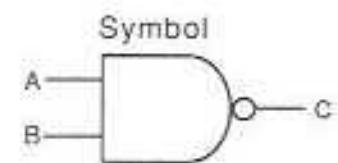
Finally, we want the light to go on if either the AND gate's conditions have been met *or* the NOR gate's conditions have been met. Otherwise we want the light to be off. Now, we know that it is physically impossible for both of the gates to be on at once (since the switches cannot be both on and off at the same time), so the final gate can be

AND

Truth Table

A	B	C
T	T	T
T	F	F
F	T	F
F	F	F

Symbol
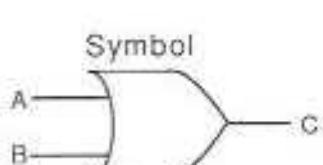
NAND

Truth Table

A	B	C
T	T	F
T	F	T
F	T	T
F	F	T

Symbol

OR
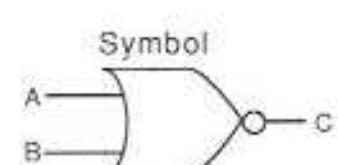
Truth Table

A	B	C
T	T	T
T	F	T
F	T	T
F	F	F

Symbol
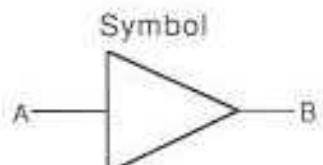
NOR

Truth Table

A	B	C
T	T	F
T	F	F
F	T	F
F	F	T

Symbol
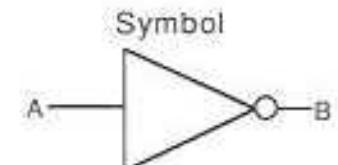
BUFFER

Truth Table

A	B
T	T
F	F

Symbol

INVERTER

Truth Table

A	B
T	F
F	T

Symbol

EXCLUSIVE OR (XOR)

Truth Table

A	B	C
T	T	F
T	F	T
F	T	T
F	F	F

Symbol
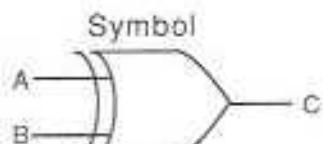
Fig. 4-5. Common logic devices.
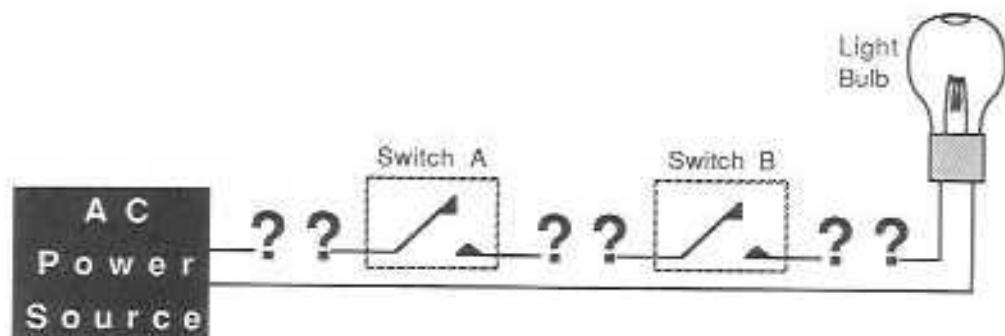
Fig. 4-6. One light, two independent switch problem.
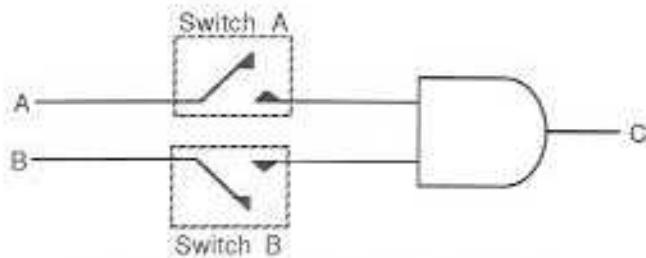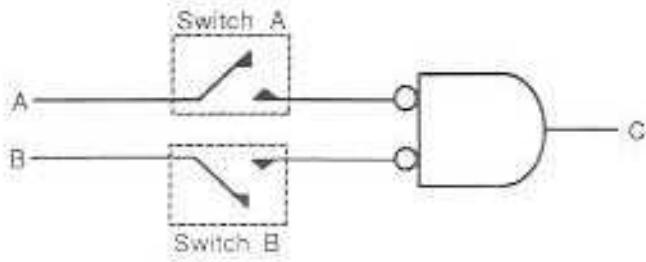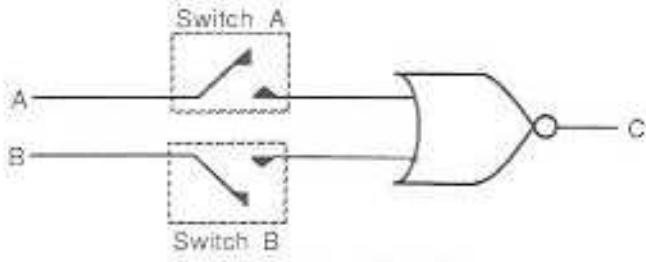
Fig. 4-7. An AND gate wired to two switches.

(A) An AND gate with negative inputs.

(B) Equivalent circuit of (A).

Fig. 4-8. Negative Input AND (NOR) gate wired to two switches.

an OR gate. This will give us a True output if either gate is True. If neither is True then it will be off. The final logic diagram is shown in Fig. 4-9.

The diagrams in Fig. 4-9 are shown with a NOR gate in 4-9A and a negative input AND gate

in 4-9B. Although both perform the same function, the one in Fig. 4-9B uses standard symbols and the one in Fig. 4-9A shows the actual logic function. In use, you may find either of these forms used.

Next, we need to translate this logic circuit into a wiring diagram. The easiest way to do this is to look at the switches we used to make the AND gates earlier (see Fig. 4-3). As you can see, the AND function is simply two switches wired in series (in-line with each other). So half of the wiring diagram would have two switches wired in series (Fig. 4-10A). The other half of the wiring diagram would be essentially the same, but reversed (Fig. 4-10B).

Finally, the two switches must be OR'ed This is accomplished by making the poles for both sets of switches common (Fig. 4-10C).

ELECTRICAL CHARACTERISTICS

We can discuss the way that logic circuits work in quite a bit of detail by simply calling the inputs and outputs to the devices True and False or on and off. However, the types of devices that we're discussing are a part of the electrical circuits that control your computer and they have certain electrical characteristics that make them behave the way they do.

Typically, logic circuits use two voltage levels to indicate True and False. These are +5 volts dc and 0 volts dc (also called ground). The +5-volt level usually indicates True while the 0-volt level indicates False. Additionally there are ranges of voltage levels that are considered "acceptable."
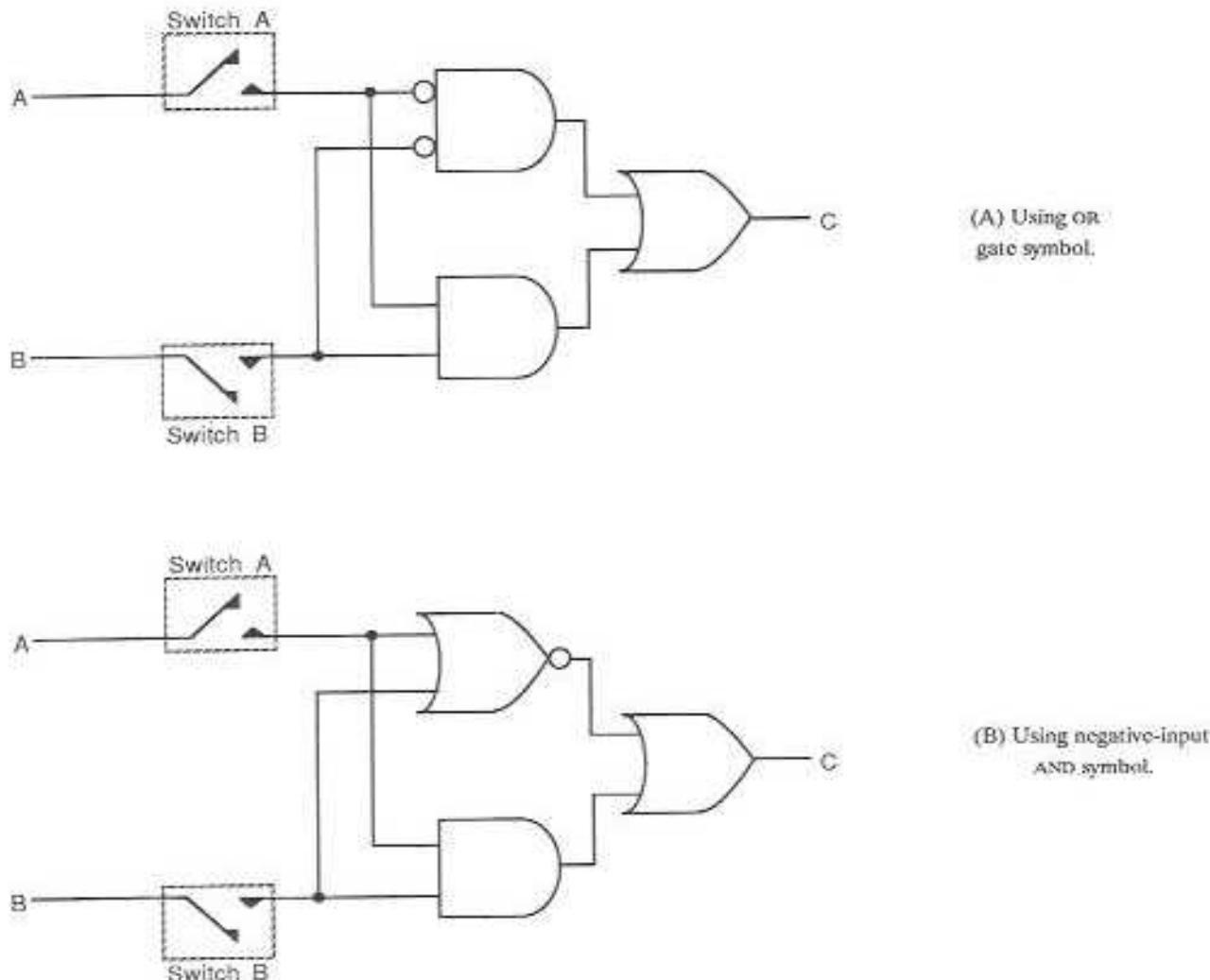
Fig. 4-9. One light, two independent switch logic diagram.

These voltages are: True = 3.8- to 5.5-volts dc; False = 0- to 0.3-volts dc. Voltage levels that fall between these limits may be recognized as either True or False; however, they will not be reliable and usually, logic levels between the 0.3- and 3.7-volts point to a faulty IC, a short, or an open circuit.

DIGITAL MEMORY DEVICES

Most digital logic devices will only produce their outputs as long as they have an appropriate input. There are circuits, however, that retain a signal after the input that produced it has ended.

These devices include single flip-flops which are devices that are designed to accept and save a single input and mass memory circuits that can store as little as a few bits of data to more than a million bits of information on a single IC.

Flip Flops

Before we can discuss flip flops, we'll need to take another look at clock signals. Clock signals are waveforms that switch from True to False and back. They may switch at a regular rate or they may be intermittent (Fig. 4-11). One reason that we need clocks is because they are used to trigger a "save" on a flip flop.

(A) First half of circuit.

(B) Second half of circuit.

(C) Combined final circuit.
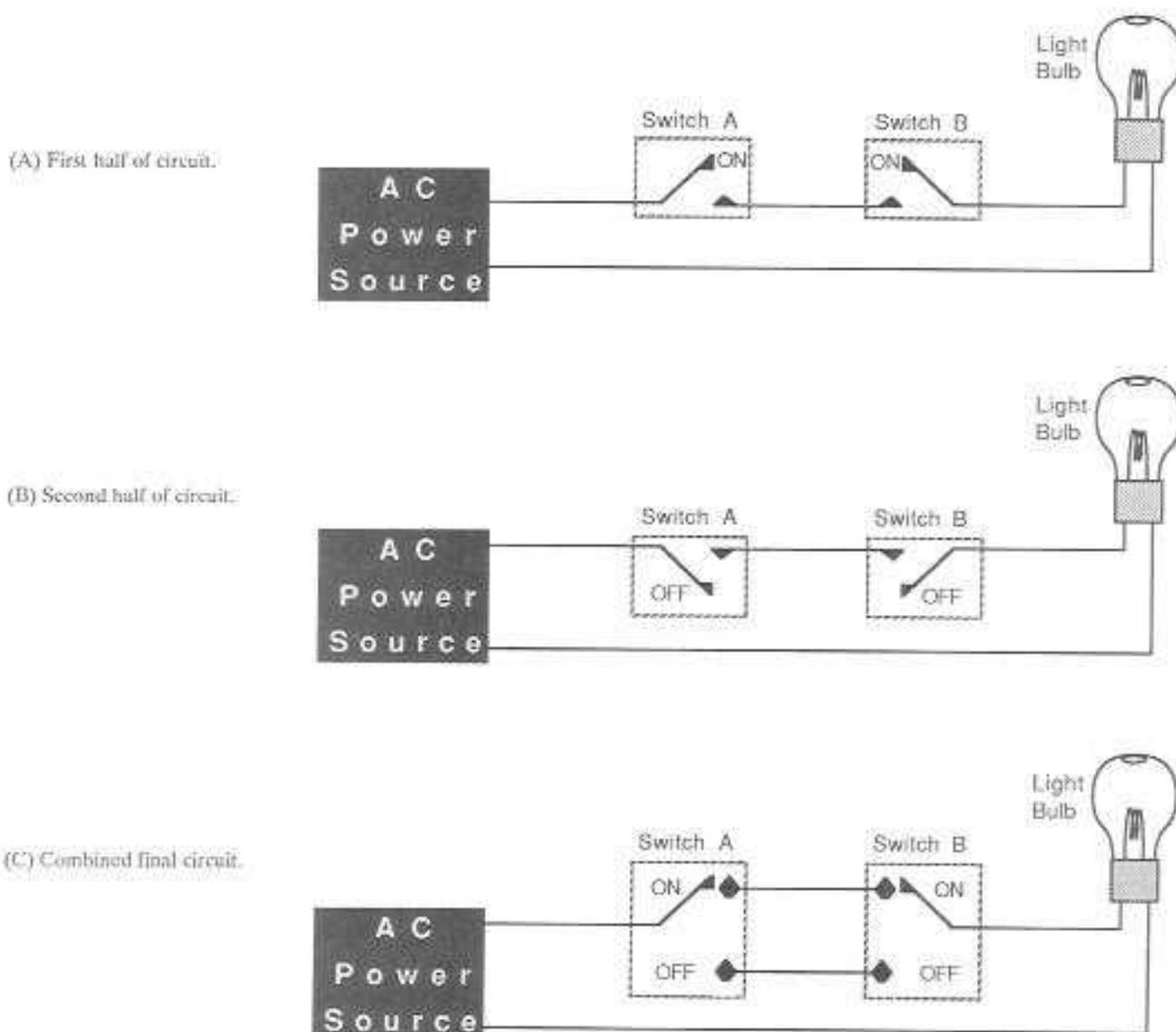
Fig. 4-10. One light, two independent switch wiring diagram.
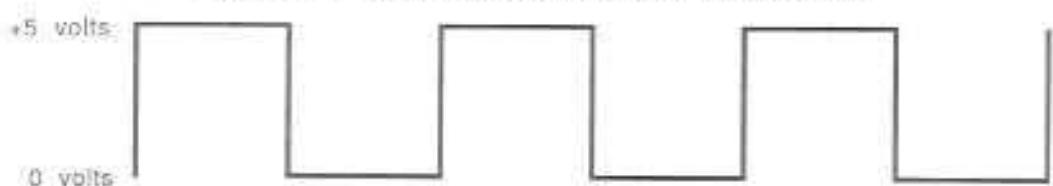
Fig. 4-11. Clock signal.

D Flip Flops

Now let's take a look at the simple D-type flip flop in Fig. 4-12. This device has a single data input (called D), a clock input (called CLK) and two outputs (called Q and Q̄). The short line above the Q̄ output indicates that it is a negative output.

Actually, the D-type flip flop will accept either a True or False input whenever it receives a low-going clock input.

This means that the clock signal goes from approximately +5 volts to approximately 0 volts (Fig. 4-13). When the D-type flip flop detects the
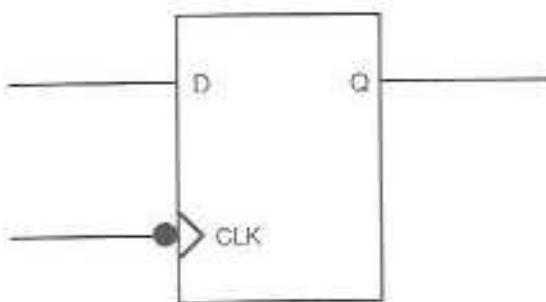
Fig. 4-12. D-type flip flop.

In actual use, circuits like the one in Fig. 4-15 can be used to simply count, or they may be used to keep track of other logic circuit activities.

RAM and ROM

Digital memory is arranged logically as a number of rows and columns. Each memory location, however, is read or written into by address (each location in memory has a unique numeric address). At one time, those memory locations could not be accessed directly. If the processor
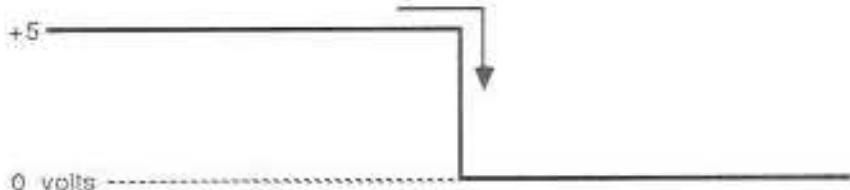
Fig. 4-13. Low-going clock signal.

clock, it transfers the current signal at its D input to the Q output and the inverse of that signal to the $\overline{Q}$ output. This output will remain at the two outputs if there are no further clock inputs, even if the input signal at "D" changes.

J-K Flip Flops

J-K flip flops (Fig. 4-14) are similar to the D-type, except they have two inputs (called J and K). If the J and K input signals are different (one True, one False) then they will be transferred to the outputs just as the D input was transferred. However, if the two inputs are both False, then the clock input will have no affect on the outputs. If both input signals are True, then the next clock input will toggle the outputs (they will switch from their previous state to the opposite—i.e., True to False and False to True).

Counters

One interesting feature of J-K flip flops is that since they are able to toggle their outputs, they are able to count. Figure 4-15 shows four J-K flip flops that have been connected together as a binary counter. The signal diagram below the circuit shows the states of the various outputs of the flip flops as they count from 0 to 15.

wanted the contents of memory location 100, for example, it would have to read through all of the memory locations from 0 through 99 first. These were serial memory.
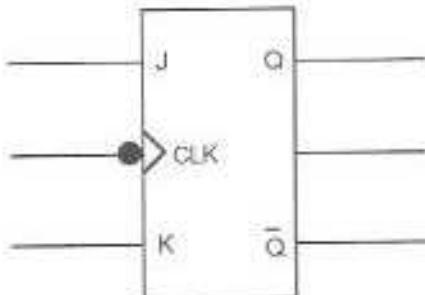
Fig. 4-14. J-K flip flop.

The term "RAM" is an acronym for *Random Access Memory*. The term "ROM", on the other hand, means *Read Only Memory*. At one time, the only type of memory available for logic circuits was serial memory. That is why RAM was called Random Access Memory—to differentiate it from serial memory. As it turns out, ROM is also "random-access"; however, while RAM will lose its contents when power is removed from its circuit, ROM will retain its memory. ROM is programmed once at the factory and cannot be reprogrammed. That is why ROM is called Read-Only Memory.

Decimal Value				
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	0	1	0
5	1	0	1	0
6	0	1	1	0
7	1	1	1	0
8	0	0	0	1
9	1	0	0	1
10	0	1	0	1
11	1	1	0	1
12	0	0	1	1
13	1	0	1	1
14	0	1	1	1
15	1	1	1	1
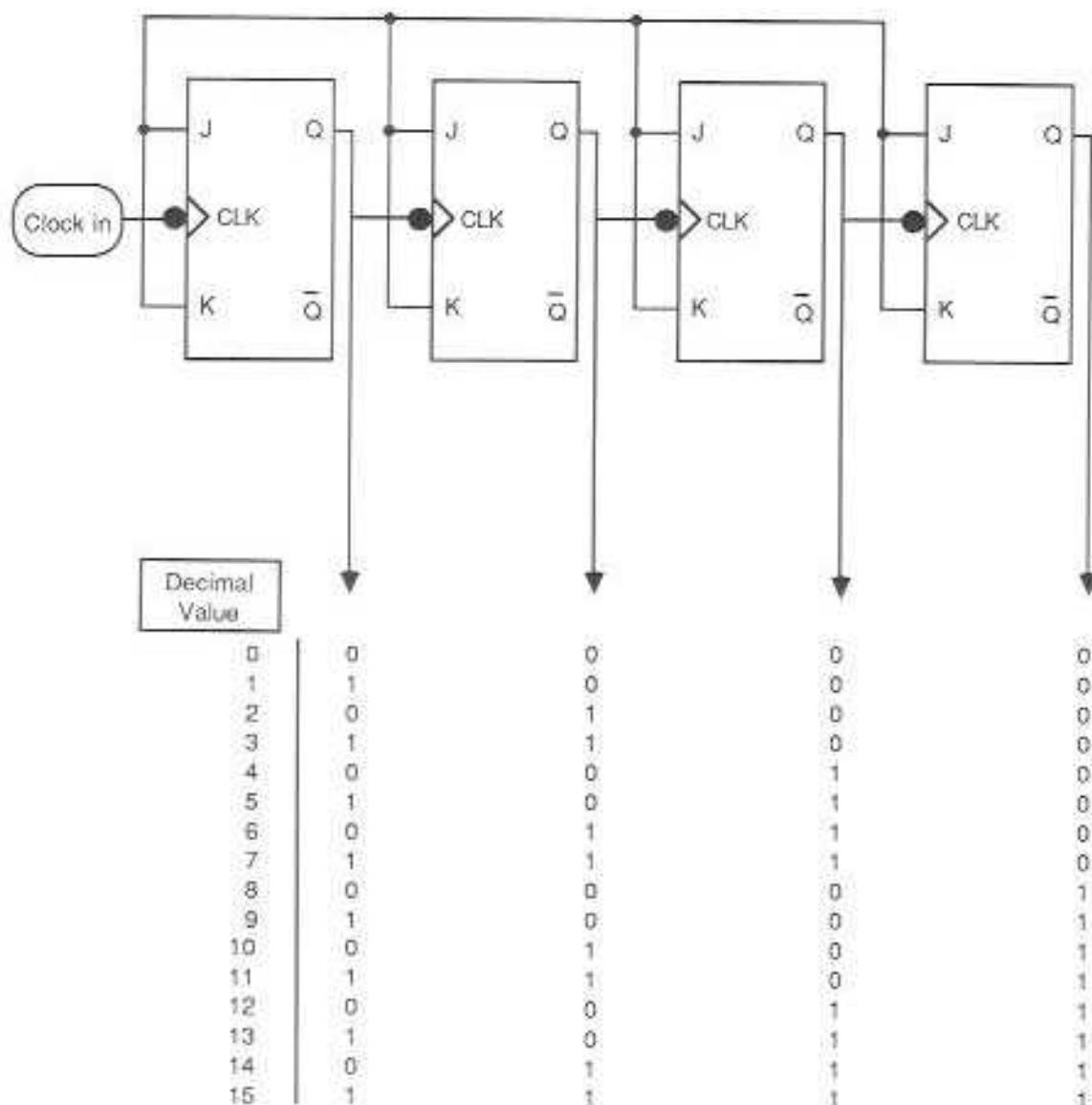
Fig. 4-15. A four-stage binary counter.

Actually, today there are also devices called EPROMs (*Erasable Programmable Read Only Memory*) which can be written to, erased, and rewritten numerous times. However, in this application, the differences between ROM and EPROM are unimportant.

MICROPROCESSORS

Microprocessors are complex, programmable logic circuits. Unlike the fixed logic devices we exam-

ined earlier (such as AND and OR which always produce the same response to any given input, microprocessors can be programmed to produce almost any kind of output for a given input. In fact, microprocessors can produce a whole string of outputs in response to a single input. They were originally designed as a low-cost, one or two chip replacement for complex logic circuits. Since that time, microprocessors have gone in two directions. Some have grown and become as powerful as some minicomputers. Others have become smaller and less expensive and are used as controllers for small systems (such as the 1571 disk drive).

5

Troubleshooting Techniques: System Doesn't Work

In the previous chapter, we looked at the way that digital logic devices behave. In this chapter (and Chapters 6, 7, and 8), we'll be using the information on digital logic to troubleshoot the computer. In the guides that follow, you'll be instructed to look for certain kinds of failures and how to fix them. The complaint of "System Doesn't Work" can be broken down in the following symptom categories:

- System does nothing
- System turns on, no display or bad display
- System turns on, no keyboard response
- System turns on, occasional strange or inappropriate messages or garbage on screen

SYSTEM DOES NOTHING

The chart at the right outlines the problems, possible causes, and repair actions for the condition where the system does nothing. Specific troubleshooting and repair techniques for each problem then follow.

Problem	Possible Cause	Repair Action
Improper voltages	No 117-V ac to power supply	Plug in power cord from power supply
	Defective fuse in power supply	Replace external fuse (in power supply)
	Defective fuse in power supply	Replace internal fuse (in power supply)
	Defective power supply	Replace power supply
	Poor/open connection inside computer	Check/replace power connector
	Defective power switch	Replace power switch
	Defective bridge rectifier	Replace CR13
	Open inductor coil	Replace L5
	Shorted/open capacitor	Replace C106

Improper Voltage from Power Supply

Defective Power Cable

The C128 power supply has two cables. One connects to the computer and the other connects to a 117-volt outlet. If either of these cables or their

connectors is defective (or not plugged in) the computer will not operate properly.

Defective Fuse in Power Supply
If both cables are connected properly, turn off the computer and disconnect the power supply from both the computer and the 117-volt ac outlet. Turn the power supply over and look for the externally accessible fuse. To check the fuse, use a small screwdriver to remove the fuse holder and remove the fuse. An open fuse will have a burned internal conductor. If you cannot see the metal conductor in the fuse, use an ohmmeter to check it for continuity.

If the fuse is open, replace it with one of the same type and rating. If it is good, open the power supply and look for the internal fuse. Check it in the same manner as the other fuse. If it is defective, desolder it and replace it with an exact replacement.

Defective Power Supply
The power supply has a five conductor cable. Connect the power supply to the 117 volt ac outlet and check the voltages at the computer connector. Fig. 5-1 is a schematic of the power supply and Fig. 5-2 shows the location of the components.

9-Volt AC Supply
Set your multimeter on the 20 volt ac scale and connect the probes between pins 3 and 5 of the connector. This reading should be approximately 9 volts ac. If it is lower than 8 volts or higher than 10, replace the power supply.

5-Volt DC Supply
The voltage between pin 1 and pin 4 or the connector shield (pin 2) should read +5 volts dc. If it is lower than $4^1/2$ volts or higher than $5^1/2$ volts, replace the power supply. Do not forget to change scales on your meter. The ac ranges on the multimeter will not measure dc voltages correctly.

Check Computer Power Receptacle

Power is supplied to the computer through the power receptacle. Check the continuity of the power through the connector to the PC board by checking the voltages at the following locations:

- negative side of the 220-μF capacitor (C104). Should measure 9 volts ac.

- "switched" side of rectifier CR13. Should measure 9 volts ac with power switch on and 0 volts with power switch off.

- Positive side of 100-μF capacitor (C107). Should be +5 volts dc when the power switch is on and 0 volts when the power switch is off.

If the voltage readings are the same regardless of the power switch position, the switch may be defective. To check the power switch, desolder it from the circuit and check continuity between each of the input and output leads. Check for shorts between the input leads and the output leads with the switch both on and off. Also check for open connections (no continuity from input to output with switch in the on position).
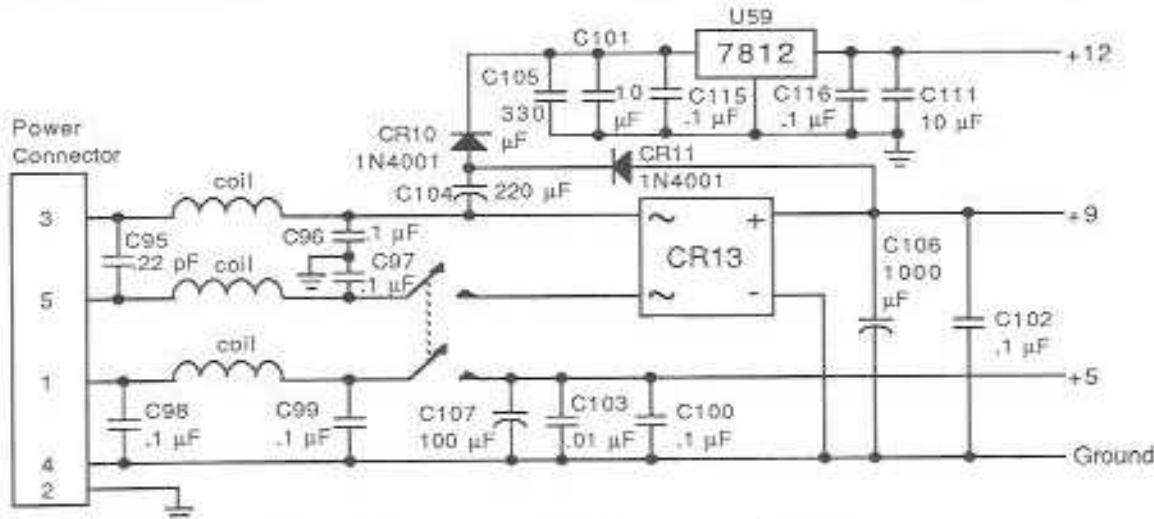
Fig. 5-1. Power supply circuit (on processor board).
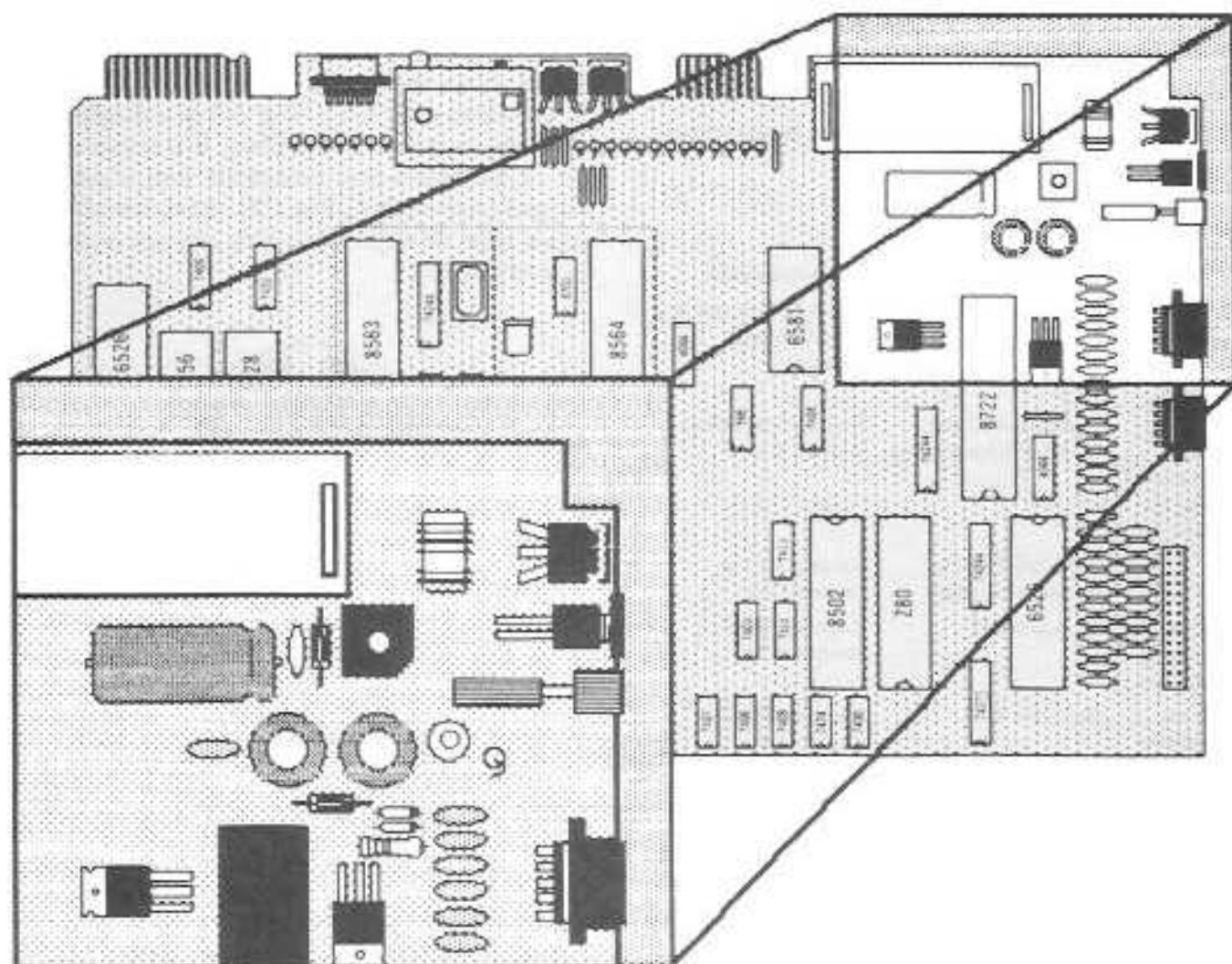
Fig. 5-2. Location of power supply components on processor board.

Check On-Board Power Circuits

The following voltage checks should be made with the negative side of the multimeter connected to pin 4 of the power connector (ground) and the meter set to 20 volt dc range.

The voltage at the positive side of capacitors C105 (330 μF), C101 (10 μF), C115 (.1 μF), C116 (.1 μF), and C111 (10 μF) should all be +12 volts. The negative side of the same capacitors should all be 0 volts.

The voltage at the positive side of the full wave rectifier CR13 should be approximately 9

volts, however, this may vary by as much as a volt or two.

SYSTEM TURNS ON, NO DISPLAY, OR BAD DISPLAY

The following chart outlines the problems, possible causes, and repair actions for the condition where the system turns on but there is no display or the display is not correct. Specific troubleshooting and repair techniques for each problem then follow.

Problem	Possible Cause	Repair Action
Monitor not working	Monitor cable not properly connected	Connect/replace cable
	Video display not set for correct type of video signal (i.e., RGBI, composite video)	Check display settings
	Defective monitor	Replace monitor
Boot-up ROMs not reading correctly	Defective ROMs at locations U32 – U36	Check ROMs, one at a time, replace if necessary
Video display chips not writing to screen	Defective VIC chip (no 40-column display)	Replace VIC (8564) at location U21
	Defective 8563 (no 80-column display)	Replace 8563 at location U22
Z80 not booting up system	Defective Z80	Replace Z80 at location U10
8502 not completing initialization	Defective 8502	Replace 8502 at location U6
RAMs/ROMs or processors not being addressed	Defective PLA	Replace 8721 at location U11
	Defective RAMs	Check/replace defective RAM chips

Monitor Not Working

Cables Not Properly Connected

The Commodore 128 can use either a composite video or an RGB monitor. Composite video monitors use RCA type cables to receive the video signals. The cable that connects the Commodore 128 to a composite video monitor has a round, DIN type connector on one end and several RCA connectors on separate wires at the other end.

If you are using a Commodore cable and monitor, you can use the color coding on the cables and monitor to connect the monitor. If you are using another brand of monitor or cable, you

may need to check the cable wiring to determine which RCA plug goes where.

To check the wiring of the cable, look at Fig. 5-3. It shows the names and numbers of the pins on the video connector. Fig. 5-3 is a diagram for the cable connector. Therefore, it is a mirror image of the video port receptacle into which it is plugged (Appendix C, Fig. C3). Also, not all video cables have all eight pins; they are not necessary for every monitor.

1: LUM/SYNC	5: AUDIO IN
2: GROUND	6: COLOR OUT
3: AUDIO OUT	7: NC
4: VIDEO OUT	8: NC

Fig. 5-3. Composite video cable connector and pinouts.

Look at the inputs for your monitor. Depending upon the type of monitor you have you may find three inputs labeled LUMIN, AUDIO, and COLOR, or you may find two inputs labeled VIDEO IN and AUDIO IN.

If you have a two cable monitor, use your multimeter to check the continuity between the video cable and the RCA cables. Pin 3 carries the audio signals and pin 4 carries video. Set the multimeter to the ohms scale and, one at a time, check the center pins on the RCA connectors to determine which is connected to pin 3 and which is connected to pin 4.

If you have a three cable monitor, use the same procedure as before, but look for pins 1 (LUMIN), 3 (AUDIO), and 6 (COLOR).

Check Display Settings

Some monitors, including the Commodore 1902, have two separate modes of operation: high resolution RGB mode and medium resolution composite video mode. These monitors have a switch to

select between the two modes. Additionally, the RGB signals and composite video signals (which are totally incompatible) connect to the monitor via separate cables.

If the computer is sending 80-column (RGB) data, the monitor will not display a picture in the composite mode. To check for mode errors in the high resolution mode, set the computer for the 80-column mode via the 80/40 key on the keyboard. Make sure the RGB cable is connected to the monitor and set the monitor switch to the RGB mode. Then, turn on the computer.

Alternately, to check for mode errors in the medium resolution mode, set the computer for 40-column mode via the 80/40 key on the keyboard. Make sure the composite cables are properly connected to the monitor (see the preceding section) and set the monitor switch to the composite video mode. Then, turn on the computer.

Checking Logic Devices

In the next few sections, you will be instructed to check various ICs and look for proper signal levels and types. The kinds of failures you'll be looking for include missing signals or signals that are present, but at the wrong voltages. In every case (except if noted), the correct voltage levels will be at either 5 volts (for high or true signals), ground (for low or false data), clock data (rising and falling at a regular intervals, or data streams (signals that rise and fall at irregular intervals). Figure 5-4 shows a graphic image of a data signal as well as an example of an incorrect signal for comparison. To check for this type of error, you will need a logic probe or (preferably) an oscilloscope.
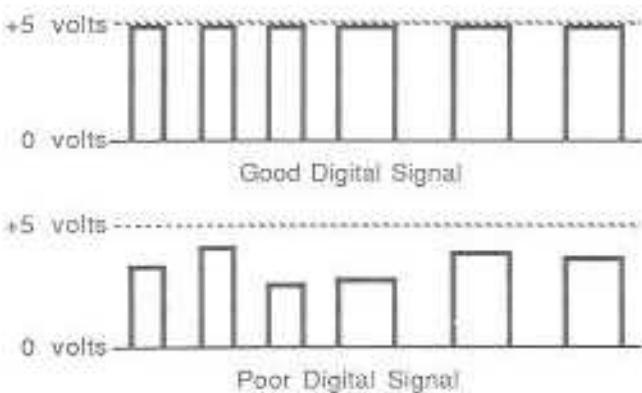
Fig. 5-4. Correct and incorrect data signals from logic and microprocessor chips.

Finding Power Problems

One of the first things you should look for is poor or missing power to ICs. If you have an open power supply line, it will often affect only one part. On the other hand, if power or ground is shorted anywhere in the computer, it will generally show up everywhere. If you cannot find any obvious reason for a power problem (such as a paper clip on the circuit board or a solder splash), you may need to trace down the problem by isolating the power supply lines. This is done by carefully cutting traces with a sharp knife and then measuring the voltages on the power supply side of the cut (Fig. 5-5).

The traces on the PC board are quite fragile and you should take every precaution to bend them as little as possible. Also, it is unadvisable to lift the same trace twice in the same place. If you ever need to lift the same trace again, use a spot a centimeter or so away if you can.

If you get a good reading on the power supply side of the line and a poor reading on the circuit side, then lay the trace back down, solder it back into place and make a cut further up into the circuit.

Continue in this way until you find a place that has either good voltage on the circuit side, poor voltage on the power supply side, or poor voltage on both sides.

The failure will be between the last good reading and the poor (or changed) reading. If you still cannot see the problem, try opening the trace at both ends and using a jumper to provide power to the circuit.

Boot-Up ROMs Not Reading Correctly

Defective boot up ROMs will prevent the computer from starting correctly and will therefore prevent the display from appearing on screen. These ROMs are in locations U32, U33, U34, U35, and U36 in Fig. 5-6. U32–U35 are 23128s and U36 is a 23256. The pinouts for these parts are given in Appendix A.

With the exception of two pins, these two ROMs have identical signals. Pins 1 and 28 should be a steady +5 volts and pin 14 should be solidly at ground (0 volts). If power or ground to any of these is defective, trace the power begin-
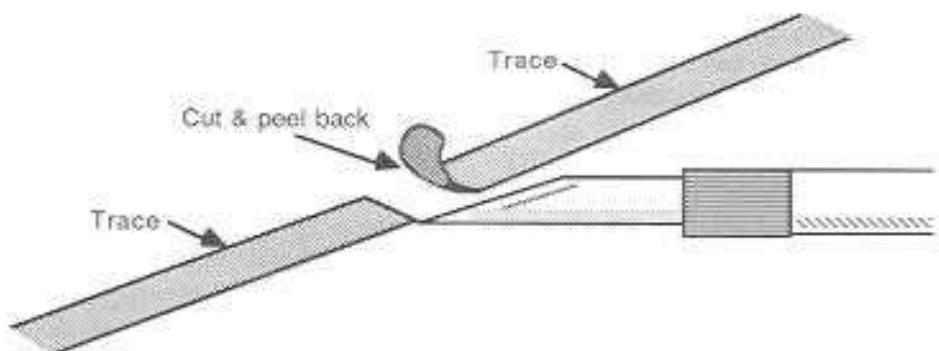
Fig. 5-5. Isolating a bad power signal by cutting the trace.
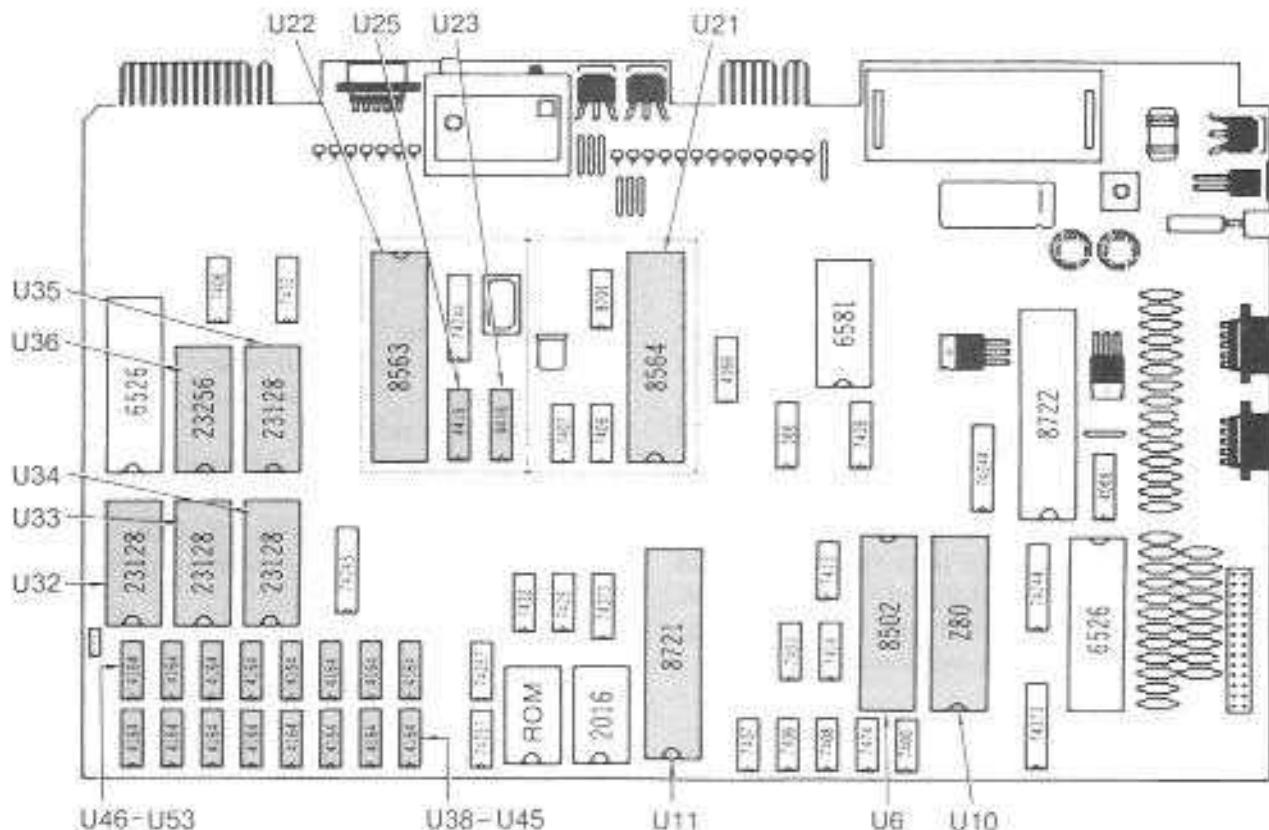
Fig. 5-6. Location of affected components for system turns on, no display, or bad display symptom.

ning at the input power source (at the power supply or regulator circuits covered in the previous section).

Pins 11, 12, 13, 15, 16, 17, 18, and 19 are data lines and should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2–3.5 volts) then the data is bad. Since these pins are outputs, this is an indication that the part may be defective. Before you assume that the part is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage
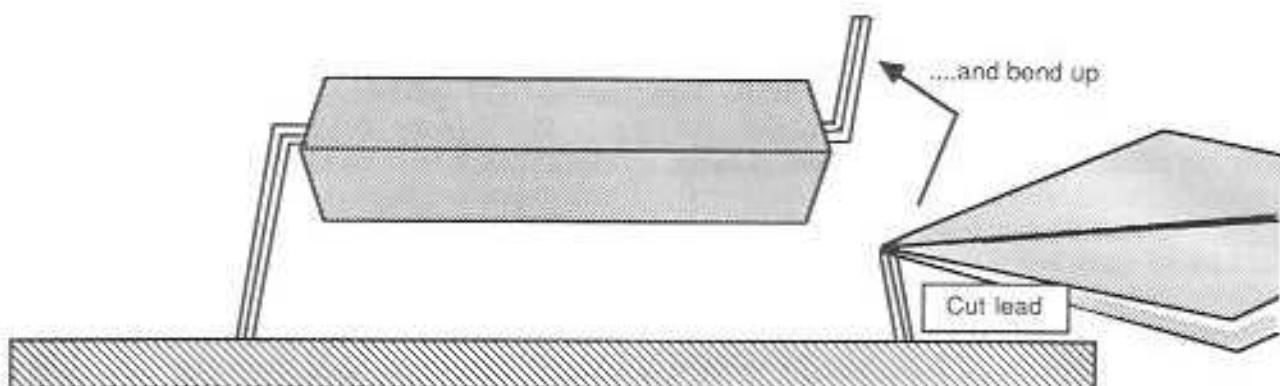
Fig. 5-7. Lifting an IC leg to isolate it from the circuit.

down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives (Fig. 5-5), or lift the leg on the IC (Fig. 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the IC.

Pins 2–10, 21, 23, 24, and 25 are address lines. This means that they are inputs. If any of these show improper signal levels trace the signal back to its source and perform the same tests we used previously for the data lines. Note: Pin 27 on the 23256 is also a data line. In both cases, pin 22 should be low to enable the device. If this pin is not low (anything higher than 1.75 volts) then the ROM will not read properly.

Display Circuit Problems

Check for Defective VIC Chip

The VIC chip (8564) is located at U21 in Fig. 5-6. It operates the 40- column display and most of the C128's graphic modes. Like the ROM chips, it has both address lines and data lines. Additionally, it produces signals that the C128 uses for an assortment of special functions. You can find the 8564 pinout diagram in Appendix A.

The data lines are pins 1, 2, 3, 4, 5, 6, 7, 43, 44, 45, 46, and 47. These pins should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2–3.5 volts) then the data is bad. Since these pins are outputs, the absence of the proper signal could be an indication that the part is defective. Before you assume that the part is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage

down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives (Fig. 5-5), or lift the leg on the IC (Fig. 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the VIC chip.

Pins 31–42 are address lines. This means that they are inputs. If any of these show improper signal levels trace the signal back to its source and perform the same tests we used previously for the data lines.

Pin 13 is the CS (chip select) line. It is used by the C128 to enable the VIC chip. This line must be low for the VIC to operate.

Pin 14 is the read/write line. It controls access to the VIC. When this pin is high, the VIC is reading data and when it is low it is writing. Ordinarily, the R/W line will be toggling up and down as the C128 operates.

Pins 18, 23, and 25 are the system clock lines. Pin 18 is the 1-MHz clock and should always produce a consistent 1-MHz signal. Pin 23 is the 2-MHz clock and it switches between 1 MHz and 2 MHz depending upon the current operating mode of the computer.

Pin 25 is the system clock for the Z80 microprocessor. It operates at 4 MHz.

Pins 29 and 30 are the dot and color clocks. They are high speed clocks and produce constant, evenly spaced outputs. They are the source for all of the other clocks in the system.

Pins 26, 27, and 28 are three of the keyboard scanning lines. They are slower than the other clocks but should produce a regular, evenly spaced output.

Pins 16 and 17 are COLOR and SYNC, respectively. They produce the final video output

from the VIC chip and must be present for the display to operate. The output from these pins looks like garbage on an oscilloscope screen. To check these lines, simply make sure that the signals are present. In almost every case, if these are operating at all, they are correct.

Pins 48 and 24 are power and ground and should be +5 volts and 0 volts, respectively. The remaining pins on the VIC chip carry asynchronous signals and will rise and fall at seemingly random times. Check them for voltage levels remembering that they should be close to +5 volts at their peaks and 0 volts at their valleys.

Check for Defective 80-Column Chip

The 80-column video display chip (8563) is located at U22 in Fig. 5-6. It operates the 80-column display mode. Like the VIC chip, it has both address lines and data lines. Additionally, it produces signals for the RGBI (high resolution) display. You can find the 8563 pinout diagram in Appendix A.

The data lines are pins 10 through 18, 34 through 36, and 38 through 42. These pins should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2−3.5 volts) then the data is bad. Since these pins are outputs, a defective signal could be an indication that the part is defective. Before you assume that the part is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives (Fig. 5-5), or lift the leg on the IC (Fig. 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the VIC chip.

Pins 26 through 33 are address lines. This means that they are inputs. If any of these show improper signal levels trace the signal back to its source and perform the same tests we used previously for the data lines.

Pin 7 is the CS (chip select) line. It is used by the C128 to enable the 6583 chip. This line must be low for the VIC to operate.

Pin 8 is the register select line which determines the data area that the chip reads. It will rise and fall, depending upon the data area being selected.

Pin 9 is the read/write line. It controls access to the 8563. When this pin is high, the 8563 is reading data and when it is low it is writing. Ordinarily, the R/W line will be toggling up and down as the C128 operates.

Pin 2 is the dot clock line. Like all other clock lines, it must be regular and even for the system to operate properly.

Pins 46, 45, 44, and 43 are the R, G, B, and I outputs, respectively. They produce the final video output from the 8563 chip and must be present for the display to operate. Like the VIC output, the output from these pins looks like garbage on an oscilloscope screen. To check these lines, simply make sure that the signals are present. In almost every case, if these are operating at all, they are correct.

Pins 37 and 12 are power and ground and should be +5 volts and 0 volts, respectively. The remaining pins on the 8563 chip carry asynchronous signals and will rise and fall at seemingly random times. Check them for voltage levels remembering that they should be close to +5 volts at their peaks and 0 volts at their valleys.

Microprocessor Problems

Check for Defective Z80 Microprocessor

The Z80 microprocessor is located at U10 in Fig. 5-6. It operates the C128 in the CP/M mode. Like the VIC chip, it has both address lines and data lines. You can find the Z80 pinout diagram in Appendix A.

The data lines are pins 7, 8, 9, 10, 12, 13, 14, and 15. When you look at these in the CP/M mode, they should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2−3.5 volts) then the data is bad. In the C128 mode, these lines are supposed to float.

Since these pins are outputs, a defective signal could be an indication that the part is defective. Before you assume that it is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives (Fig. 5-5), or lift the leg on the IC (Fig. 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the Z80 chip.

Pins 1 through 5 and 30 through 40 are address lines. This means that they are inputs. If any of these show improper signal levels trace the

signal back to its source and perform the same tests we used previously for the data lines.

Pins 11 and 29 are power and ground, respectively. They should be a steady +5 volts (power) and 0 volts (ground).

Pin 26 is the reset line. In normal operation, this pin will always be high. A low or intermediate voltage level will prevent the Z80 from operating.

Pin 6 is a clock signal and must be present for the Z80 to run.

The remaining pins on the Z80 carry asynchronous signals and will rise and fall at seemingly random times. Check them for voltage levels remembering that they should be close to +5 volts at their peaks and 0 volts at their valleys.

Check for Defective 8502 Microprocessor

The 8502 microprocessor is located at U6 in Fig. 5-6. It operates the C128 in the C128 mode. Like the VIC chip, it has both address lines and data lines. You can find the 8502 pinout diagram in Appendix A.

The data lines are pins 31 through 38. When you look at these in the C128 mode, they should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2 – 3.5 volts) then the data is bad. Note: In the CP/M mode, these lines are supposed to float.

Since these pins are outputs, a defective signal could be an indication that the part is defective. Before you assume that it is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives (Fig. 5-5), or lift the leg on the IC (Fig. 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the 8502 chip.

Pins 7 through 20, 22, and 23 are address lines. This means that they are inputs. If any of these show improper signal levels trace the signal back to its source and perform the same tests we used previously for the data lines.

Pins 6 and 21 are power and ground, respectively. They should be a steady +5 volts (power) and 0 volts (ground).

Pin 40 is the reset line. In normal operation, this pin will always be high. A low or intermediate voltage level will prevent the 8502 from operating.

Pin 1 is a clock signal and must be present for the 8502 to run.

The port I/O data lines are pins 24 through 30. When you look at these during I/O accesses, they should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2 – 3.5 volts) then the data is bad.

Since these pins are both inputs and outputs, a defective signal could be an indication that the part is defective. Before you assume that it is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives (Fig. 5-5), or lift the leg on the IC (Fig. 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the 8502 chip.

The remaining pins on the 8502 carry asynchronous signals and will rise and fall at seemingly random times. Check them for voltage levels remembering that they should be close to +5 volts at their peaks and 0 volts at their valleys.

Memory Problems

Check for Defective 8721 PLA

The 8721 PLA (Programmed Logic Array) is located at U11 in Fig. 5-6. It generates all of the control signals for the C128 while it is in C64 mode as well as several that are used while the computer is in the C128 mode. Unlike the processors and display chips, the PLA does not have grouped data lines. However, it does have address lines and its outputs behave very much like data lines. You can find the 8721 PLA pinout diagram in Appendix A. The PLA's outputs are given in Table 5-1.

Since these pins are outputs, a defective signal could be an indication that the part is defective. Before you assume that it is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives (Fig. 5-5), or lift the leg on the IC (Fig. 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the 8721 chip.

Table 5-1. PLA Outputs

Pin No.	Signal Name	Pin No.	Signal Name
8	DMAACK	32	CLRBNK
11	GAME	33	$\overline{\text{FROM}}$
12	EXROM	34	$\overline{\text{ROM 4}}$
13	Z80 EN	35	$\overline{\text{ROM 3}}$
14	Z80 I/O	36	$\overline{\text{ROM 2}}$
15	64/128	37	$\overline{\text{ROM 1}}$
16	I/O CE	38	I/O CS
17	ROMBANKHI	39	DIR
18	ROMBANKLO	40	DWE
22	LORAM	41	CASENB
23	HIRAM	42	$\overline{\text{VIC}}$
25	CHAREN	43	$\overline{\text{I/O ACC}}$
27	128/256	44	GWE
30	$\overline{\text{ROM L}}$	45	$\overline{\text{COLRAM}}$
31	$\overline{\text{ROM H}}$	46	$\overline{\text{CHAROM}}$

Pins 1 through 6 are address lines. This means that they are inputs. If any of these pins show improper signal levels trace the signal back to its source and perform the same tests we used previously for the data lines.

Pins 48 and 24 are power and ground, respectively. They should be a steady +5 volts (power) and 0 volts (ground).

Pin 47 is a clock signal and must be present for the 8721 to run.

The remaining pins on the 8721 carry asynchronous signals and will rise and fall at seemingly random times. Check them for voltage levels remembering that they should be close to +5 volts at their peaks and 0 volts at their valleys.

Check for Defective RAMs

The C128 has two different kinds of RAMs: 64K type 4164 dynamic RAMs (U38 through U53) and 16K type 4416 dynamic RAMs (U23 and U25). You can find the 4164 and 4416 pinout diagrams in Appendix A.

Pins 5, 6, 7, 9, 10, 11, 12, and 13 are I/O lines. This means that they can act as data lines or as address lines.

Since these pins are I/O lines, a defective signal could be an indication that the part is defective. Before you assume that it is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good

part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives (Fig. 5-5), or lift the leg on the IC (Fig. 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the suspected chip.

One problem with defective RAMs is that they are all connected. This means that a bad signal line on one chip will be shorted to that same pin on all the other RAMs. Additionally, in some cases, lifting a leg on one chip can cause all of the chips to stop working temporarily.

If you suspect a RAM failure and you cannot get the computer running (to help you track down the memory location that is defective) it is often easiest to desolder all of the RAMs (very carefully) and solder sockets in their locations. Then insert the RAMs in the sockets.

After the RAMs have been socketed, you can buy a few new RAMs and simply swap them with the old RAMs one at a time until the problem clears up.

SYSTEM TURNS ON, NO KEYBOARD RESPONSE

The following chart outlines the problems, possible causes, and repair actions for the condition where the system turns on but there is no response from the keyboard. Specific troubleshooting and repair techniques for each problem then follow.

Problem	Possible Cause	Repair Action
No response from keyboard	Keyboard connector not installed	Install keyboard connector
	Defective keyboard connector/cable	Check/replace keyboard cable/connector
	Software problem	Try running different program or just booting up to start-up screen
	Defective CIA	Check/replace CIA at location U1
	Defective VIC	Check/replace VIC at location U21

Keyboard Problems

Check Keyboard Connector

Although the keyboard connector can become detached because of vibration, it is most likely to be disconnected because of a previous repair session. If there is no response from the keyboard, open the computer case and check the connector to make sure it is properly seated. The connector is keyed to fit only one way, so you cannot install it incorrectly without really forcing it.

Defective Keyboard Connector Cable

A defective cable is much more common than a cable that simply "falls off." The wires that are attached to the keyboard connector are crimped into place and held there through the wire's insulation. If the computer receives excessive vibration, one or more of these wires can become disconnected.

To test the wires, use a multimeter (set to ohms) and check the continuity between the wires at the connector and where they are soldered to the keyboard PC board. If any of the wires are open, repair them by resoldering or replace them.

Check Your Software

Some software packages (especially games that run on cartridges) are designed to run by joystick only. If you boot up with one of these in place, the keyboard will not respond because the computer will not be looking at the keyboard for input.

Check for Defective CIA

There are two 6526 CIAs (Complex Interface Adapters) in the C128. They are located at U1 and U4 in Fig. 5-8. CIA1 (at U1) handles the keyboard. Like the VIC chip, the CIA has both address and data lines. However, the data lines of the CIA are grouped into data bus data lines, port A data lines, and port B data lines. In each case, these are both input and output lines. You can find the 6526 pinout diagram in Appendix A.

The data bus data lines are pins 26 through 33. Pins 2 through 9 are the data lines for port A, and pins 10 through 17 are the data lines for port B.

The data lines on the CIA are designed to operate in three states: high, low, and tri-state (also called high impedance). When the data lines are active, they should have irregular rising and
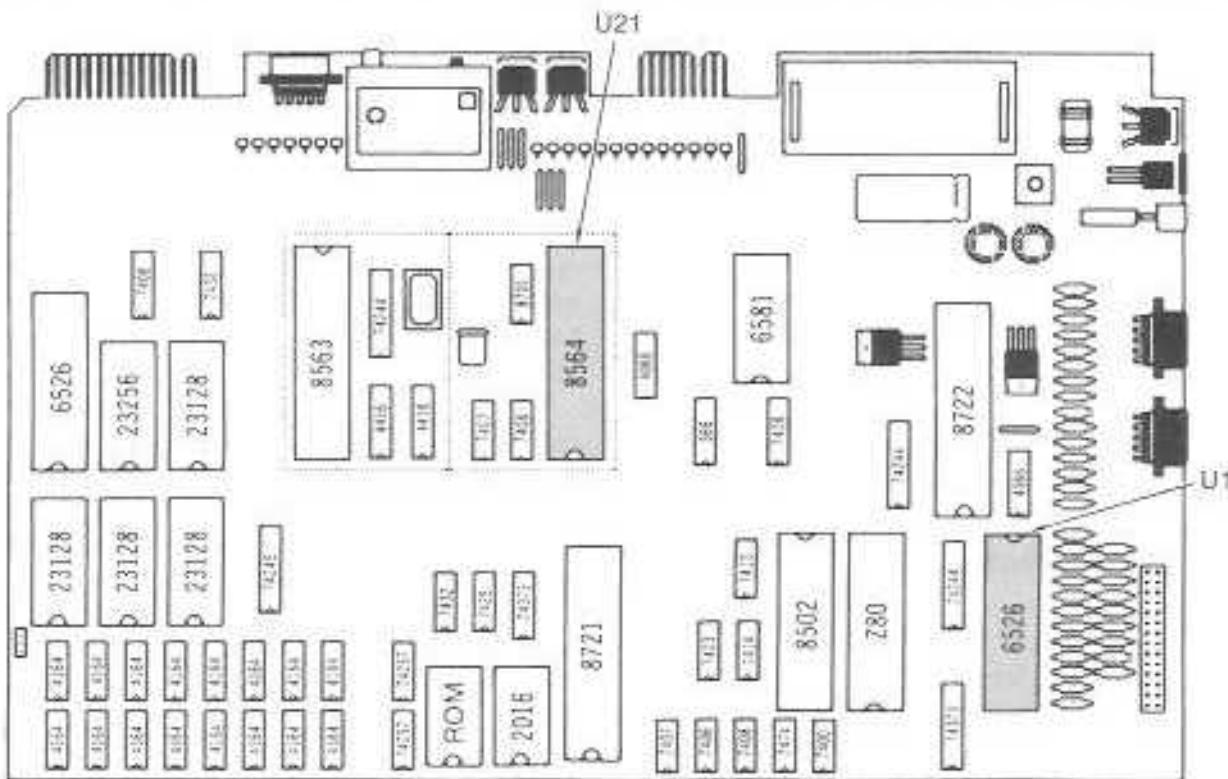

Fig. 5-8. Location of affected components for system turns on but no keyboard response symptom.

falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2–3.5volts) then the data is bad.

You will need to program the computer to read or write via the CIA being tested to check the data lines. The simplest way to do this is to press keys on the keyboard and look at the data lines on ports A & B. Although the data lines will occasionally tri-state, they will toggle up and down during the actual keyboard read cycles.

If the data lines on the CIA never toggle between +5 volts and ground (0 volts), it may be an indication that the part may be defective. Before you assume that it is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives (Fig. 5-5), or lift the leg on the IC (Fig. 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the 6526 chip.

Pins 35 through 38 are address lines. This means that they are inputs. If any of these show improper signal levels trace the signal back to its source and perform the same tests we used previously for the data lines.

Pins 20 and 1 are power and ground, respectively. They should be a steady +5 volts (power) and 0 volts (ground).

Pin 34 is the reset line. In normal operation, this pin will always be high. A low or intermediate voltage level will prevent the 6526 from operating.

Pin 25 is a clock signal and must be present for the 6526 to run properly.

The remaining pins on the 6526 carry asynchronous signals and will rise and fall at seemingly random times. Check them for voltage levels remembering that they should be close to +5 volts at their peaks and 0 volts at their valleys.

Display Circuit Problems

Check for Defective VIC Chip

The VIC chip (8564) is located at U21 in Fig. 5-8. In addition to operating the 40-column display and most of the C128's graphic modes, it reads part of the keyboard data lines. Like the ROM chips, it has both address lines and data lines. Additional-

ly, it produces signals that the C128 uses for an assortment of special functions. You can find the 8564 VIC chip pinout diagram in Appendix A.

The data lines are pins 1, 2, 3, 4, 5, 6, 7, 43, 44, 45, 46, and 47. These pins should have irregular rising and falling signals. If any of these pins are floating up and down or are steady at some voltage in the middle (2–3.5 volts) then the data is bad. Since these pins are outputs, this condition is an indication that the part may be defective. Before you assume that the part is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives (Fig. 5-5), or lift the leg on the IC (Fig. 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the VIC chip.

Pins 31–42 are address lines. This means that they are inputs. If any of these show improper signal levels trace the signal back to its source and perform the same tests we used previously for the data lines.

Pin 13 is the CS (chip select) line. It is used by the C128 to enable the VIC chip. This line must be low for the VIC to operate.

Pin 14 is the read/write line. It controls access to the VIC. When this pin is high, the VIC is reading data and when it is low it is writing. Ordinarily, the R/W line will be toggling up and down as the C128 operates.

Pins 18, 23, and 25 are the system clock lines. Pin 18 is the 1-MHz clock and should always produce a consistent 1-MHz signal. Pin 23 is the 2-MHz clock and it switches between 1 MHz and 2 MHz depending upon the current operating mode of the computer.

Pin 25 is the system clock for the Z80 microprocessor. It operates at 4 MHz.

Pins 29 and 30 are the dot and color clocks. They are high speed clocks and produce constant, evenly spaced outputs. They are the source for all of the other clocks in the system.

Pins 26, 27, and 28 are three of the keyboard scanning lines. They are slower than the other clocks but should produce a regular, evenly spaced output.

Pins 16 and 17 are COLOR and SYNC, respectively. They produce the final video output from the VIC chip and must be present for the display to operate. The output from these pins

looks like garbage on an oscilloscope screen. To check these lines, simply make sure that the signals are present. In almost every case, if these are operating at all, they are correct.

Pins 48 and 24 are power and ground and should be +5 volts and 0 volts, respectively. The remaining pins on the VIC chip are asynchronous signals and will rise and fall at seemingly random times. Check them for voltage levels remembering that they should be close to +5 volts at their peaks and 0 volts at their valleys.

Keyboard Contact Problems

Before you disassemble the keyboard, perform a continuity test of the keyboard at the connector (refer to Fig. 5-9). Using the ohms range on your multimeter, check the lines to make sure than none are shorted or open.

Usually shorted keyboards will produce a continuous string of the same character(s) or they will lock up entirely. However, an intermittent short can cause unpredictable results. Open circuits, on the other hand, will produce no signals at all.

Check continuity between each of the keyboard lines when the keys are open (up) and when you are pressing them. Use the keyboard circuitry guide in Fig 5-9 as you check.

STRANGE OR INAPPROPRIATE MESSAGES OR GARBAGE ON SCREEN

The following chart outlines the problems, possible causes, and repair actions for the condition where occasional strange or inappropriate messages or garbage appear on the screen. Specific troubleshooting and repair techniques for each problem then follow.

| Problem	Possible Cause	Repair Action
Memory problems	Defective RAM(s)	Check/replace defective RAM(s) at locations U38–U53
	Defective ROM(s)	Check/replace defective ROM(s) at locations U32–U36
CPU problems	Defective 8502	Check/replace defective 8502 at location U6
	Defective Z80	Check/replace defective Z80 at location U10
Display circuit problems	Defective VIC chip	Check/replace defective 8564 at location U21
	Defective 80-column display chip	Check/replace defective 8563 at location U22
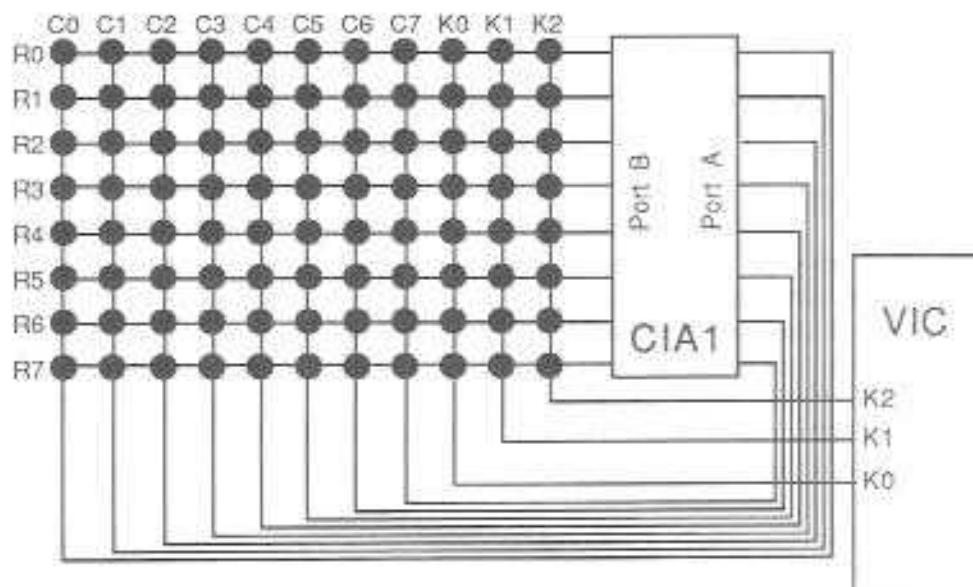
Fig. 5-9. Keyboard matrix, scan logic, and detection circuits.

Memory Problems

Check for Defective RAMs

The C128 has two different kinds of RAMs: 64K type 4164 dynamic RAMs (U38 through U53) and 16K type 4416 dynamic RAMs (U23 and U25). You can find the 4164 and 4416 pinout diagrams in Appendix A.

Pins 5, 6, 7, 9, 10, 11, 12, and 13 are I/O lines. This means that they can act as data lines or as address lines.

Since these pins are I/O lines, a defective signal could be an indication that the part is defective. Before you assume that it is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives (Fig. 5-5), or lift the leg on the IC (Fig. 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the suspected chip. One problem with defective RAMs is that they are all connected. This means that a bad signal line one chip will be shorted to that same pin on all the other RAMs. Additionally, in some cases, lifting a leg on one chip can cause all of the chips to stop working temporarily.

If you suspect a RAM failure and you cannot get the computer running (to help you track down the memory location that is defective) it is often easiest to desolder all of the RAMs (very carefully) and solder sockets in their locations. Then insert the RAMs in the sockets.

After the RAMs have been socketed, you can buy a few new RAMs and simply swap them with the old RAMs one at a time until the problem clears up.

ROMs Not Reading Correctly

Defective ROMs will prevent the computer from starting correctly and will therefore prevent the display from appearing on screen. Alternatively, defective ROMs can cause the display to display bad data if only s few bytes are defective. The ROMs are in locations U32, U33, U34, U35 and U36 in Fig. 5-10. U32–U35 are 23128s and U36 is a 23256. The pinouts for these parts are in Appendix A.

With the exception of two pins, the ROMs have identical signals. Pins 1 and 28 should be a steady +5 volts and pin 14 should be solidly at ground (0 volts). If power or ground to any of these is defective, trace the power beginning at the input power source (at the power supply or regulator circuits covered in the previous section).

Pins 11, 12, 13, 15, 16, 17, 18, and 19 are data lines and should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2–3.5 volts) then the data is bad. Since these parts are outputs, this condition may be an indication that the part may be defective. Before you assume that the part is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives (Fig. 5-5), or lift the leg on the IC (Fig. 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the IC.

Pins 2–10, 21, 23, 24, and 25 are address lines. This means that they are inputs. If any of these show improper signal levels trace the signal back to its source and perform the same tests we used for the data lines. Pin 27 on the 23256 is also a data line. In both cases, pin 22 should be low to enable the device. If this pin is not low (anything higher than 1.75 volts) then the ROM will not read properly.

CPU Problems

Check for Defective 8502 Microprocessor

The 8502 microprocessor is located at U6 in Fig. 5-10. It operates the C128 in the C128 mode. Like the VIC chip, it has both address lines and data lines. You can find the 8502 pinout diagram in Appendix A.

The data lines are pins 31 through 38. When you look at these in the C128 mode, they should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2–3.5 volts) then the data is bad. In the CP/M mode, these lines are supposed to float.

Since these pins are outputs, a defective signal could be an indication that the part is defective. Before you assume that it is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by

Fig. 5-10. Location of affected components for inappropriate messages or garbage on screen symptoms.

cutting the trace(s) that it drives (Fig. 5-5), or lift the leg on the IC (Fig. 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the 8502 chip.

Pins 7 through 20, 22, and 23 are address lines. This means that they are inputs. If any of these show improper signal levels trace the signal back to its source and perform the same tests we used previously for the data lines.

Pins 6 and 21 are power and ground, respectively. They should be a steady +5 volts (power) and 0 volts (ground).

Pin 40 is the reset line. In normal operation, this pin will always be high. A low or intermediate voltage level will prevent the 8502 from operating.

Pin 1 is a clock signal and must be present for the 8502 to run.

The port I/O data lines are pins 24 through 30. When you look at these during I/O accesses, they should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2-3.5 volts) then the data is bad.

Since these pins are both inputs and outputs, a defective signal could be an indication that the part is defective. Before you assume that it is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives

(Fig. 5-5), or lift the leg on the IC (Fig. 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the 8502 chip.

The remaining pins on the 8502 are asynchronous signals and will rise and fall at seemingly random times. Check them for voltage levels remembering that they should be close to +5 volts at their peaks and 0 volts at their valleys.

Check for Defective Z80 Microprocessor

The Z80 microprocessor is located at U10 in Fig. 5-10. It operates the C128 in the CP/M mode. Like the VIC chip, it has both address lines and data lines. You can find the Z80 pinout diagram in Appendix A.

The data lines are pins 7, 8, 9, 10, 12, 13, 14, and 15. When you look at these in the CP/M mode, they should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2 – 3.5 volts) then the data is bad. In the C128 mode, these lines are supposed to float.

Since these pins are outputs, the absence of the proper signal could be an indication that the part is defective. Before you assume that it is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives (Fig. 5-5), or lift the leg on the IC (Fig. 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the Z80 chip.

Pins 1 through 5 and 30 through 40 are address lines. This means that they are inputs. If any of these show improper signal levels trace the signal back to its source and perform the same tests we used previously for the data lines.

Pins 11 and 29 are power and ground, respectively. They should be a steady +5 volts (power) and 0 volts (ground).

Pin 26 is the reset line. In normal operation, this pin will always be high. A low or intermediate voltage level will prevent the Z80 from operating.

Pin 6 is a clock signal and must be present for the Z80 to run.

The remaining pins on the Z80 are asynchronous signals and will rise and fall at seemingly random times. Check them for voltage levels remembering that they should be close to +5 volts at their peaks and 0 volts at their valleys.

Display Circuit Problems

Check for Defective VIC Chip

The VIC chip (8564) is located at U21 in Fig. 5-10. It operates the 40-column display and most of the C128's graphic modes. Like the ROM chips, it has both address lines and data lines. Additionally, it produces signals that the C128 uses for an assortment of special functions. You can find the 8564 pinout diagram in Appendix A.

The data lines are pins 1, 2, 3, 4, 5, 6, 7, 43, 44, 45, 46, and 47. These pins should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2 – 3.5 volts) then the data is bad. Since these pins are outputs, this condition may be an indication that the part is defective. Before you assume that the part is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives (Fig. 5-5), or lift the leg on the IC (Fig. 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the VIC chip.

Pins 31 – 42 are address lines. This means that they are inputs. If any of these show improper signal levels trace the signal back to its source and perform the same tests we used previously for the data lines.

Pin 13 is the CS (chip select) line. It is used by the C128 to enable the VIC chip. This line must be low for the VIC to operate.

Pin 14 is the read/write line. It controls access to the VIC. When this pin is high, the VIC is reading data and when it is low it is writing. Ordinarily, the R/W line will be toggling up and down as the C128 operates.

Pins 18, 23, and 25 are the system clock lines. Pin 18 is the 1-MHz clock and should always produce a consistent 1-MHz signal. Pin 23 is the 2-MHz clock and it switches between 1 MHz and 2 MHz depending upon the current operating mode of the computer.

Pin 25 is the system clock for the Z80 microprocessor. It operates at 4 MHz.

Pins 29 and 30 are the dot and color clocks. They are high speed clocks and produce constant, evenly spaced outputs. They are the source for all of the other clocks in the system.

Pins 26, 27, and 28 are three of the keyboard scanning lines. They are slower than the other clocks but should produce a regular, evenly spaced output.

Pins 16 and 17 are COLOR and SYNC, respectively. They produce the final video output from the VIC chip and must be present for the display to operate. The output from these pins looks like garbage on an oscilloscope screen. To check these lines, simply make sure that the signals are present. In almost every case, if these are operating at all, they are correct.

Pins 48 and 24 are power and ground and should be +5 volts and 0 volts, respectively. The remaining pins on the VIC chip are asynchronous signals and will rise and fall at seemingly random times. Check them for voltage levels remembering that they should be close to +5 volts at their peaks and 0 volts at their valleys.

Check for Defective 80-Column Video Display Chip

The 80-column video display chip (8563) is located at U22 in Fig. 5-10. It operates the 80-column display mode. Like the VIC chip, it has both address lines and data lines. Additionally, it produces signals for the RGBI (high resolution) display. You can find the 8563 pinout diagram in Appendix A.

The data lines are pins 10 through 18, 34 through 36, and 38 through 42. These pins should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2 – 3.5 volts) then the data is bad. Since these pins are outputs, this condition could be an indication that the part is defective. Before you assume that the part is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, iso-

late it by cutting the trace(s) that it drives (Fig. 5-5), or lift the leg on the IC (Fig. 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the VIC chip.

Pins 26 through 33 are address lines. This means that they are inputs. If any of these show improper signal levels trace the signal back to its source and perform the same tests we used previously for the data lines.

Pin 7 is the CS (chip select) line. It is used by the C128 to enable the 6583 chip. This line must be low for the VIC to operate.

Pin 8 is the register select line which determines the data area that the chip reads. It will rise and fall, depending upon the data area being selected.

Pin 9 is the read/write line. It controls access to the 8563. When this pin is high, the 8563 is reading data and when it is low it is writing. Ordinarily, the R/W line will be toggling up and down as the C128 operates.

Pin 2 is the dot clock line. Like all other clock lines, it must be regular and even for the system to operate properly.

Pins 46, 45, 44, and 43 are the R, G, B, and I outputs, respectively. They produce the final video output from the 8563 chip and must be present for the display to operate. Like the VIC output, the output from these pins looks like garbage on an oscilloscope screen. To check these lines, simply make sure that the signals are present. In almost every case, if these are operating at all, they are correct.

Pins 37 and 12 are power and ground and should be +5 volts and 0 volts, respectively. The remaining pins on the 8563 chip are asynchronous signals and will rise and fall at seemingly random times. Check them for voltage levels remembering that they should be close to +5 volts at their peaks and 0 volts at their valleys.

Troubleshooting Techniques:
Poor Video or No Video

In this chapter, the complaint of "Poor Video" or "No Video" will be investigated. This complaint can be broken down into the following symptom categories:

- No picture at all
- No color or wrong colors
- Picture rolls/tilts

NO PICTURE AT ALL

The chart at the right outlines the problems, possible causes, and repair actions for the condition where there is no picture at all. Specific troubleshooting and repair techniques for each problem then follow.

Monitor Problems

Cables Not Properly Connected

The Commodore 128 can use two different kinds of monitors—composite video and RGB. Composite video monitors use RCA-type cables to receive the video signals. The cable that connects

Problem	Possible Cause	Repair Action
Monitor problems	Defective monitor	Check/replace video monitor
	Defective video interface	Check/replace video cable
		Check/correct monitor settings (i.e., RGBI/ composite settings)
Display circuit problems	Defective VIC chip	Check/replace defective 8564 at location U21
	Defective 80-column display chip	Check/replace at location U22
CPU problems	Defective 8502	Check/replace defective 8502 at location U6
	Defective Z80	Check/replace defective Z80 at location U10

the Commodore 128 to a composite video monitor has a round, DIN type connector on one end and several RCA connectors on separate wires at the other end.

If you are using a Commodore cable and monitor, you can use the color coding on the cables and monitor to connect the monitor. If you are using another brand of monitor or cable, you may need to check the cable wiring to determine which RCA plug goes where.

To check the wiring of the cable, look at Fig. 6-1. It shows the names and numbers of the pins on the video connector. Figure 6-1 is a diagram for the cable connector and is a mirror image of the video port receptacle into which it is plugged (Appendix C, Fig. C3). Also, not all video cables have all eight pins; they are not necessary for every monitor.

1: LUM/SYNC	5: AUDIO IN
2: GROUND	6: COLOR OUT
3: AUDIO OUT	7: NC
4: VIDEO OUT	8: NC

Fig. 6-1. Composite video cable connector and pinouts.

Look at the inputs for your monitor. Depending upon the type of monitor you have you may find three inputs labeled LUMIN, AUDIO, and COLOR, or you may find two inputs labeled VIDEO IN and AUDIO IN.

If you have a two cable monitor, use your multimeter to check the continuity between the video cable and the RCA cables. Pin 3 carries the audio signals and pin 4 carries video. Set the multimeter to the ohms scale and, one at a time, check the center pins on the RCA connectors to determine which is connected to pin 3 and which is connected to pin 4.

If you have a three cable monitor, use the same procedure as before, but look for pins 1 (LUMIN), 3 (AUDIO), and 6 (COLOR).

Check Display Settings

Some monitors, including the Commodore 1902 have two separate modes of operation: high reso-

lution RGB mode and medium resolution composite video mode. These monitors select between these two modes by way of a switch. Additionally, the RGB signals and composite video signals (which are totally incompatible) connect to the monitor via separate cables.

If the computer is sending 80-column (RGB) data, the monitor will not display a picture in the composite mode. To check for mode errors in the high resolution mode, set the computer for 80-column mode via the 80/40 key on the keyboard. Ensure the RGB cable is connected to the monitor and set the monitor switch to RGB mode. Then, turn on the computer.

Alternately, to check for mode errors in medium resolution mode, set the computer for 40-column mode via the 80/40 key on the keyboard. Ensure the composite cables are properly connected to the monitor (see the preceding section) and set the monitor switch to composite video mode. Then, turn on the computer.

Display Circuit Problems

Check for Defective VIC Chip

The VIC chip (8564) is located at U21 in Fig. 6-2. It operates the 40-column display and most of the C128's graphic modes. Like the ROM chips, it has both address lines and data lines. Additionally, it produces signals that the C128 uses for an assortment of special functions. You can find the 8564 pinout diagram in Appendix A.

The data lines are pins 1, 2, 3, 4, 5, 6, 7, 43, 44, 45, 46, and 47. These pins should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2–3.5 volts) then the data is bad. Since these pins are outputs, this condition is an indication that the part may be defective. Before you assume that the part is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives, or lift the leg on the IC as outlined in Chapter 5 (Figs. 5-5 and 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the VIC chip.

Pins 31–42 are address lines. This means that they are inputs. If any of these show improp-

Fig. 6-2. Location of affected components for no picture symptom.

er signal levels trace the signal back to its source and perform the same tests we used previously for the data lines.

Pin 13 is the CS (chip select) line. It is used by the C128 to enable the VIC chip. This line must be low for the VIC to operate.

Pin 14 is the read/write line. It controls access to the VIC. When this pin is high, the VIC is reading data and when it is low it is writing. Ordinarily, the R/W line will be toggling up and down as the C128 operates.

Pins 18, 23, and 25 are the system clock lines. Pin 18 is the 1-MHz clock and should always produce a consistent 1-MHz signal. Pin 23 is the 2-MHz clock and it switches between 1 MHz and 2 MHz depending upon the current operating mode of the computer.

Pin 25 is the system clock for the Z80 microprocessor. It operates at 4 MHz.

Pins 29 and 30 are the dot and color clocks. They are high speed clocks and produce constant,

evenly spaced outputs. They are the source for all of the other clocks in the system.

Pins 26, 27, and 28 are three of the keyboard scanning lines. They are slower than the other clocks but should produce a regular, evenly spaced output.

Pins 16 and 17 are COLOR and SYNC, respectively. They produce the final video output from the VIC chip and must be present for the display to operate. The output from these pins looks like garbage on an oscilloscope screen. To check these lines, simply make sure that the signals are present. In almost every case, if these are operating at all, they are correct.

Pins 48 and 24 are power and ground and should be +5 volts and 0 volts, respectively. The remaining pins on the VIC chip are asynchronous signals and will rise and fall at seemingly random times. Check them for voltage levels remembering that they should be close to +5 volts at their peaks and 0 volts at their valleys.

Check 80-Column Video Display Chip

The 8563 80-column video display chip is located at U22 in Fig. 6-2. It operates the 80-column mode. Like the VIC chip, it has both address lines and data lines. Additionally, it produces signals for the RGBI (high resolution) display. You can find the 8563 pinout diagram in Appendix A.

The data lines are pins 10 through 18, 34 thorough 36, and 38 through 42. These pins should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2–3.5 volts) then the data is bad. Since these pins are outputs, this condition could be an indication that the part is defective. Before you assume that the part is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives, or lift the leg on the IC as outlined in Chapter 5 (Figs. 5-5 and 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the VIC chip.

Pins 26 through 33 are address lines. This means that they are inputs. If any of these pins show improper signal levels, trace the signal back to its source and perform the same tests we used previously for the data lines.

Pin 7 is the CS (chip select) line. It is used by the C128 to enable the 6583 chip. This line must be low for the VIC to operate.

Pin 8 is the register select line which determines the data area that the chip reads. It will rise and fall, depending upon the data area being selected.

Pin 9 is the read/write line. It controls access to the 8563. When this pin is high, the 8563 is reading data and when it is low it is writing. Ordinarily, the R/W line will be toggling up and down as the C128 operates.

Pin 2 is the dot clock line. Like all other clock lines, it must be regular and even for the system to operate properly.

Pins 46, 45, 44, and 43 are the R, G, B, and I outputs, respectively. They produce the final video output from the 8563 chip and must be present for the display to operate. Like the VIC output, the output from these pins looks like garbage on an oscilloscope screen. To check these lines, simply make sure that the signals are present. In almost every case, if these are operating at all, they are correct.

Pins 37 and 12 are power and ground and should be +5 volts and 0 volts, respectively. The remaining pins on the 8563 chip are asynchronous signals and will rise and fall at seemingly random times. Check them for voltage levels remembering that they should be close to +5 volts at their peaks and 0 volts at their valleys.

CPU Problems

Check for Defective 8502 Microprocessor

The 8502 microprocessor is located at U6 in Fig. 6-2. It operates the C128 in the C128 mode. Like the VIC chip, it has both address lines and data lines. You can find the 8502 pinout diagram in Appendix A.

The data lines are pins 31 through 38. When you look at these in the C128 mode, they should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2–3.5 volts) then the data is bad. In the CP/M mode, these lines are supposed to float.

Since these pins are outputs, a defective signal could be an indication that the part is defective. Before you assume that it is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives, or lift the leg on the IC as outlined in Chapter 5 (Figs. 5-5 and 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the 8502 chip.

Pins 7 through 20, 22, and 23 are address lines. This means that they are inputs. If any of these show improper signal levels trace the signal back to its source and perform the same tests we used previously for the data lines.

Pins 6 and 21 are power and ground, respectively. They should be a steady +5 volts (power) and 0 volts (ground).

Pin 40 is the reset line. In normal operation, this pin will always be high. A low or intermediate voltage level will prevent the 8502 from operating.

Pin 1 is a clock signal and must be present for the 8502 to run.

The port I/O data lines are pins 24 through

30. When you look at these during I/O accesses, they should have irregular rising and falling sig- they should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2–3.5 volts) then the data is bad.

Since these pins are both inputs and outputs, a defective signal could be an indication that the part is defective. Before you assume that it is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives, or lift the leg on the IC as outlined in Chapter 5 (Figs. 5-5 and 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the 8502 chip.

The remaining pins on the 8502 are asynchronous signals and will rise and fall at seemingly random times. Check them for voltage levels remembering that they should be close to +5 volts at their peaks and 0 volts at their valleys.

Check for Defective Z80 Microprocessor

The Z80 microprocessor is located at U10 in Fig. 6-2. It operates the C128 in the CP/M mode. Like the VIC chip, it has both address lines and data lines. You can find the Z80 pinout diagram in Appendix A.

The data lines are pins 7, 8, 9, 10, 12, 13, 14, and 15. When you look at these in the CP/M mode, they should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2–3.5 volts) then the data is bad. In the C128 mode, these lines are supposed to float.

Since these pins are outputs, the absence of the proper signal could be an indication that the part is defective. Before you assume that it is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives, or lift the leg on the IC as outlined in Chapter 5 (Figs. 5-5 and 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the Z80 chip.

Pins 1 through 5 and 30 through 40 are ad- dress lines. This means that they are inputs. If any of these show improper signal levels trace the

signal back to its source and perform the same tests we used previously for the data lines.

Pins 11 and 29 are power and ground, respec- tively. They should be a steady +5 volts (power) and 0 volts (ground).

Pin 26 is the reset line. In normal operation, this pin will always be high. A low or intermediate voltage level will prevent the Z80 from operating.

Pin 6 is a clock signal and must be present for the Z80 to run.

The remaining pins on the Z80 are asynchro- nous signals and will rise and fall at seemingly ran- dom times. Check them for voltage levels remembering that they should be close to +5 volts at their peaks and 0 volts at their valleys.

NO COLOR OR WRONG COLORS

The following chart outlines the problems, possi- ble causes, and repair actions for the condition where there is no color or the wrong colors are displayed. Specific troubleshooting and repair techniques for each problem then follow.

Problem	Possible Cause	Repair action
CPU problems	Defective 8502	Check/replace defective 8502 at location U6
	Defective Z80	
	Check/replace defective Z80 at location U10	
Display circuit problems	Defective VIC chip	Check/replace defective 8564 at location U21
	Defective 80-column display chip	Check/replace defective 8563 at location U22
Memory problems	Defective color RAM	Check/replace color RAM (2016) at location U19
	Adjust color trimmer capacitor C20	
Modulator problems	Defective video modulator	Check/adjust/replace video modulator

Check for Defective 8502 Microprocessor

The 8502 microprocessor is located at U6 in Fig. 6-3. It operates the C128 in the C128 mode. Like the VIC chip, it has both address lines and data lines. You can find the 8502 pinout diagram in Appendix A.

The data lines are pins 31 through 38. When you look at these in the C128 mode, they should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2–3.5 volts) then the data is bad. In the CP/M mode, these lines are supposed to float.

Since these pins are outputs, a defective signal could be an indication that the part is defective. Before you assume that it is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives, or lift the leg on the IC as outlined in Chapter 5 (Figs. 5-5 and 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the 8502 chip.

Pins 7 through 20, 22, and 23 are address lines. This means that they are inputs. If any of these show improper signal levels trace the signal back to its source and perform the same tests used previously for the data lines.

Pins 6 and 21 are power and ground, respectively. They should be a steady +5 volts (power) and 0 volts (ground).

Pin 40 is the reset line. In normal operation, this pin will always be high. A low or intermediate voltage level will prevent the 8502 from operating.

Pin 1 is a clock signal and must be present for the 8502 to run.

The port I/O data lines are pins 24 through 30. When you look at these during I/O accesses, they should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2–3.5 volts) then the data is bad.

Since these pins are both inputs and outputs, a defective signal could be an indication that the part is defective. Before you assume that it is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives, or lift the leg on the IC as outlined in Chapter 5 (Figs. 5-5 and 5-7). Then look at the signal again.

If it is still in the wrong voltage range, replace the 8502 chip.

The remaining pins on the 8502 are asynchronous signals and will rise and fall at seemingly random times. Check them for voltage levels remembering that they should be close to +5 volts at their peaks and 0 volts at their valleys.

Check for Defective Z80 Microprocessor

The Z80 microprocessor is located at U10 in Fig. 6-3, operates the C128 in the CP/M mode. Like the VIC chip, it has both address lines and data lines. You can find the Z80 pinout diagram in Appendix A.

The data lines are pins 7, 8, 9, 10, 12, 13, 14, and 15. When you look at these in the CP/M mode, they should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2–3.5 volts) then the data is bad. In the C128 mode, these lines are supposed to float.

Since these pins are outputs, the absence of the proper signal could be an indication that the part is defective. Before you assume that it is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives, or lift the leg on the IC as outlined in Chapter 5 (Figs. 5-5 and 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the Z80 chip.

Pins 1 through 5 and 30 through 40 are address lines. This means that they are inputs. If any of these show improper signal levels trace the signal back to its source and perform the same tests we used previously for the data lines.

Pins 11 and 29 are power and ground, respectively. They should be a steady +5 volts (power) and 0 volts (ground).

Pin 26 is the reset line. In normal operation, this pin will always be high. A low or intermediate voltage level will prevent the Z80 from operating.

Pin 6 is a clock signal and must be present for the Z80 to run.

The remaining pins on the Z80 are asynchronous signals and will rise and fall at seemingly random times. Check them for voltage levels remembering that they should be close to +5 volts at their peaks and 0 volts at their valleys.

Fig. 6-3. Location of affected components for no color or wrong colors symptom.

Display Circuit Problems

Check for Defective VIC Chip

The VIC chip (8564) is located at U21 in Fig. 6-3. It operates the 40-column display and most of the C128's graphic modes. Like the ROM chips, it has both address lines and data lines. Additionally, it produces signals that the C128 uses for an assortment of special functions. You can find the 8564 pinout diagram in Appendix A.

The data lines are pins 1, 2, 3, 4, 5, 6, 7, 43, 44, 45, 46, and 47. These pins should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2–3.5 volts) then the data is bad. Since these pins are outputs, this condition is an indication that the part may be defective. Before you assume that the part is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives, or lift the leg on the IC as outlined in Chapter 5 (Figs. 5-5 and

5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the VIC chip.

Pins 31–42 are address lines. This means that they are inputs. If any of these show improper signal levels trace the signal back to its source and perform the same tests we used previously for the data lines.

Pin 13 is the CS (chip select) line. It is used by the C128 to enable the VIC chip. This line must be low for the VIC to operate.

Pin 14 is the read/write line. It controls access to the VIC. When this pin is high, the VIC is reading data and when it is low it is writing. Ordinarily, the R/W line will be toggling up and down as the C128 operates.

Pins 18, 23, and 25 are the system clock lines. Pin 18 is the 1-MHz clock and should always produce a consistent 1-MHz signal. Pin 23 is the 2-MHz clock and it switches between 1 MHz and 2 MHz depending upon the current operating mode of the computer.

Pin 25 is the system clock for the Z80 microprocessor. It operates at 4 MHz.

Pins 29 and 30 are the dot and color clocks. They are high speed clocks and produce constant, evenly spaced outputs. They are the source for all of the other clocks in the system.

Pins 26, 27, and 28 are three of the keyboard scanning lines. They are slower than the other clocks but should produce a regular, evenly spaced output.

Pins 16 and 17 are COLOR and SYNC, respectively. They produce the final video output from the VIC chip and must be present for the display to operate. The output from these pins looks like garbage on an oscilloscope screen. To check these lines, simply make sure that the signals are present. In almost every case, if these are operating at all, they are correct.

Pins 48 and 24 are power and ground and should be +5 volts and 0 volts, respectively. The remaining pins on the VIC chip are asynchronous signals and will rise and fall at seemingly random times. Check them for voltage levels remembering that they should be close to +5 volts at their peaks and 0 volts at their valleys.

Check for Defective 80-Column Video Display Chip

The 80-column video display chip (8563) is located at U22 in Fig. 6-3. It operates the 80-column display mode. Like the VIC chip, it has both address lines and data lines. Additionally, it produces signals for the RGBI (high resolution) display. You can find the 8563 pinout diagram in Appendix A.

The data lines are pins 10 through 18, 34 thorough 36, and 38 through 42. These pins should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2−3.5 volts) then the data is bad. Since these pins are outputs, the absence of the proper signal could be an indication that the part is defective. Before you assume that the part is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives, or lift the leg on the IC as outlined in Chapter 5 (Figs. 5-5 and 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the VIC chip.

Pins 26 through 33 are address lines. This means that they are inputs. If any of these pins show improper signal levels trace the signal back to its source and perform the same tests we used previously for the data lines.

Pin 7 is the CS (chip select) line. It is used by the C128 to enable the 6583 chip. This line must be low for the VIC to operate.

Pin 8 is the register select line which determines the data area that the chip reads. It will rise and fall, depending upon the data area being selected.

Pin 9 is the read/write line. It controls access to the 8563. When this pin is high, the 8563 is reading data and when it is low it is writing. Ordinarily, the R/W line will be toggling up and down as the C128 operates.

Pin 2 is the dot clock line. Like all other clock lines, it must be regular and even for the system to operate properly.

Pins 46, 45, 44, and 43 are the R, G, B, and I outputs, respectively. They produce the final video output from the 8563 chip and must be present for the display to operate. Like the VIC output, the output from these pins looks like garbage on an oscilloscope screen. To check these lines, simply make sure that the signals are present. In almost every case, if these are operating at all, they are correct.

Pins 37 and 12 are power and ground and should be +5 volts and 0 volts, respectively. The remaining pins on the 8563 chip are asynchronous signals and will rise and fall at seemingly random times. Check them for voltage levels remembering that they should be close to +5 volts at their peaks and 0 volts at their valleys.

Memory Problems

Check for Defective RAMs

In addition to the standard dynamic RAMs (4416s and 4164s) that the C128 uses for general purpose data storage, the C128 has a special (static) RAM called a 2016 that it uses to store color data. The 2016 is in location U19 on the processor board (Fig. 6-3) and you can find a pinout diagram of the chip in Appendix A.

Like the other RAMs, the 2016 has both address and data lines. However, unlike the other RAMs, these lines are supplied on separate pins. This means that the address lines are only inputs and the data lines are only outputs.

The address lines are on pins 1 through 8 and the data lines are on pins 9, 10, 11, 13, 14, 15, 16, and 17.

While the computer is operating, the data lines should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2–3.5 volts) then the data is bad. Since these pins are outputs, the absence of the proper signal could be an indication that the part is defective. Before you assume that the part is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives, or lift the leg on the IC as outlined in Chapter 5 (Figs. 5-5 and 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the VIC chip.

If any of the address lines show improper signal levels trace the signal back to its source and perform the same tests we used previously for the data lines.

Adjust Color Trimmer Capacitor

The small trimmer capacitor (C20) controls the color balance of the display (this capacitor may be inside a metal RFI shield). If the colors are all present, but they simply seem the wrong tint, try turning the adjusting screw (very slowly) while you watch the display.

Modulator Problems

Check for Defective Video Modulator

If you are using the C128 to run a standard television, you will need to connect it to a video modulator. The C128 has a video modulator (M1) built in that can send out video and audio signals to either channel 3 or channel 4. If you are unable to obtain a good picture by setting the modulator (and your television) to one of these channels, try using an external modulator (available at most computer stores).

To connect the modulator to the C128, use the composite monitor cable to connect the video and audio outputs to the external modulator.

PICTURE ROLLS OR TILTS

The following chart outlines the problems, possible causes, and repair actions for the condition where the picture rolls or tilts. Specific troubleshooting and repair techniques for each problem then follow.

Problem	Possible Cause	Repair Action
Monitor problems	Defective monitor	Check/replace video monitor
	Defective video interface cable	Check/replace video cable
		Check/correct monitor settings (i.e., RGBI/composite settings)
Display circuit problems	Defective VIC chip	Check/replace defective 8564 at location U21
	Defective 80-column display chip	Check/replace defective 8563 at location U22
Modulator problems	Defective video modulator	Check/adjust/replace video modulator
	Defective video clock circuit	Check/replace crystal Y2, or 8701 at location U28

Monitor Problems

Cables Not Properly Connected

The Commodore 128 can use two different kinds of monitors—composite video and RGB. Composite video monitors use RCA type cables to receive the video signals. The cable that connects the Commodore 128 to a composite video monitor has a round, DIN-type connector on one end and several RCA connectors on separate wires at the other end. If you are using a Commodore cable and monitor, you can use the color coding on the cables and monitor to connect the monitor.

If you are using another brand of monitor or cable, you may need to check the cable wiring to determine which RCA plug goes where.

To check the wiring of the cable, look at Fig. 6-1. It shows the names and numbers of the pins on the video connector. This is a diagram for the cable connector and is a mirror image of the video port receptacle into which it is plugged (Appendix C, Fig. C3). Also, not all video cables have all eight pins; they are not necessary for every monitor.

Look at the inputs for your monitor. Depending upon the type of monitor you have you may find three inputs labeled LUMIN, AUDIO, and COLOR, or you may find two inputs labeled VIDEO IN and AUDIO IN.

If you have a two cable monitor, use your multimeter to check the continuity between the video cable and the RCA cables. Pin 3 carries the audio signals and pin 4 carries video. Set the multimeter to the ohms scale and, one at a time, check the center pins on the RCA connectors to determine which is connected to pin 3 and which is connected to pin 4.

If you have a three cable monitor, use the same procedure as before, but look for pins 1 (LUMIN), 3 (AUDIO), and 6 (COLOR).

Check Display Settings

Some monitors, including the Commodore 1902 have two separate modes of operation: high resolution RGB mode and medium resolution composite video mode. These monitors select between these two modes by way of a switch. Additionally, the RGB signals and composite video signals (which are totally incompatible) connect to the monitor via separate cables.

If the computer is sending 80-column (RGB) data, the monitor will not display a picture in composite mode. To check for mode errors in the high resolution mode, set the computer for 80-column mode via the 80/40 key on the keyboard. Ensure the RGB cable is connected to the monitor and set the monitor switch to RGB mode. Then, turn on the computer.

Alternately, to check for mode errors in medium resolution mode, set the computer for 40-column mode via the 80/40 key on the keyboard. Ensure the composite cables are properly connected to the monitor (see the preceding section) and set the monitor switch to composite video mode. Then, turn on the computer.

Display Circuit Problems

Check for Defective VIC Chip

The VIC chip is located at U21 in Fig. 6-4. It operates the 40-column display and most of the C128's graphic modes. Like the ROM chips, it has both address lines and data lines. Additionally, it produces signals that the C128 uses for an assortment of special functions. You can find the 8564 pinout diagram in Appendix A.

The data lines are pins 1, 2, 3, 4, 5, 6, 7, 43, 44, 45, 46, and 47. These pins should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2–3.5 volts) then the data is bad. Since these pins are outputs, this condition is an indication that the part may be defective. Before you assume that the part is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives, or lift the leg on the IC as outlined in Chapter 5 (Figs. 5-5 and 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the VIC chip.

Pins 31–42 are address lines. This means that they are inputs. If any of these show improper signal levels trace the signal back to its source and perform the same tests we used previously for the data lines.

Pin 13 is the CS (chip select) line. It is used by the C128 to enable the VIC chip. This line must be low for the VIC to operate.

Pin 14 is the read/write line. It controls access to the VIC. When this pin is high, the VIC is reading data and when it is low it is writing. Ordinarily, the R/W line will be toggling up and down as the C128 operates.

Pins 18, 23, and 25 are the system clock lines. Pin 18 is the 1-MHz clock and should always produce a consistent 1-MHz signal. Pin 23 is the 2-MHz clock and it switches between 1 MHz and 2 MHz depending upon the current operating mode of the computer.

Pin 25 is the system clock for the Z80 microprocessor. It operates at 4 MHz.

Pins 29 and 30 are the dot and color clocks. They are high speed clocks and produce constant, evenly spaced outputs. They are the source for all of the other clocks in the system.

Fig. 6-4. Location of affected components for picture rolls or tilts symptom.

Pins 26, 27, and 28 are three of the keyboard scanning lines. They are slower than the other clocks but should produce a regular, evenly spaced output.

Pins 16 and 17 are COLOR and SYNC, respectively. They produce the final video output from the VIC chip and must be present for the display to operate. The output from these pins looks like garbage on an oscilloscope screen. To check these lines, simply make sure that the signals are present. In almost every case, if these are operating at all, they are correct.

Pins 48 and 24 are power and ground and should be +5 volts and 0 volts, respectively. The remaining pins on the VIC chip are asynchronous signals and will rise and fall at seemingly random times. Check them for voltage levels remembering that they should be close to +5 volts at their peaks and 0 volts at their valleys.

Check 80-Column Video Display Chip

The 8563 80-column video display chip is located at U22 in Fig. 6-4. It operates the 80-column display mode. Like the VIC chip, it has both address lines and data lines. Additionally, it produces signals for the RGBI (high resolution) display. You can find the 8563 pinout diagram in Appendix A.

The data lines are pins 10 through 18, 34 thorough 36, and 38 through 42. These pins should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2–3.5volts) then the data is bad. Since these pins are outputs, this condition could be an indication that the part is defective. Before you assume that the part is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives, or lift the leg on the IC as outlined in Chapter 5 (Figs. 5-5 and 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the VIC chip.

Pins 26 through 33 are address lines. This means that they are inputs. If any of these pins

show improper signal levels trace the signal back to its source and perform the same tests we used previously for the data lines.

Pin 7 is the CS (chip select) line. It is used by the C128 to enable the 6583 chip. This line must be low for the VIC to operate.

Pin 8 is the register select line which determines the data area that the chip reads. It will rise and fall, depending upon the data area being selected.

Pin 9 is the read/write line. It controls access to the 8563. When this pin is high, the 8563 is reading data and when it is low it is writing. Ordinarily, the R/W line will be toggling up and down as the C128 operates.

Pin 2 is the dot clock line. Like all other clock lines, it must be regular and even for the system to operate properly.

Pins 46, 45, 44, and 43 are the R, G, B, and I outputs, respectively. They produce the final video output from the 8563 chip and must be present for the display to operate. Like the VIC output, the output from these pins looks like garbage on an oscilloscope screen. To check these lines, simply make sure that the signals are present. In almost every case, if these are operating at all, they are correct.

Pins 37 and 12 are power and ground and should be +5 volts and 0 volts, respectively. The remaining pins on the 8563 chip are asynchronous signals and will rise and fall at seemingly random times. Check them for voltage levels remembering that they should be close to +5 volts at their peaks and 0 volts at their valleys.

Modulator or Clock Problems

Check for Defective Video Modulator
If you are using the C128 to run a standard television, you will need to connect it to a video modulator. The C128 has a video modulator built in that can send out video and audio signals to either channel 3 or channel 4. If you are unable to obtain a good picture by setting the modulator (and your television) to one of these channels, try using an external modulator (available at most computer stores).

To connect the modulator to the C128, use the composite monitor cable to connect the video and audio outputs to the external modulator.

Check Video Clock Circuitry
The video clock circuitry controls all of the timing functions of the C128. If the clock is the wrong speed or voltage level, the display can become unstable.

The inputs to the clock circuit, U28 (8701) are pins 13 and 14. If the signal there is a good solid sine wave, check the output at pin 2 of U29. You can adjust the frequency of the clock by turning the adjustment screw on C20.

Troubleshooting Techniques:
Defective Keyboard

Problems involving a defective keyboard can be subdivided into the following symptom categories:

- Keyboard doesn't work at all
- Keyboard generates the wrong or extra characters

KEYBOARD DOESN'T WORK AT ALL

The chart at the right outlines the problems, possible causes, and repair actions for the condition where the keyboard doesn't work at all. Specific troubleshooting and repair techniques for each problem then follow.

Keyboard Problems

Check Keyboard Connector

Although the keyboard connector can become detached because of vibration, it is most likely to be disconnected because of a previous repair session. If there is no response from the keyboard, open the computer case and check the connector to

Problem	Possible Cause	Repair Action
Keyboard problems	Keyboard not connected	Install keyboard connector
	Defective keyboard wiring harness	Check/repair/replace keyboard wiring harness
Logic circuit problems	Defective CIA1	Check/replace CIA1 (6526) at location U1
	Defective VIC	Check/replace VIC (8564) at location U21
CPU problems	Defective 8502	Check/replace defective 8502 at location U6
	Defective Z80	Check/replace defective Z80 at location U10
Some (not all) keys don't work	Dirty keys	Disassemble & clean keyboard PC board and conductive rubber pads

make sure it is properly seated. The connector is keyed to fit only one way, so you cannot install it incorrectly without really forcing it.

Defective Keyboard Connector Cable
A defective keyboard cable is much more common than a cable that simply "falls off." The wires that are attached to the keyboard connector are crimped into place and held there through the wire's insulation. If the computer receives excessive vibration, one or more of these wires can become disconnected.

To test the wires, use a multimeter (set to ohms) and check the continuity between the wires at the connector and where they are soldered to the keyboard PC board. If any of the wires are open, repair them by resoldering or replace them.

Logic Circuit Problems

Check for Defective 6526 CIA
There are two 6526 CIAs (Complex Interface Adapters) in the C128. They are located at U1 and U4 in Fig. 7-1. CIA1 (at U1) handles the keyboard. Like the VIC chip, the CIA has both address and data lines. However, the data lines of the CIA are grouped into data bus data lines, port A data lines, and port B data lines. In each case, these are both input and output lines. You can find the 6526 pinout diagram in Appendix A.

The data bus data lines are pins 26 through 33. Pins 2 through 9 are the data lines for port A, and pins 10 through 17 are the data lines for port B.

The data lines on the CIAs are designed to operate in three states: high, low, and tri-state (also called high impedance). When the data lines are active, they should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2–3.5volts) then the data is bad.

You will need to program the computer to read or write via the CIA being tested to check the data lines. The simplest way to do this is to press keys on the keyboard and look at the data lines on ports A & B. Although the data lines will occasionally tri-state, they will toggle up and down during the actual keyboard read cycles.

If the data lines on the CIA never toggle between +5 volts and ground (0 volts), it may be an indication that the CIA is defective. Before you assume that it is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To deter-

mine if the part is bad, isolate it by cutting the trace(s) that it drives, or lift the leg on the IC as outlined in Chapter 5 (Figs. 5-5 and 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the 6526 chip.

Pins 35 through 38 are address lines. This means that they are inputs. If any of these show improper signal levels trace the signal back to its source and perform the same tests we used previously for the data lines.

Pins 20 and 1 are power and ground, respectively. They should be a steady +5 volts (power) and 0 volts (ground).

Pin 34 is the reset line. In normal operation, this pin will always be high. A low or intermediate voltage level will prevent the 6526 from operating.

Pin 25 is a clock signal and must be present for the 6526 to run properly.

The remaining pins on the 6526 carry asynchronous signals and will rise and fall at seemingly random times. Check them for voltage levels remembering that they should be close to +5 volts at their peaks and 0 volts at their valleys.

Check for Defective VIC Chip
The VIC chip (8564) is located at U21 in Fig. 7-1. It operates the 40-column display and most of the C128's graphic modes. Like the ROM chips, it has both address lines and data lines. Additionally, it produces signals that the C128 uses for an assortment of special functions like scanning the upper three lines of the keyboard. You can find the 8564 pinout diagram in Appendix A.

The data lines are pins 1, 2, 3, 4, 5, 7, 43, 44, 45, 46, and 47. These pins should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2–3.5 volts) then the data is bad. Since these pins are outputs, this condition may be an indication that the part is defective. Before you assume that the part is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives, or lift the leg on the IC as outlined in Chapter 5 (Figs. 5-5 and 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the VIC chip.

Pins 31–42 are address lines. This means that they are inputs. If any of these show improper signal levels trace the signal back to its source

U21

Fig. 7-1. Location of affected components for keyboard doesn't work symptom.

and perform the same tests we used previously for the data lines.

Pin 13 is the CS (chip select) line. It is used by the C128 to enable the VIC chip. This line must be low for the VIC to operate.

Pin 14 is the read/write line. It controls access to the VIC. When this pin is high, the VIC is reading data and when it is low it is writing. Ordinarily, the R/W line will be toggling up and down as the C128 operates.

Pins 18, 23, and 25 are the system clock lines. Pin 18 is the 1-MHz clock and should always produce a consistent 1-MHz signal. Pin 23 is the 2-MHz clock and it switches between 1 MHz and 2 MHz depending upon the current operating mode of the computer.

Pin 25 is the system clock for the Z80 microprocessor. It operates at 4 MHz.

Pins 29 and 30 are the dot and color clocks. They are high speed clocks and produce constant, evenly spaced outputs. They are the source for all

of the other clocks in the system.

Pins 26, 27, and 28 are three of the keyboard scanning lines. They are slower than the other clocks but should produce a regular, evenly spaced output.

Pins 16 and 17 are COLOR and SYNC, respectively. They produce the final video output from the VIC chip and must be present for the display to operate. The output from these pins looks like garbage on an oscilloscope screen. To check these lines, simply make sure that the signals are present. In almost every case, if these are operating at all, they are correct.

Pins 48 and 24 are power and ground and should be +5 volts and 0 volts, respectively. The remaining pins on the VIC chip are asynchronous signals and will rise and fall at seemingly random times. Check them for voltage levels remembering that they should be close to +5 volts at their peaks and 0 volts at their valleys.

CPU Problems

Check for Defective 8502 Microprocessor

The 8502 microprocessor is located at U6 in Fig. 7-1. It operates the C128 in the C128 mode. Like the VIC chip, it has both address lines and data lines. You can find the 8502 pinout diagram in Appendix A.

The data lines are pins 31 through 38. When you look at these in the C128 mode, they should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2–3.5 volts) then the data is bad. In the CP/M mode, these lines are supposed to float.

Since these pins are outputs, a defective signal could be an indication that the part is defective. Before you assume that it is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives, or lift the leg on the IC as outlined in Chapter 5 (Figs. 5-5 and 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the 8502 chip.

Pins 7 through 20, 22, and 23 are address lines. This means that they are inputs. If any of these show improper signal levels trace the signal back to its source and perform the same tests we used previously for the data lines.

Pins 6 and 21 are power and ground, respectively. They should be a steady +5 volts (power) and 0 volts (ground).

Pin 40 is the reset line. In normal operation, this pin will always be high. A low or intermediate voltage level will prevent the 8502 from operating.

Pin 1 is a clock signal and must be present for the 8502 to run.

The port I/O data lines are pins 24 through 30. When you look at these during I/O accesses, they should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2–5 volts) then the data is bad.

Since these pins are both inputs and outputs, a defective signal could be an indication that the part is defective. Before you assume that it is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives, or

lift the leg on the IC as outlined in Chapter 5 (Figs. 5-5 and 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the 8502 chip.

The remaining pins on the 8502 are asynchronous signals and will rise and fall at seemingly random times. Check them for voltage levels remembering that they should be close to +5 volts at their peaks and 0 volts at their valleys.

Check for Defective Z80 Microprocessor

The Z80 microprocessor is located at U10 in Fig. 7-1. It operates the C128 in the CP/M mode. Like the VIC chip, it has both address lines and data lines. You can find the Z80 pinout diagram in Appendix A.

The data lines are pins 7, 8, 9, 10, 12, 13, 14, and 15. When you look at these in the CP/M mode, they should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2–3.5 volts) then the data is bad. In the C128 mode, these lines are supposed to float.

Since these pins are outputs, the absence of the proper signal could be an indication that the part is defective. Before you assume that it is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives, or lift the leg on the IC as outlined in Chapter 5 (Figs. 5-5 and 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the Z80 chip.

Pins 1 through 5 and 30 through 40 are address lines. This means that they are inputs. If any of these show improper signal levels trace the signal back to its source and perform the same tests we used previously for the data lines.

Pins 11 and 29 are power and ground, respectively. They should be a steady +5 volts (power) and 0 volts (ground).

Pin 26 is the reset line. In normal operation, this pin will always be high. A low or intermediate voltage level will prevent the Z80 from operating.

Pin 6 is a clock signal and must be present for the Z80 to run.

The remaining pins on the Z80 are asynchronous signals and will rise and fall at seemingly random times. Check them for voltage levels remem-

bering that they should be close to +5 volts at their peaks and 0 volts at their valleys.

Check for Dirty Keys

If you have checked all of the preceding devices and still cannot find the problem, you may find that your problems stem from dirty keys. The contacts on the C128 keyboard are not sealed and can become contaminated if you spill anything onto the keyboard (such as coffee, tea, or other beverages).

To check the keyboard (before disassembling it), remove the cable and check the continuity between the keyboard I/O lines as you press the keys. Use the keyboard circuitry schematic in Fig. 7-2 as a guide.

KEYBOARD GENERATES THE WRONG CHARACTERS

The following chart outlines the problems, possible causes, and repair actions for the condition where the keyboard generates the wrong characters. Specific troubleshooting and repair techniques for each problem then follow.

Problem	Possible Cause	Repair Action
Keyboard	Defective keyboard wiring harness	Check/repair/replace keyboard wiring harness
Logic circuit problems	Defective CIA1	Check/replace CIA1 (6526) at location U1
Display circuit problems	Defective VIC	Check/replace VIC (8564) at location U21
CPU problems	Defective 8502	Check/replace defective 8502 at location U6
	Defective Z80	Check/replace defective Z80 at location U10
Defective key switches	Shorted contacts on keyboard PC	Disassemble and clean/clear shorts on PC board

Check Keyboard Connector

Although the keyboard connector can become detached because of vibration, it is most likely to be disconnected because of a previous repair session. If there is no response from the keyboard, open the computer case and check it to make sure the connector is properly seated. The connector is keyed to fit only one way, so you cannot install it incorrectly without really forcing it.

Defective Keyboard Connector Cable

A defective cable is much more common than a cable that simply "falls off." The wires that are attached to the keyboard connector are crimped into place and held there through the wire's insulation. If the computer receives excessive vibration, one or more of these wires can become disconnected.

To test the wires, use a multimeter (set to ohms) and check the continuity between the wires at the connector and where they are soldered to the keyboard PC board. If any of the wires are open, repair them by resoldering or replace them.

Logic Circuit Problems

Check for Defective 6526 CIA

There are two 6526 CIAs (Complex Interface Adapters) in the C128. They are located at U1 and U4. CIA1 (at U1 in Fig. 7-3) handles the keyboard. Like the VIC chip, the CIAs has both address and data lines as shown in Fig. 7-3. However, the data lines of the CIA are grouped into data bus data lines, port A data lines, and port B data lines. In each case, these are both input and output lines. You can find the 6526 pinout diagram in Appendix A.

The data bus data lines are pins 26 through 33. Pins 2 through 9 are the data lines for port A, and pins 10 through 17 are the data lines for port B.

The data lines on the CIAs are designed to operate in three states: high, low, and tri-state (also called high impedance). When the data lines are active, they should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2–3.5 volts) then the data is bad.

Fig. 7-2. Keyboard circuitry.
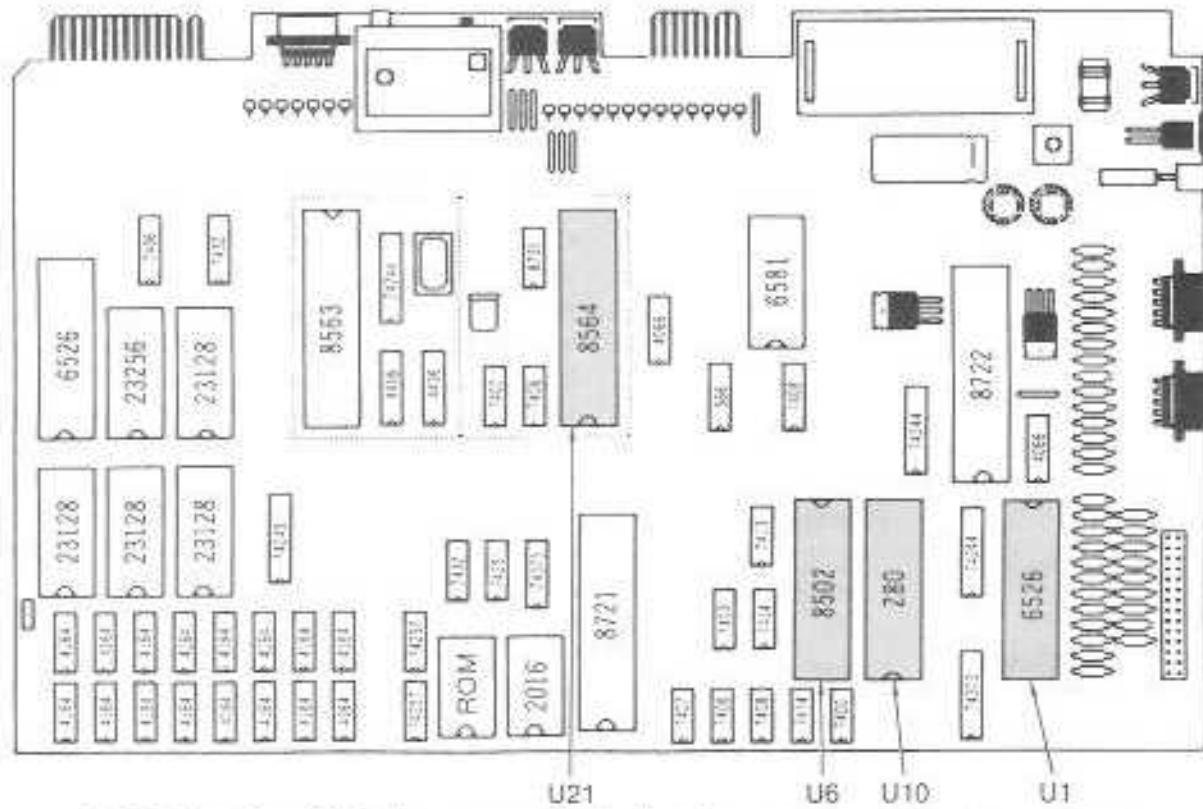
Fig. 7-3. Location of affected components for keyboard generates wrong characters symptom.

You will need to program the computer to read or write via the CIA being tested to check the data lines. The simplest way to do this is to press keys on the keyboard and look at the data lines on ports A & B. Although the data lines will occasionally tri-state, they will toggle up and down during the actual keyboard read cycles.

If the data lines on the CIA never toggle between +5 volts and ground (0 volts) the CIA may be an indication that the part may be defective. Before you assume that it is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives, or lift the leg on the IC as outlined in Chapter 5 (Figs. 5-5 and 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the 6526 chip.

Pins 35 through 38 are address lines. This means that they are inputs. If any of these show improper signal levels, trace the signal back to its source and perform the same tests we used previously for the data lines.

Pins 20 and 1 are power and ground, respectively. They should be a steady +5 volts (power) and 0 volts (ground).

Pin 34 is the reset line. In normal operation, this pin will always be high. A low or intermediate voltage level will prevent the 6526 from operating.

Pin 25 is a clock signal and must be present for the 6526 to run properly.

The remaining pins on the 6526 carry asynchronous signals and will rise and fall at seemingly random times. Check them for voltage levels remembering that they should be close to +5 volts at their peaks and 0 volts at their valleys.

Display Circuit Problems

Check for Defective VIC Chip

The VIC chip (8564) is located at U21 in Fig. 7-3. It operates the 40-column display and most of the C128's graphic modes. Like the ROM chips, it has both address lines and data lines. Additionally, it produces signals that the C128 uses for an assortment of special functions like scanning the upper three lines of the keyboard. You can find the 8564 pinout diagram in Appendix A.

The data lines are pins 1, 2, 3, 4, 5, 7, 43, 44, 45, 46, and 47. These pins should have irregular rising and falling signals. If any are floating up and down or are steady at some voltage in the middle (2-3.5 volts) then the data is bad. Since these pins are outputs, this condition may be an indication that the part is defective. Before you assume that the part is bad, however, be aware

that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives, or lift the leg on the IC as outlined in Chapter 5 (Figs. 5-5 and 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the VIC chip.

Pins 31-42 are address lines. This means that they are inputs. If any of these show improper signal levels trace the signal back to its source and perform the same tests we used previously for the data lines.

Pin 13 is the CS (chip select) line. It is used by the C128 to enable the VIC chip. This line must be low for the VIC to operate.

Pin 14 is the read/write line. It controls access to the VIC. When this pin is high, the VIC is reading data and when it is low it is writing. Ordinarily, the R/W line will be toggling up and down as the C128 operates.

Pins 18, 23, and 25 are the system clock lines. Pin 18 is the 1-MHz clock and should always produce a consistent 1-MHz signal. Pin 23 is the 2-MHz clock and it switches between 1 MHz and 2 MHz depending upon the current operating mode of the computer.

Pin 25 is the system clock for the Z80 microprocessor. It operates at 4 MHz.

Pins 29 and 30 are the dot and color clocks. They are high speed clocks and produce constant, evenly spaced outputs. They are the source for all of the other clocks in the system.

Pins 26, 27, and 28 are three of the keyboard scanning lines. They are slower than the other clocks but should produce a regular, evenly spaced output.

Pins 16 and 17 are COLOR and SYNC, respectively. They produce the final video output from the VIC chip and must be present for the display to operate. The output from these pins looks like garbage on an oscilloscope screen. To check these lines, simply make sure that the signals are present. In almost every case, if these are operating at all, they are correct.

Pins 48 and 24 are power and ground and should be +5 volts and 0 volts, respectively. The remaining pins on the VIC chip are asynchronous signals and will rise and fall at seemingly random times. Check them for voltage levels remembering that they should be close to +5 volts at their peaks and 0 volts at their valleys.

CPU Problems

Check for Defective 8502 Microprocessor

The 8502 microprocessor is located at U6 in Fig. 7-3. It operates the C128 in the C128 mode. Like the VIC chip, it has both address lines and data lines. You can find the 8502 pinout diagram in Appendix A.

The data lines are pins 31 through 38. When you look at these in the C128 mode, they should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2–3.5 volts) then the data is bad. In the CP/M mode, these lines are supposed to float.

Since these pins are outputs, a defective signal could be an indication that the part is defective. Before you assume that it is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives, or lift the leg on the IC as outlined in Chapter 5 (Figs. 5-5 and 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the 8502 chip.

Pins 7 through 20, 22, and 23 are address lines. This means that they are inputs. If any of these show improper signal levels trace the signal back to its source and perform the same tests we used previously for the data lines.

Pins 6 and 21 are power and ground, respectively. They should be a steady +5 volts (power) and 0 volts (ground).

Pin 40 is the reset line. In normal operation, this pin will always be high. A low or intermediate voltage level will prevent the 8502 from operating.

Pin 1 is a clock signal and must be present for the 8502 to run.

The port I/O data lines are pins 24 through 30. When you look at these during I/O accesses, they should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2–3.5 volts) then the data is bad.

Since these pins are both inputs and outputs, a defective signal could be an indication that the part is defective. Before you assume that it is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives, or

lift the leg on the IC as outlined in Chapter 5 (Figs. 5-5 and 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the 8502 chip.

The remaining pins on the 8502 are asynchronous signals and will rise and fall at seemingly random times. Check them for voltage levels remembering that they should be close to +5 volts at their peaks and 0 volts at their valleys.

Check for Defective Z80 Microprocessor

The Z80 microprocessor is located at U10 in Fig. 7-3. It operates the C128 in the CP/M mode. Like the VIC chip, it has both address lines and data lines. You can find the Z80 pinout diagram in Appendix A.

The data lines are pins 7, 8, 9, 10, 12, 13, 14, and 15. When you look at these in the CP/M mode, they should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2–3.5 volts) then the data is bad. In C128 mode, these lines are supposed to float.

Since these pins are outputs, the absence of the proper signal could be an indication that the part is defective. Before you assume that it is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives, or lift the leg on the IC as outlined in Chapter 5 (Figs. 5-5 and 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the Z80 chip.

Pins 1 through 5 and 30 through 40 are address lines. This means that they are inputs. If any of these show improper signal levels trace the signal back to its source and perform the same tests we used previously for the data lines.

Pins 11 and 29 are power and ground, respectively. They should be a steady +5 volts (power) and 0 volts (ground).

Pin 26 is the reset line. In normal operation, this pin will always be high. A low or intermediate voltage level will prevent the Z80 from operating.

Pin 6 is a clock signal and must be present for the Z80 to run.

The remaining pins on the Z80 are asynchronous signals and will rise and fall at seemingly random times. Check them for voltage levels remem-

bering that they should be close to +5 volts at their peaks and 0 volts at their valleys.

Keyboard Problems

Before you disassemble the keyboard, perform a continuity test of the keyboard at the connector. Using the ohms range on your multimeter, check the lines to make sure than none are shorted.

Usually shorted keyboards will produce a continuous string of the same character(s) or they will lock up entirely. However, an intermittent short can cause unpredictable results.

Check for continuity between each of the keyboard lines when the keys are open, and again when you are pressing them. Use the keyboard circuitry guide in Fig 7-2.

8

Troubleshooting Techniques: Input/Output Problems

In this chapter problems related to input/output devices will be examined. Problems encountered in reading and writing to the disk drive(s) or datasette recorder, and operation of the joystick or mouse will be examined.

DISK DRIVE PROBLEMS

Disk drive complaints that are related to computer operation can be broken down into the following symptom categories:

- Disk drive will not respond
- Disk drive lights flashing all the time
- Can't read or write disks or reads or writes to them poorly

The chart at the right outlines the problems, possible causes, and repair actions for the condition where the disk drive system is not operating properly. Specific troubleshooting and repair techniques for each problem then follow.

Problem	Possible Cause	Repair Action
Drive not receiving data	Drive cables defective or not properly connected	Check/install/repair or replace disk drive data and power cables
	Drive set to wrong device number	Check drive selector jumper on disk drive logic board
	More than one device with same device number on the same port	Check/change device number of one or more devices on port
	Serial port connector shorted or open	Check/replace serial port connector at location CN6
Logic problems	Defective CIA2 (serial port controller)	Check/replace CIA2 (6526) at location U4
	Defective Kernal ROM(s)	Check/replace ROMs at locations U32 – U36
CPU problems	Defective 8502	Check/replace defective 8502 at location U6
	Defective Z80	Check/replace defective Z80 at location U10

Drive Not Receiving Data

Check Drive Cables

The disk drive(s) connect to the C128 by way of the serial cable. To connect a single drive to the computer, simply connect the serial cable to the back of the computer and to one of the two serial connectors at the back of the disk drive (it doesn't matter which one you use).

If you are using more than one serial device with the C128, connect the second serial cable to the extra serial connector at the back of the disk drive and the other end of the cable to one of the serial connectors at the back of the second device.

This cabling scheme is called daisy-chaining. If the disk drive is not on, the computer will not be able to communicate with it. Similarly, if the cable is not connected or is defective, the data will not be transferred.

To check the data cable, disconnect it from both ends and use the ohms range on a multimeter to check continuity between each of the data pins on the connectors.

Check Device IDs

Each device on the serial port of the C128 must have a unique device number. Typically, the disk drive is No. 8, the printer is No. 4, and so on. If you connect more than one disk drive to the system you will need to change the device number of the second drive. This drive should be set to device No. 9.

Logic Problems

Check for Defective 6526 CIA

There are two 6526 CIAs (Complex Interface Adapters) in the C128. They are located at U1 and U4 in Fig. 8-1. CIA2 (at U4) handles the disk drive(s). Like the VIC chip, the CIA has both address and data lines. However, the data lines of the CIA are grouped into data bus data lines, port A data lines, and port B data lines. In each case, these are both input and output lines. You can find the 6526 pinout diagram in Appendix A.

The data bus data lines are pins 26 through 33. Pins 2 through 9 are the data lines for port A, and pins 10 through 17 are the data lines for port B.

The data lines on the CIAs are designed to operate in three states: high, low, and tri-state

(also called high impedance). When the data lines are active, they should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2 – 3.5 volts) then the data is bad.

You will need to program the computer to read or write via the CIA being tested to check the data lines. The simplest way to do this is for CIA2 is to attempt to read or write to the disk drive.

Although the data lines will occasionally tristate, they will toggle up and down during the actual disk drive read/write cycles.

If the data lines on the CIA never toggle between +5 volts and ground (0 volts) it may be an indication that the part is defective. Before you assume that it is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives, or lift the leg on the IC as outlined in Chapter 5 (Figs. 5-5 and 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the 6526 chip.

Pins 35 through 38 are address lines. This means that they are inputs. If any of these show improper signal levels trace the signal back to its source and perform the same tests we used previously for the data lines.

Pins 20 and 1 are power and ground, respectively. They should be a steady +5 volts (power) and 0 volts (ground).

Pin 34 is the reset line. In normal operation, this pin will always be high. A low or intermediate voltage level will prevent the 6526 from operating.

Pin 25 is a clock signal and must be present for the 6526 to run properly.

The remaining pins on the 6526 carry asynchronous signals and will rise and fall at seemingly random times. Check them for voltage levels remembering that they should be close to +5 volts at their peaks and 0 volts at their valleys.

Kernal ROMs Not Reading Correctly

Defective ROMs will prevent the computer from operating correctly and can therefore prevent the disk drive from functioning. These ROMs are in locations U32, U33, U34, U35, and U36 (Fig. 8-1). U32 – U35 are 23128s and U36 is a 23256. The pinouts for these parts is in Appendix A.

With the exception of two pins, these two ROMs have identical signals. Pins 1 and 28
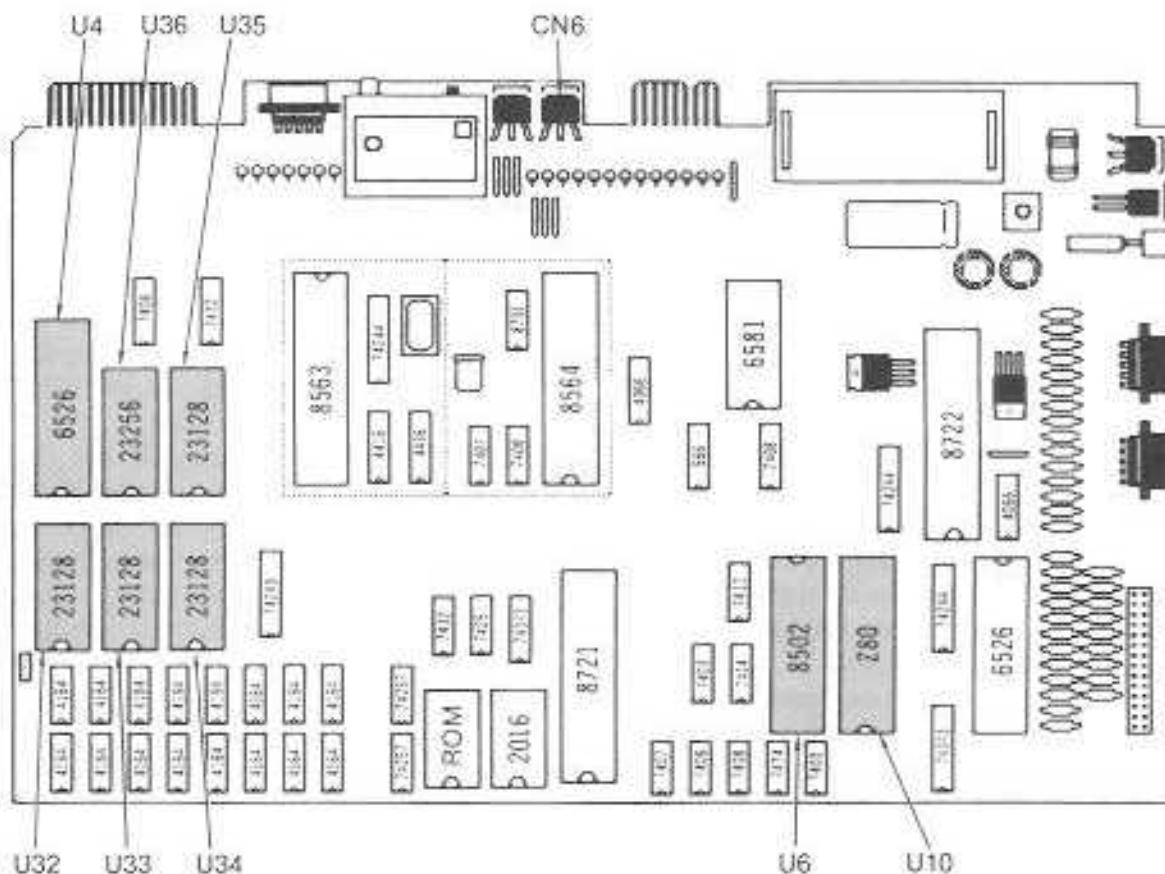
Fig. 8-1. Location of affected components for disk drive problems.

should be a steady +5 volts and pin 14 should be solidly at ground (0 volts). If power or ground to any of these is defective, trace the power beginning at the input power source (at the power supply or regulator circuits covered in the previous section).

Pins 11, 12, 13, 15, 16, 17, 18, and 19 are data lines and should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2–3.5 volts) then the data is bad. Since these parts are outputs, this condition may be an indication that the part is defective. Before you assume that the part is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives, or lift the leg on the IC as outlined in Chapter 5 (Figs. 5-5 and 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the IC.

Pins 2–10, 21, 23, 24, 25, and 26 are address lines. This means that they are inputs. If any of these show improper signal levels trace the signal back to its source and perform the same tests we used above for the data lines. Pin 27 on the 23256 is also a data line. In both cases, pin 22 should be low to enable the device. If this pin is not low (anything higher than 1.75 volts) then the ROM will not read properly.

CPU Problems

Check for Defective 8502 Microprocessor
The 8502 microprocessor is located at U6 in Fig. 8-1. It operates the C128 in the C128 mode. Like the VIC chip, it has both address lines and data lines. You can find the 8502 pinout diagram in Appendix A.

The data lines are pins 31 through 38. When you look at these in the C128 mode, they should have irregular rising and falling signals. If any of

these are floating up and down or are steady at some voltage in the middle (2–3.5 volts) then the data is bad. In the CP/M mode, these lines are supposed to float.

Since these pins are outputs, a defective signal could be an indication that the part is defective. Before you assume that it is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives, or lift the leg on the IC as outlined in Chapter 5 (Figs. 5-5 and 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the 8502 chip.

Pins 7 through 20, 22, and 23 are address lines. This means that they are inputs. If any of these show improper signal levels trace the signal back to its source and perform the same tests we used previously for the data lines.

Pins 6 and 21 are power and ground, respectively. They should be a steady +5 volts (power) and 0 volts (ground).

Pin 40 is the reset line. In normal operation, this pin will always be high. A low or intermediate voltage level will prevent the 8502 from operating.

Pin 1 is a clock signal and must be present for the 8502 to run.

The port I/O data lines are pins 24 through 30. When you look at these during I/O accesses, they should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2–3.5 volts) then the data is bad.

Since these pins are both inputs and outputs, a defective signal could be an indication that the part is defective. Before you assume that it is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives, or lift the leg on the IC as outlined in Chapter 5 (Figs. 5-5 and 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the 8502 chip.

The remaining pins on the 8502 are asynchronous signals and will rise and fall at seemingly random times. Check them for voltage levels remembering that they should be close to +5 volts at their peaks and 0 volts at their valleys.

Check for Defective Z80 Microprocessor

The Z80 microprocessor is located at U10 in Fig. 8-1. It operates the C128 in the CP/M mode. Like the VIC chip, it has both address lines and data lines. You can find the Z80 pinout diagram in Appendix A.

The data lines are pins 7, 8, 9, 10, 12, 13, 14, and 15. When you look at these in the CP/M mode, they should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2–3.5 volts) then the data is bad. In the C128 mode, these lines are supposed to float.

Since these pins are outputs, the absence of the proper signal could be an indication that the part is defective. Before you assume that it is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives, or lift the leg on the IC as outlined in Chapter 5 (Figs. 5-5 and 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the Z80 chip.

Pins 1 through 5 and 30 through 40 are address lines. This means that they are inputs. If any of these show improper signal levels trace the signal back to its source and perform the same tests we used previously for the data lines.

Pins 11 and 29 are power and ground, respectively. They should be a steady +5 volts (power) and 0 volts (ground).

Pin 26 is the reset line. In normal operation, this pin will always be high. A low or intermediate voltage level will prevent the Z80 from operating.

Pin 6 is a clock signal and must be present for the Z80 to run.

The remaining pins on the Z80 are asynchronous signals and will rise and fall at seemingly random times. Check them for voltage levels remembering that they should be close to +5 volts at their peaks and 0 volts at their valleys.

CASSETTE PROBLEMS

Problems with the cassette drive normally involve cases where the datasette will not respond or it reads and/or writes unreliably.

The following chart outlines the problems, possible causes, and repair actions for the condi-

tion where the cassette drive system is not operating properly. Specific troubleshooting and repair techniques for each problem then follow.

Problem	Possible Cause	Repair Action
Datasette not receiving	Cable defective or not properly connected	Check/install/repair or replace datasette cable
	Defective Kernal ROM(s)	Check/replace ROMs at locations U32–U36
CPU problems	Defective 8502	Check/replace defective 8502 at location U6

Datasette Not Receiving

Check Datasette Cable

The datasette cable is designed to be inserted only one way. It is, however, possible to defeat the key on the connector. If you do, you may install the cable upside down. Check the cable connector and confirm that the key is in place and the cable is not upside down.

The wires that make up the datasette cable are quite sturdy, however, the connection at the drive itself or the connector may break. To check the datasette cable, use the ohms range of your multimeter and make sure that the connector contacts are connected to the contacts inside the datasette.

Kernal ROMs Not Reading Correctly

These ROMs are in locations U32, U33, U34, U35, and U36. See Fig. 8-2. U32–U35 are 23128s and U36 is a 23256. The pinouts for these parts are in Appendix A.

With the exception of two pins, these two ROMs have identical signals. Pins 1 and 28 should be a steady +5 volts and pin 14 should be solidly at ground (0 volts). If power or ground to any of these is defective, trace the power beginning at the input power source (at the power supply or regulator circuits covered in the previous section).

Pins 11, 12, 13, 15, 16, 17, 18, and 19 are data lines and should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2–3.5

volts) then the data is bad. Since these parts are outputs, this condition may be an indication that the part is defective. Before you assume that the part is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives, or lift the leg on the IC as outlined in Chapter 5 (Figs. 5-5 and 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the IC.

Pins 2–10, 21, 23, 24, 25, and 26 are address lines. This means that they are inputs. If any of these show improper signal levels trace the signal back to its source and perform the same tests we used above for the data lines. Pin 27 on the 23256 is also a data line. In both cases, pin 22 should be low to enable the device. If this pin is not low (anything higher than 1.75 volts) then the ROM will not read properly.

CPU Problems

Check for Defective 8502 Microprocessor

The 8502 microprocessor is located at U6 in Fig. 8-2. It operates the C128 in the C128 mode. Like the VIC chip, it has both address lines and data lines. You can find the 8502 pinout diagram in Appendix A.

The data lines are pins 31 through 38. When you look at these in the C128 mode, they should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2–3.5 volts) then the data is bad. In the CP/M mode, these lines are supposed to float.

Since these pins are outputs, a defective signal could be an indication that the part is defective. Before you assume that it is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives, or lift the leg on the IC as outlined in Chapter 5 (Figs. 5-5 and 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the 8502 chip.

Pins 7 through 20, 22, and 23 are address lines. This means that they are inputs. If any of these show improper signal levels trace the signal back to its source and perform the same tests we used previously for the data lines.

Fig. 8-2. Location of affected components for cassette problems.

Pins 6 and 21 are power and ground, respectively. They should be a steady +5 volts (power) and 0 volts (ground).

Pin 40 is the reset line. In normal operation, this pin will always be high. A low or intermediate voltage level will prevent the 8502 from operating.

Pin 1 is a clock signal and must be present for the 8502 to run.

The port I/O data lines are pins 24 through 30. When you look at these during I/O accesses, they should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2–3.5 volts) then the data is bad.

Since these pins are both inputs and outputs, a defective signal could be an indication that the part is defective. Before you assume that it is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives, or lift the leg on the IC as outlined in Chapter 5

(Figs. 5-5 and 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the 8502 chip.

The remaining pins on the 8502 are asynchronous signals and will rise and fall at seemingly random times. Check them for voltage levels remembering that they should be close to +5 volts at their peaks and 0 volts at their valleys.

GAME CONTROLLER PROBLEMS

Problems with game controllers involve cases where the joystick or mouse won't work, or won't work properly.

The following chart outlines the problems, possible causes, and repair actions for the condition where the game controller(s) is not operating properly. Specific troubleshooting and repair techniques for each problem then follow.

Problem	Possible Cause	Repair Action
Not receiving commands	Defective game port(s)	Check/repair/replace game controller connector(s)
	Defective joystick(s)	Check/repair/replace joystick(s)
	Defective joystick cable(s)	Check/repair/replace joystick cable(s)
Defective control logic	Defective CIA1	Check/replace CIA1 (6526) at location U1

Not Receiving Commands

Check Game Port(s)

The connectors used in the game ports are the most frequently damaged parts in the C128. It is quite easy to jam a game controller onto the connector pins, bending one or more in the process.

The first thing to check is the pins themselves. Are any of the pins bent, broken or missing? If so, replace the connector. *Do not* try to repair it; they are inexpensive and repairs on them are seldom lasting.

Check Joystick

The joystick has five internal switches (Fig. 8-3). To check the joystick, use a multimeter to check the switches for continuity. Put one lead of the multimeter on the common pin and the other on each of the other connectors in turn, pushing the joystick in each of the four primary positions. Check for nonfunctional switches and for shorted switches.

Although the joystick cables are fairly sturdy, they can become disconnected inside the controller. To check for a defective cable, open the joystick and make the same test(s) as before but place the multimeter probe at the cable connector instead of the internal connectors.
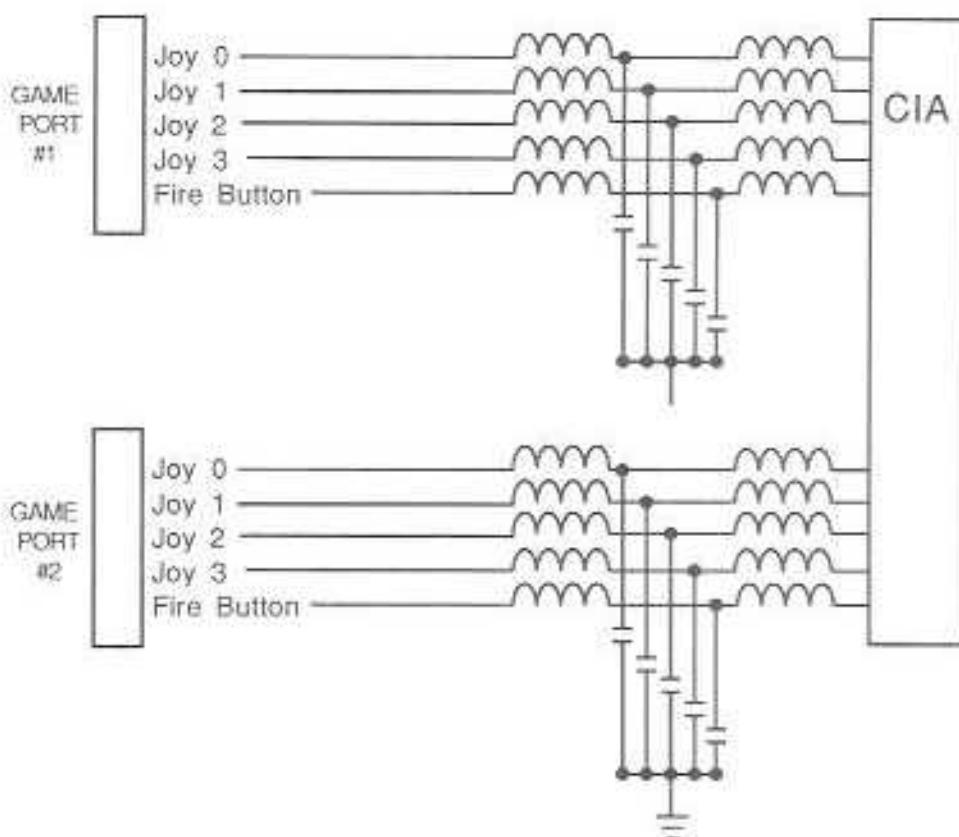
Fig. 8-3. Joystick circuitry.

Defective Control Logic

Check for Defective 6526 CIA

There are two 6526 CIAs (Complex Interface Adapters) in the C128. They are located at U1 and U4 in Fig. 8-4. CIA1 (at U1 handles the joysticks. Like the VIC chip, the CIA has both address and data lines. However, the data lines of the CIA are grouped into data bus data lines, port A data lines, and port B data lines. In each case, these are both input and output lines. You can find the 6526 pinout diagram in Appendix A.

The data bus data lines are pins 26 through 33. Pins 2 through 9 are the data lines for port A, and pins 10 through 17 are the data lines for port B.

The data lines on the CIA are designed to operate in three states: high, low, and tri-state (also called high impedance). When the data lines are active, they should have irregular rising and falling signals. If any of these are floating up and down or are steady at some voltage in the middle (2–3.5volts) then the data is bad.

You will need to program the computer to read or write via the CIA being tested to check the data lines. The simplest way to do this is to press keys on the keyboard and look at the data lines on ports A & B. Although the data lines will occasionally tri-state, they will toggle up and down during the actual keyboard read cycles.

If the data lines on the CIA never toggle between +5 volts and ground (0 volts) it may be an indication that the part is defective. Before you assume that it is bad, however, be aware that a shorted trace or a defective input circuit can drag the output voltage down on a good part. To determine if the part is bad, isolate it by cutting the trace(s) that it drives, or lift the leg on the IC as outlined in Chapter 5 (Figs. 5-5 and 5-7). Then look at the signal again. If it is still in the wrong voltage range, replace the 6526 chip.

Pins 35 through 38 are address lines. This means that they are inputs. If any of these show improper signal levels trace the signal back to its source and perform the same tests we used previously for the data lines.

Pins 20 and 1 are power and ground, respectively. They should be a steady +5 volts (power) and 0 volts (ground).

Fig. 8-4. Location of affected components for game controller problems.

Pin 34 is the reset line. In normal operation, this pin will always be high. A low or intermediate voltage level will prevent the 6526 from operating.

Pin 25 is a clock signal and must be present for the 6526 to run properly.

The remaining pins on the 6526 carry asynchronous signals and will rise and fall at seemingly random times. Check them for voltage levels remembering that they should be close to +5 volts at their peaks and 0 volts at their valleys.

9

Preventive Maintenance

If you're like most computer owners and users, repairing your computer is not the thing that you enjoy the most. In fact, most people prefer to simply use their computers. Unfortunately, nothing lasts forever, not even computers. However, there are any number of common causes for breakdowns that can be minimized or avoided with a bit of care. In this chapter we'll look at some of the things that you can do to keep your computer alive and well once you've repaired it, or (better still), what you can do before it breaks down to keep it operating.

Before you can begin any program of preventive maintenance you'll need to find the areas in your computer that are likely to become worn. If you don't do this, you might find yourself replacing, and/or adjusting the wrong parts. To help you avoid this, the first thing we'll do is take a look at how (and which) things become nonfunctional due to use (and occasional abuse) of the computer.

LOOKING FOR TROUBLE

There are two classifications of devices associated with a computer: those things that are a part of the computer itself and those things which must be connected to it such as printers, disk drives, and so on. Additionally, each of these devices can be separated into one of three major classifications: mechanical assemblies such as motors, gears, and print heads; electronic assemblies such as circuit boards and power supplies; and expendables such as ribbons, paper, and printwheels. In general circuit boards and other strictly electronic components don't require any specific maintenance other than making sure they are properly fastened, however, circuits are very susceptible to damage or stress (which shortens their life) from their environment.

In this chapter we'll look at the kinds of things that can shorten the life of your computer and the things that you might connect to it (such as printers, disk drives and so on) or use in, on, or about it (such as diskettes, ribbons, paper, etc.).

PROTECTING THE LIFE OF YOUR COMPUTER

Although PC (printed circuit) boards are fairly robust devices, there are a number of things that can affect them adversely. These things can be

broken down into three categories: electrical problems, mechanical problems, and atmospheric problems. We'll take a look at each of these things, how they may cause you problems and what you can do to avoid them.

One thing you should note: all of the peripheral devices that we'll be covering have electronic circuits in them as much as the computer itself. Therefore, you can apply the concepts given here to the peripherals as well.

Electrical Problems

Electronic circuits are designed to use very specific amounts and types of electrical current. The power supplies on the Commodore 128 and its peripherals supply very specific voltages. For instance, pin 1 of the power connector has +5 volts dc; pin 2 has no connection; pin 3 and pin 5 supply 9 volts ac and pin 4 is at ground (0 volts) (see Fig. 9-1).

Voltage Variations

All of the voltages coming the Commodore 128 power supply are derived from the 117-volt power from a standard wall socket. Unfortunately, the power companies are not always able to supply the precise voltage that the power supply needs. If the voltage going into the power supply is too high for example, it might either blow one of its two fuses (either the one at the bottom of the supply or the one on the inside) or it may (unfortunately) simply produce excessively high voltage to the computer.

Additionally, sometimes appliances that are connected to the same electrical circuit as the computer can draw high amounts of current for short times. For example, the compressor on a refrigerator will draw enough power from the line that the voltage can drop to as little as 80 or 90 volts for a few moments. Then, after the compressor has come up to speed or after is shuts down, the power may actually surge to as much as 200 volts!

When this happens, the power supply may fail, a fuse may blow (Fig. 9-2), or it may simply withstand the extra electrical strain. However, both the power supply and the rest of the computer will lose a bit of their life expectancy from each such event.
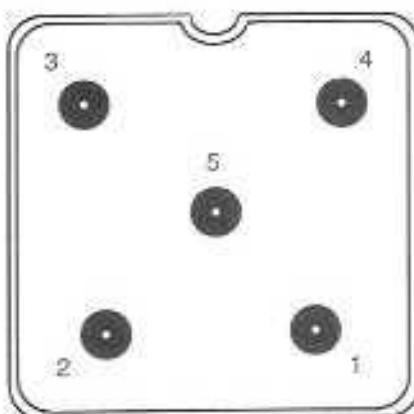
To avoid these kinds of problems, make sure that you plug the computer and its peripherals into a circuit that is (preferably) isolated from any large appliances.

Voltage Spikes and Natural Hazards

Another problem that can arise from the electrical system is called spikes. Spikes are enormous voltage peaks that can be as high as 20,000 to 30,000 volts or more. They are called spikes because they never last more than a few microseconds to a millisecond or so. That, translated into English is about one millionth of a second to one or two thousandths of a second.

While spikes also rarely do permanent damage immediately, they will often halt the computer and its peripherals and they will definitely do harm over the course of time.

Spikes usually come from one of three sources: electrical storms; big equipment on your power lines; and static discharge. To avoid spikes that are caused by the electrical power lines you

Pin	Connector
1	+5 DC
2	Shield
3	9 V AC
4	GND
5	9 V AC

Fig. 9-1. The Commodore 128 power connector.
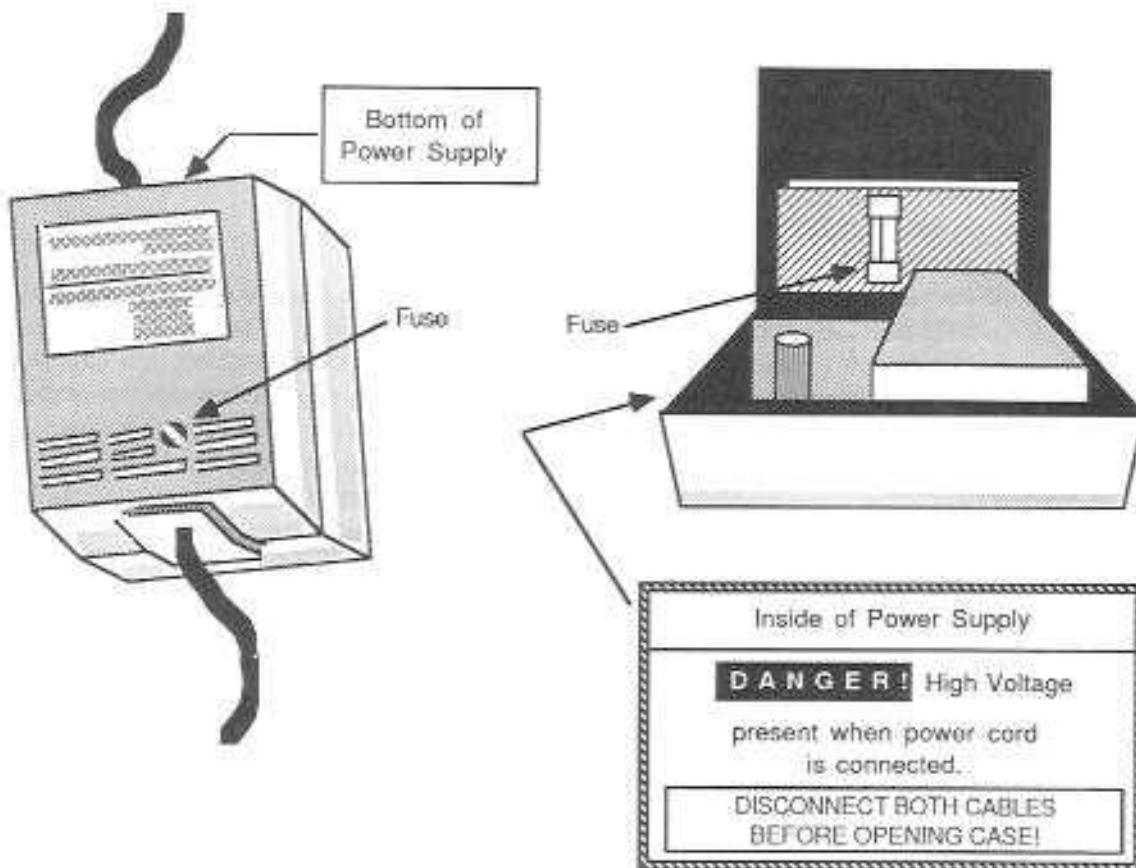
Fig. 9-2. Location of the Commodore 128 power supply fuses.

can obtain a surge suppressor. These handy devices will filter out most small and short electrical problems such as the ones caused by large equipment and/or electrical storms. Unfortunately, they provide no protection from static discharge. Most static discharge is caused by people walking on rugs on dry days and building up a good charge. You may have noticed this when you occasionally touch a door knob and get a small shock that feels a bit like a pin prick.

Shocks like this can actually destroy a computer! To avoid these problems, you can spray your carpets with antistatic spray or simply use a spray bottle with a small amount of detergent. This will prevent the build up of static charges and the resulting problems from "zapping" your computer.

Mechanical Problems

Mechanical problems that can cause trouble for computers are usually centered around dust, dirt,

vibration, and sudden shocks. Most of us will assume that dropping the computer will be of little benefit to it; however, believe it or not, placing a computer near to a large speaker (such as for a stereo) can produce sufficient vibration for socketed chips (ICs) to work out of the sockets, producing poor connections.

Far more harmful than vibration, however, is dust and dirt. These can build up onto circuits, causing excessive heat build up and (occasionally) short circuits because some types of dust and smoke are actually somewhat electrically conductive.

Atmospheric Problems

Atmospheric problems include excessive humidity, corrosive or particle-laden smoke (such as cigarette smoke) chemical fumes, and so on. These can all result in damaged circuits and shorted traces.

Another problem that can be related to atmosphere is heat (and cold). Heat is the single most destructive force to computers. If the temperature becomes too high, circuits will behave unpredictably because the semiconductor process changes with temperature. In may cases, some devices will have much lower resistance at higher or lower temperatures, causing them to draw an excessive amount of current. This type of stress can cause both immediate and long-term failures.

To avoid these kinds of problems, try to maintain the computer at a temperature that is comfortable to you. If you are uncomfortable, the computer probably is also. Additionally, avoid smoking around the computer. The smoke from a cigarette can cause both corrosive and particulate damage to computer components.

In terms of maintenance, the most that you can do for your computer is:

1. Avoid excessive heat
2. Avoid smoke and other kinds of fumes
3. Protect your computer from electrical stress
4. Avoid excessive vibrations or mechanical shocks
5. Keep the computer clean

If you follow these guidelines you will minimize the major causes for actual computer failures.

PERIPHERAL DEVICES

As you can see, there is actually very little you can do in the way of maintenance for your computer. On the other hand, most of the peripheral devices that are used with the Commodore 128 are more mechanical in nature and require occasional "tune-ups." In this section, we'll look at some things that can go wrong with the Commodore 128 peripherals, and how you avoid many of the problems that may arise.

Printers

Printers are the most commonly used peripheral. They provide a way of taking your computer work and turning it into something that can be read and used directly. Unfortunately, printers are also one of the most complex pieces of mechanical equipment made for computers. In this section, we'll look at the parts of a printer, how they may fail, and how to avoid those failures.

Print Heads

Print heads are designed to withstand the most hostile environment in the computer. Most of them strike paper (which releases small amounts of dust every time it is hit) through an inked ribbon (which releases small amounts of oily material each time it is hit). This mixture of paper dust and ink produces a glue-like substance which can (and usually does) work its way into the print head. Without proper maintenance print heads can come to a screeching halt. In first section we'll look at adjusting and cleaning procedures to help keep print heads printing.

DOT MATRIX PRINT HEADS—Dot matrix print heads consist of numerous print wires that are housed in tight-fitting sleeves (Fig. 9-3). Typically they are driven forward by a solenoid and retracted by a spring. In order for the wires to operate smoothly, they must slide smoothly within their sleeves.

Ordinarily, maintaining the print wires is simply a matter of wiping the front surface(s) of the
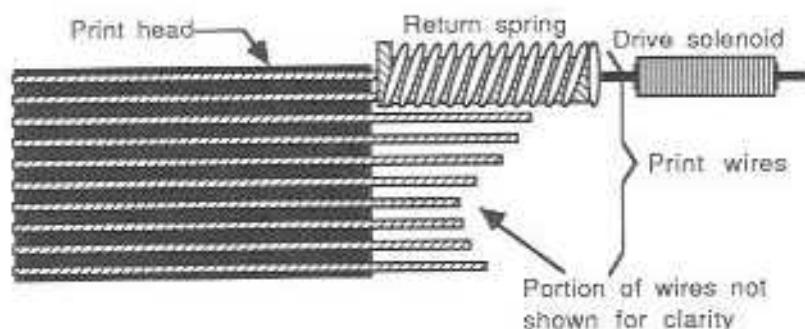
Fig. 9-3. Cross section of dot matrix print head.
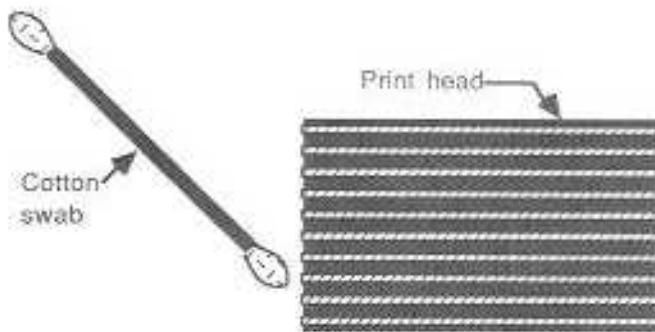
Fig. 9-4. Cleaning the face of the print head.

ABCD — Dirty type

ABCD — Normal type

Fig. 9-5. Filled characters produced by a dirty printwheel.

head and the surrounding areas with a cotton swab as shown in Fig. 9-4. This should be done every time you change the ribbon and additionally whenever the build up is visible.

If the build up is excessive, one or more of the print wires may become stuck in its guide. In these cases, you may be able to free the wire by pulling it forward to it fully extended position and gently cleaning it with a cotton swab which has been dipped in tape head cleaner or alcohol and light oil.

DAISY WHEEL PRINT HEADS—Daisy wheel print heads are subject to the same kinds of materials problems that the dot matrix heads are, however, instead of sticking, daisy wheels simply become clogged with ink-soaked dust. This will

Fig. 9-6. Cross section of an ink jet head.

result in partially filled characters such as the ones shown in Fig. 9-5. In these cases, you should remove the printwheel and clean it with a small bristle brush in soap and water. If some of the ink is stubborn, you can dip the brush in a small amount of alcohol. Never use solvents to clean a printwheel. They can actually soften or dissolve the plastic.

INK JET PRINT HEADS—Ink jets are actually nothing more (on the outside) than some very small holes. Fig. 9-6 shows a cross-sectional view of an ink jet head. In order to print, the ink must be able to squirt out through the holes freely.

Ordinarily, an ink jet computer will have a "home" position for the head which keeps the jets moist so the ink in the holes does not harden and cause a blockage. However, if an ink jet computer is not used for a long time, the moisture will evaporate and the jets can become blocked. To avoid this, the best maintenance for an ink jet computer is to operate it at least once or twice a week.

If the jets become blocked anyway, use one of the following procedures to clear them:

Fig. 9-7. Clearing replaceable ink jets.

Ink stream
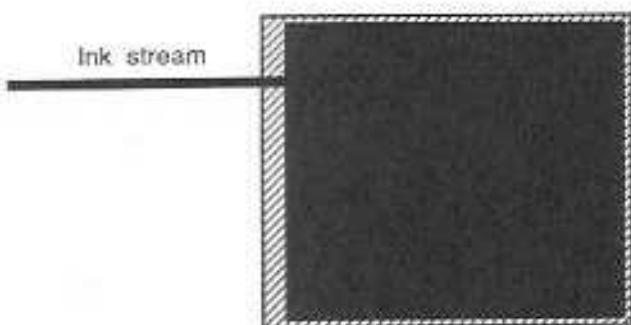
Fig. 9-8. Purge Cycle in the nonreplaceable ink jet.

1. If your computer has a replaceable ink jet head, remove the unit, wipe its front surface with a clean swab and press on the ink supply bladder (Fig. 9-7).

2. If your heads are nonreplaceable, try running a purge cycle (if the system has one). This pumps ink through the heads a high velocity (Fig. 9-8).

3. If the system does not have a purge cycle, or if the purge cycle is unsuccessful, you may need to use a plunger to force liquid through the jets (Fig. 9-9). In most cases, the manufacturer will be able to supply you with a plunger that fits your computer and a special liquid to clear the jets. You should not use water or solvents for this purpose; They can (and almost always do) damage the jets. For more information about your specific computer, contact the manufacturer.

Plunger

Clearing liquid

Ink jet head

Ink jet discharge
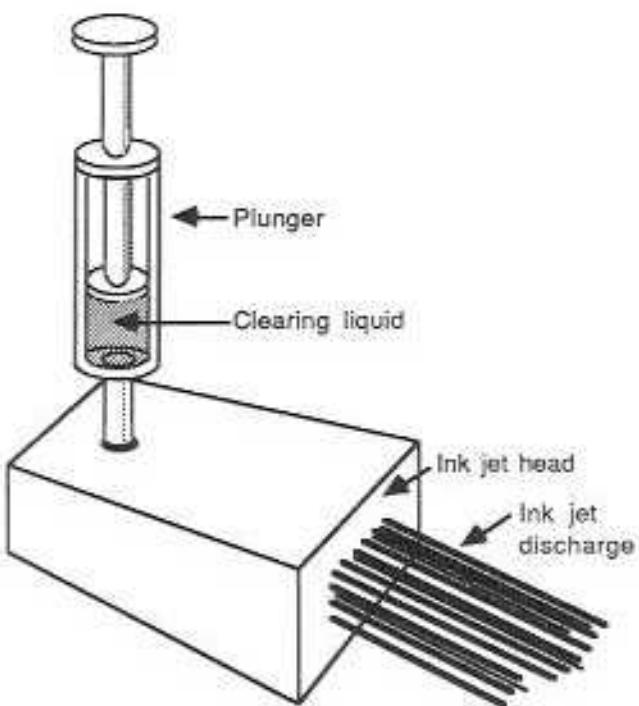
Fig. 9-9. Clearing the ink jets with a plunger.

Head Positioners

The head positioning mechanism (also called the carriage assembly) in most printers rides on one, two, or more rails that run the width of the printer. The rails are usually steel and can become rusty and/or dirty. To keep the head moving smoothly, you should clean the rails with a soft

Carriage assembly

Rails

(Top View)

Soft cotton cloth
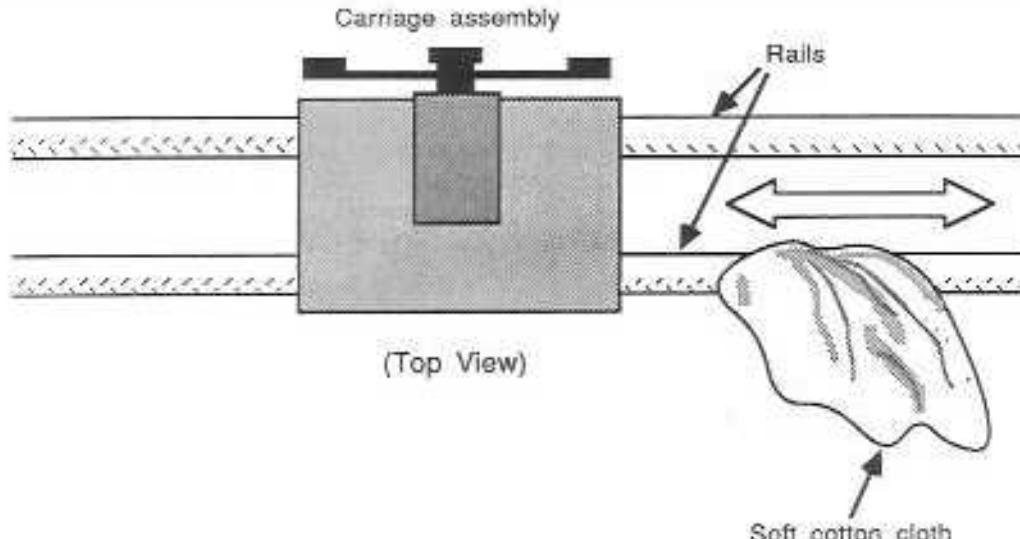
Fig. 9-10. Cleaning and lubricating the rails.
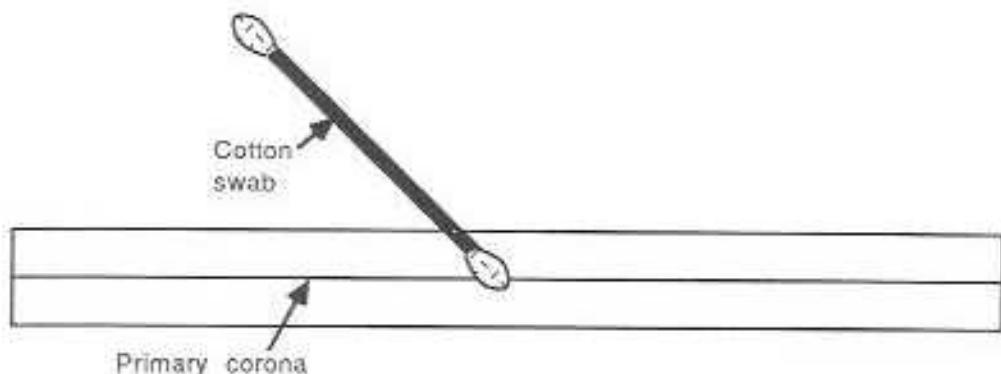
Fig. 9-11. Cleaning the primary corona.

cloth and lubricate them lightly with light oil each time you replace the ribbon (Fig. 9-10).

Laser Print Heads

The laser unit itself in a laser printer is fairly maintenance free. However, the toner cartridge and support mechanisms can become dirty and may need to be cleaned. The areas that can cause problems are the corona wires, the shutters and the rollers.

The corona wires are very thin wires that are charged with a high voltage. The high voltage around the wires causes the air around the wire to become charged (produce a corona). Laser printers have two corona wires: the primary corona and the transfer corona. The primary corona is a part of the replaceable toner cartridge and can be cleaned by removing the cartridge and wiping it with a cotton swab or the cleaning tool that was supplied with the unit (Fig. 9-11).

The transfer corona is a permanent part of the printer and is generally positioned below the paper path (Fig. 9-12). To clean the transfer corona, use a cotton swab. Often the transfer corona is mounted inside a housing that has wraps of nylon around it. Be very careful not to break the wraps or the corona wire. Replacing these is *not fun*.

Paper Transport Mechanisms

Paper transport mechanisms are not really very susceptible to wear. They do, however, tend to become misadjusted with very little provocation. Additionally, they are generally driven by gear mechanisms that can become dirty and will therefore require cleaning and lubricating.

Gear trains consist of gears, drive shafts, and (sometimes) pulleys. To clean the gears, you'll need access to them. The best way to clean them is to remove any surrounding mechanisms and then remove the gears and soak them in alcohol and/or nonsolvent cleaner if they are plastic or any standard solvent if they are metal.

Before you remove any mechanisms (especially gear trains) you should make a sketch of how they go together. It is very easy to assemble gear trains incorrectly.
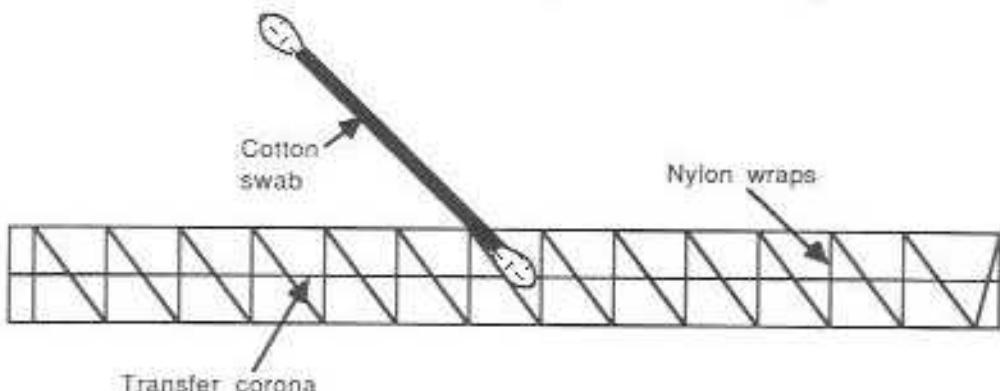
Fig. 9-12. Cleaning the transfer corona.
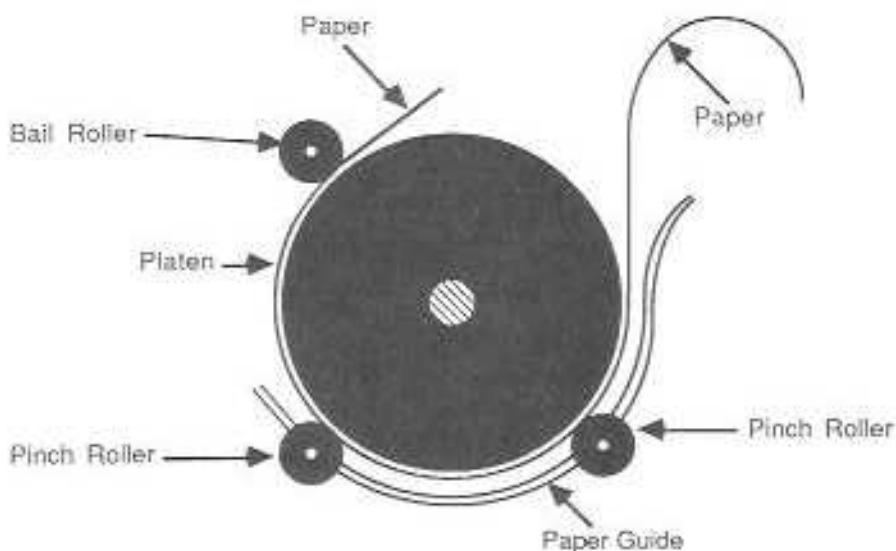
Fig. 9-13.
Cross-sectional view
of a typical friction
feed assembly.

When you lubricate gears, you should apply the same kind of lubrication that was on the gears originally. If you are not sure of the kind to use, contact the manufacturer.

FRICTION FEED—Friction feed mechanisms consist of a platen and an assortment of pressure rollers that press the paper against the platen. The lower rollers are attached to an assembly called the cradle and the upper rollers are attached to the bail arm (Fig. 9-13).

In general, the only maintenance required with friction feed mechanisms is aligning and cleaning the rollers. After a lot of use, platens and

other rubber components become hardened. To help extend their life, the rollers and platen should be cleaned with a special compound available at typewriter supply houses.

DISK DRIVES

Disk drives have far fewer moving parts than do printers. The Commodore 1571, for instance has only the head assembly (which moves in and out) and the rotating spindle which spins the diskette. In addition to the problems we discussed in
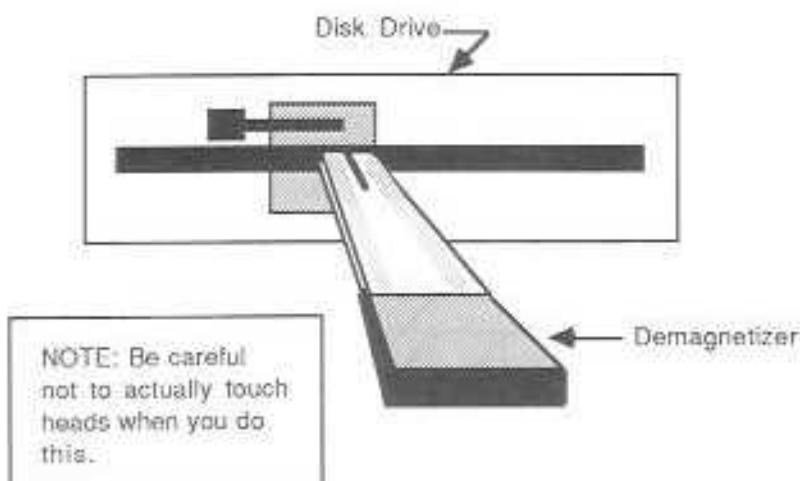
Fig. 9-14. Demagnetizing the heads on a disk drive.

NOTE: Be careful not to actually touch heads when you do this.

Disk Drive

NOTE: Do not apply much force, the material on the heads is powdery, not hard and you can damage the heads if you are not careful!

Cotton swab

Long handle cotton swab, dipped in alcohol (just barely damp, not wet)
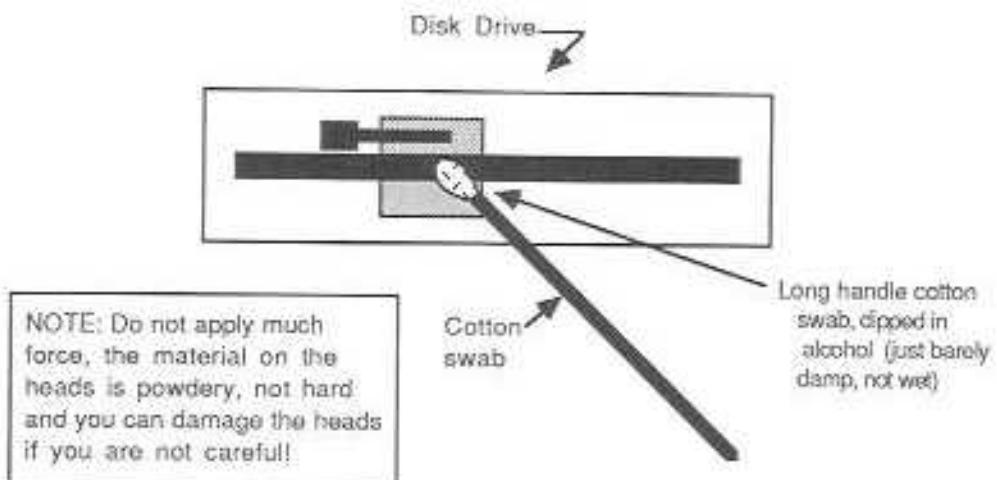
Fig. 9-15. Cleaning the heads with a cotton swab.

Chapter 8, magnetic head/diskette surface problems can also occur.

The surface of a floppy diskette is very similar to the material on a magnetic tape. Additionally, the heads on a floppy disk drive are very similar to the heads on a tape recorder/player. The kinds of problems that can arise in these areas are related to magnetism and dirt.

The medium that the disk drive uses to read and write onto diskettes is magnetism. After a while the magnetic fields in the head and those on the diskette surfaces can deposit a permanent magnetic field in the head(s). This will result in a lower signal level to the drive circuitry and can actually damage the diskette data.

To keep the heads from becoming magnetized, it is useful to demagnetize them periodically (once a year or so). Tape head demagnetizers work fine for this purpose and are available at most electronic supply stores (Fig 9-14).

The second thing that can cause problems with a disk drive is dirt. Dirty heads cannot read or write properly. Floppy disk drives are designed to have the surface of the head actually contact the diskette surface. If there is dirt, grease, dust, smoke, or other particulate matter on the diskette or head, the drive will have trouble reading and writing data.

Disk Drive

Head-cleaning diskette
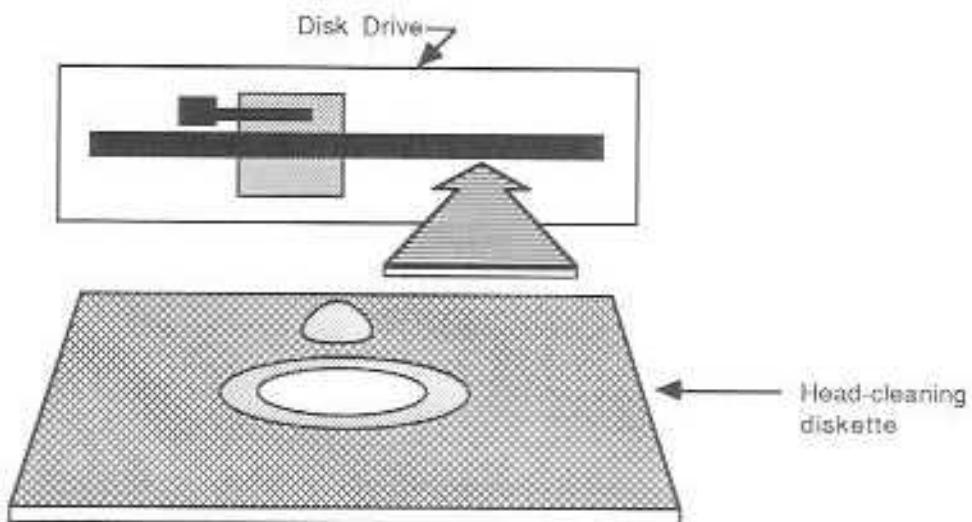
Fig. 9-16. Cleaning the heads with a special head-cleaning diskette.

To clean the heads on the disk drive, use a long cotton swab dipped in alcohol. Then, gently wipe the head surfaces with the swab and let them dry (Fig. 9-15).

Alternatively, you may use special head-cleaning diskettes to clean the disk heads (Fig. 9-16). These usually use a special paper diskette that will hold a special solvent. When the special diskette is "read" in the drive, it automatically cleans the head.

A FEW FINAL NOTES

Every computer is different from and similar to, every other computer on the market. But, like any device, a computer can be reliable or unreliable. Part of this is determined by the design of the system and the quality of the components used. But today, the parts and designs of computers are all quite similar. In fact, to a large extent, computers can be purchased based upon features alone. However, any mechanical device is subject to wear and your best insurance against failures is to become acquainted with the way your computer works. Then, if you notice anything different, you can check it out and make repairs and/or adjustments before anything really bad happens.

The main thrust of this book is to show you how your computer works and how to look for problems. This information, coupled with the information in the appendices, and from the computer manufacturer (if necessary) is still of no use unless you use your senses to find problems. Look and listen to your computer—it will tell you what it needs. And finally, always make notes to yourself. Include drawings of how things looked before you started taking them apart. There is nothing more frustrating than fixing a problem and then, not being able to put the computer back together again because you forgot how one or more parts fit together.

Appendices

A

Integrated Circuit Pinouts
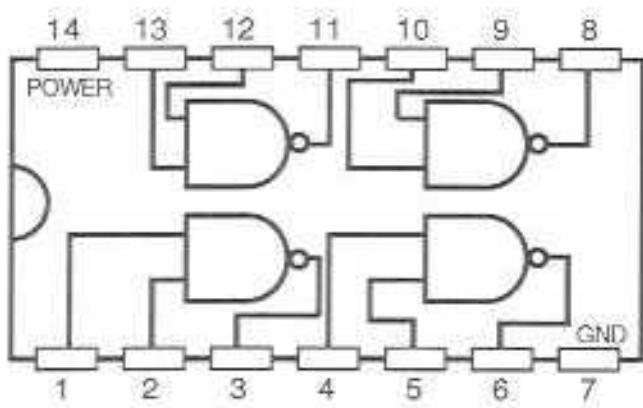
Fig. A-1. 7403 quad 2-input NAND gate.
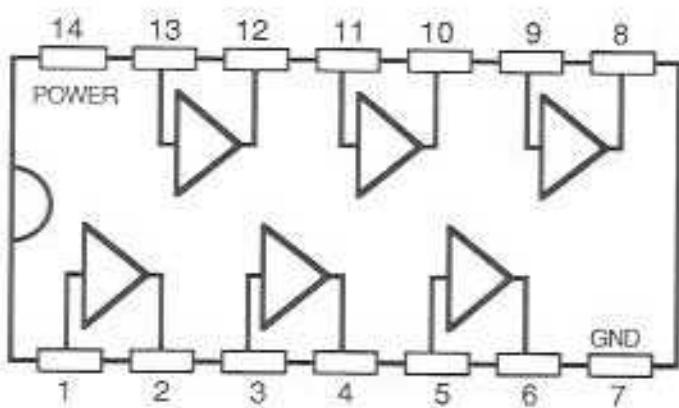
Fig. A-3. 7407 hex buffer/driver.
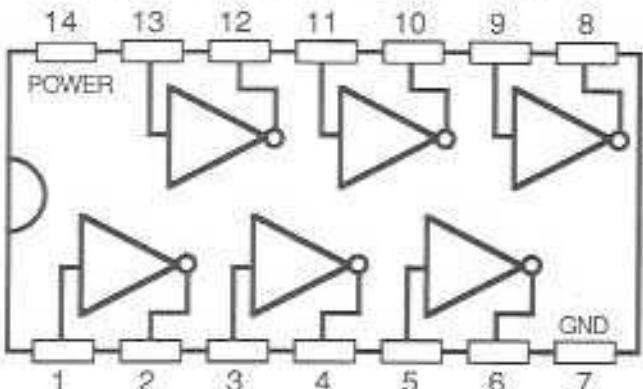
Fig. A-2. 7406 hex inverter buffer/driver.
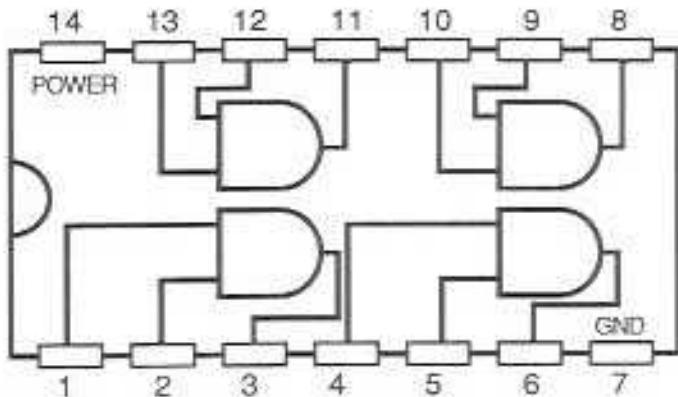
Fig. A-4. 7408 quad
2-input positive NAND gate.
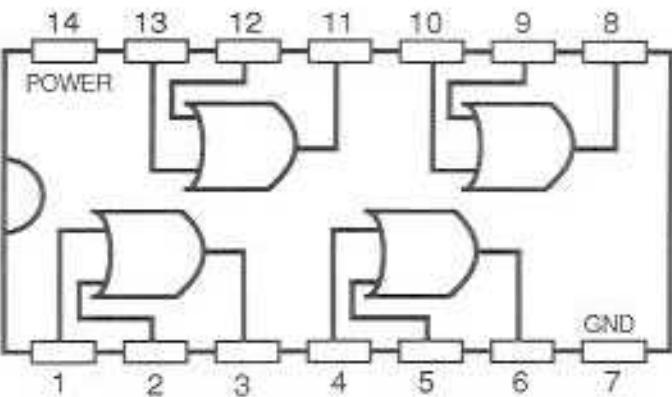
Fig. A-7. 7432 quad 2-input
positive OR gate.
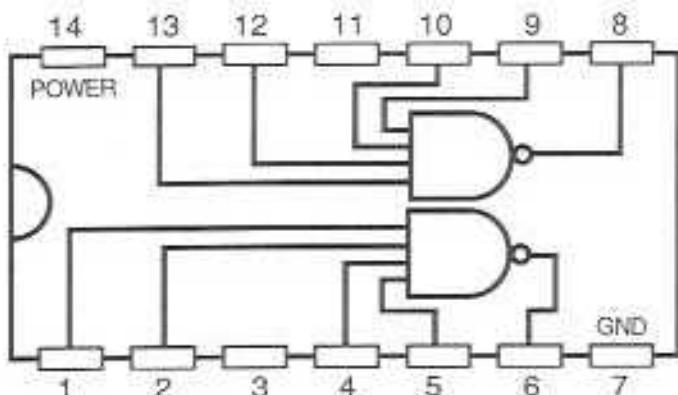
Fig. A-5. 7413 dual 4-input
positive NAND Schmitt-trigger.
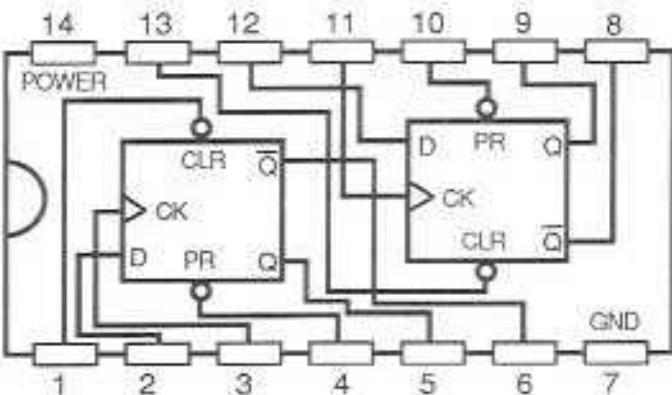
Fig. A-8. 7474 dual D-type
positive-edge-trigger flip flop.
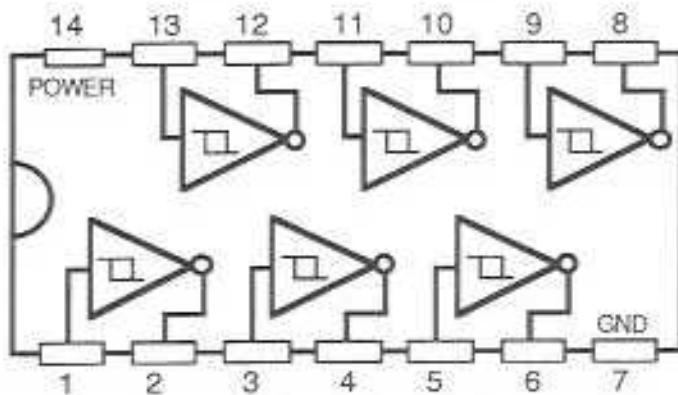
Fig. A-6. 7414 hex Schmitt-trigger inverter.
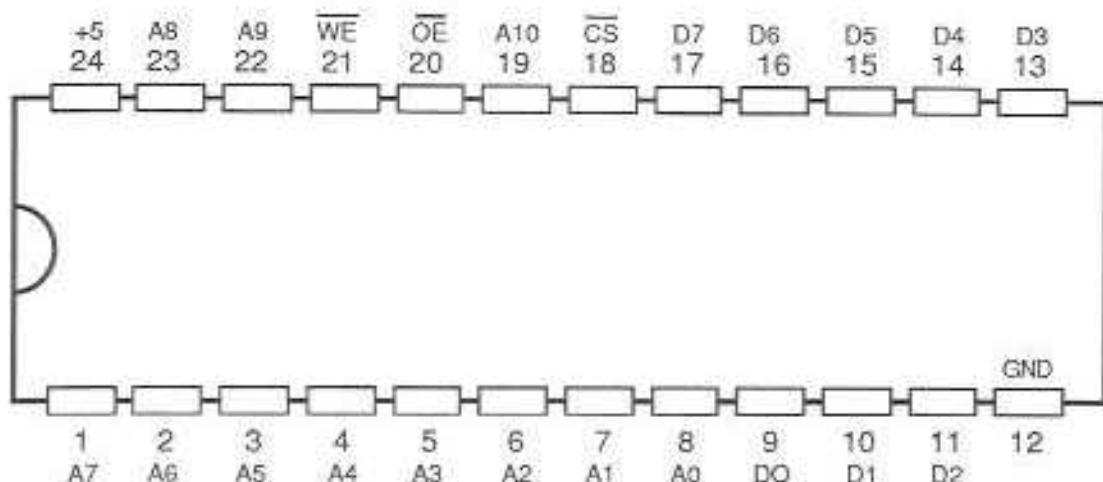
Fig. A-9. 2016 2048-word × 8-bit static RAM.
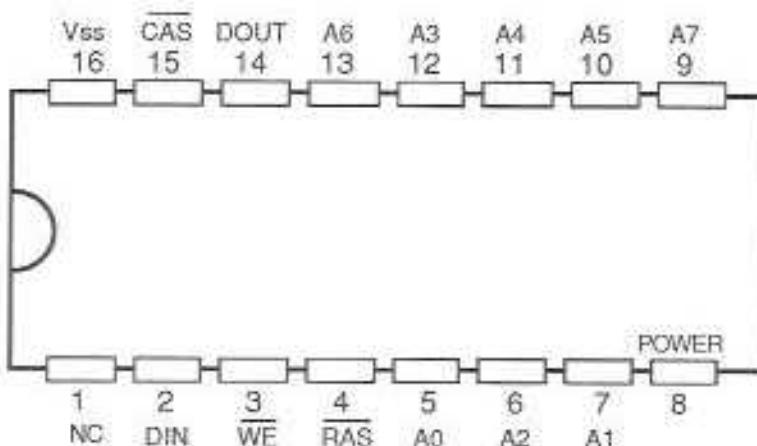
Fig. A-10. 4164 64K dynamic RAM.
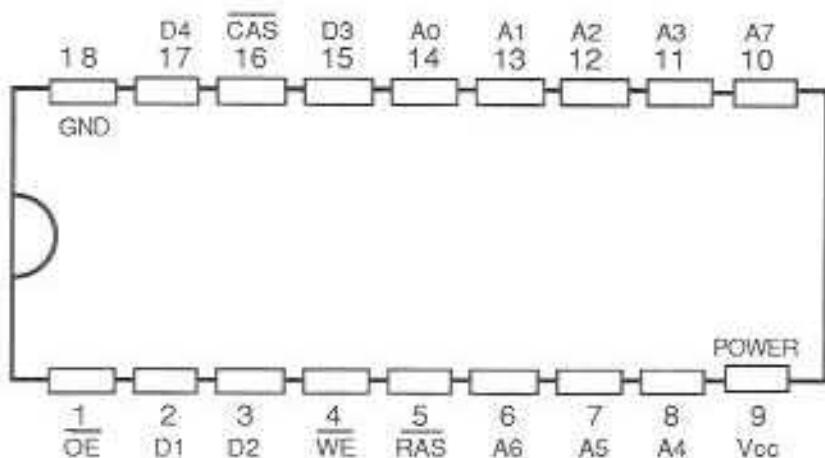
Fig. A-11. 4416 16K dynamic RAM.
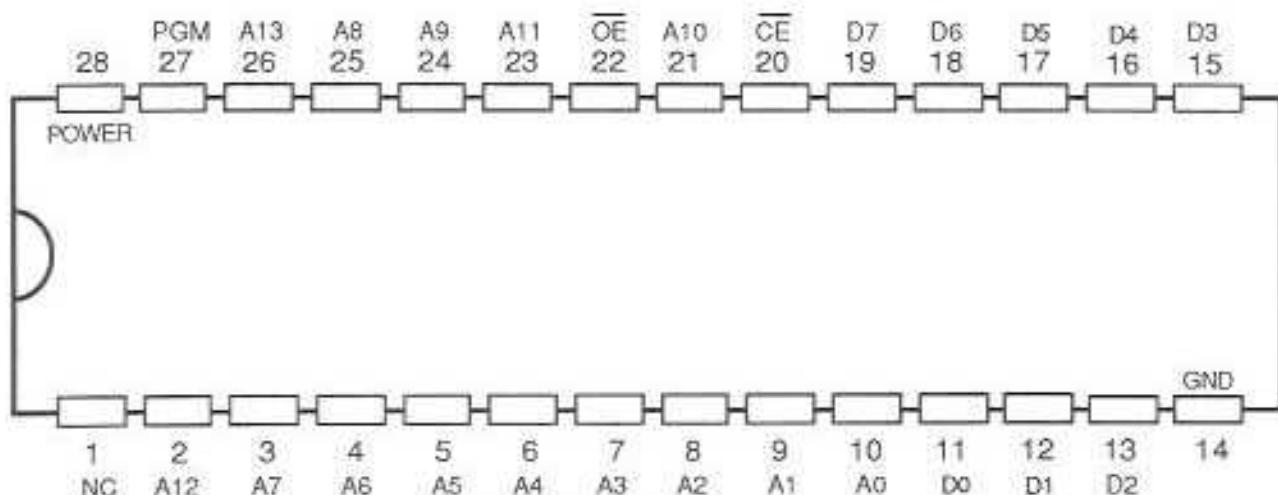
Fig. A-12. 23128 128K ROM.
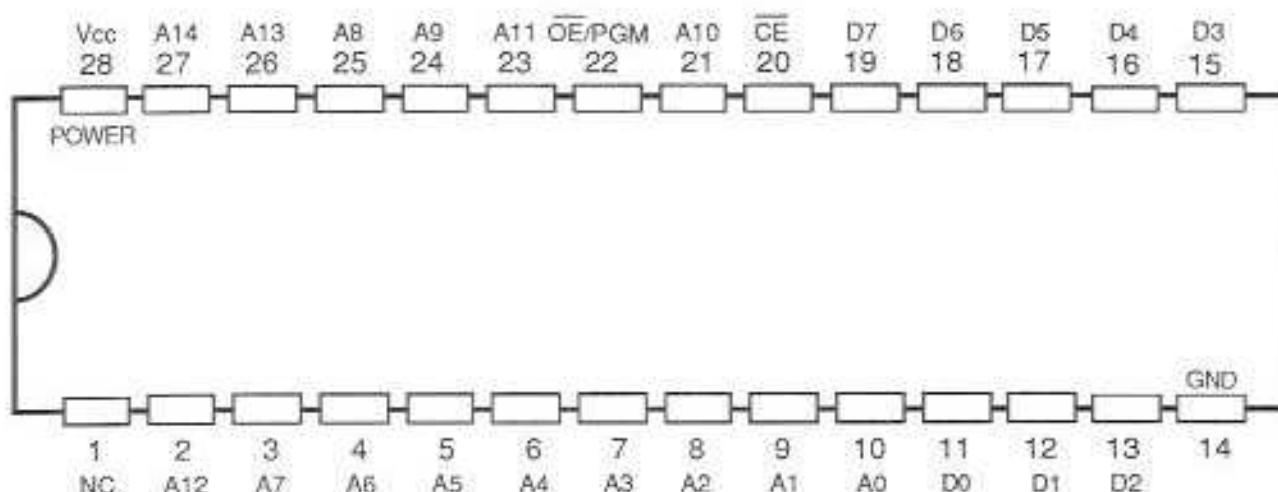
Fig. A-13. 23256 256K ROM.
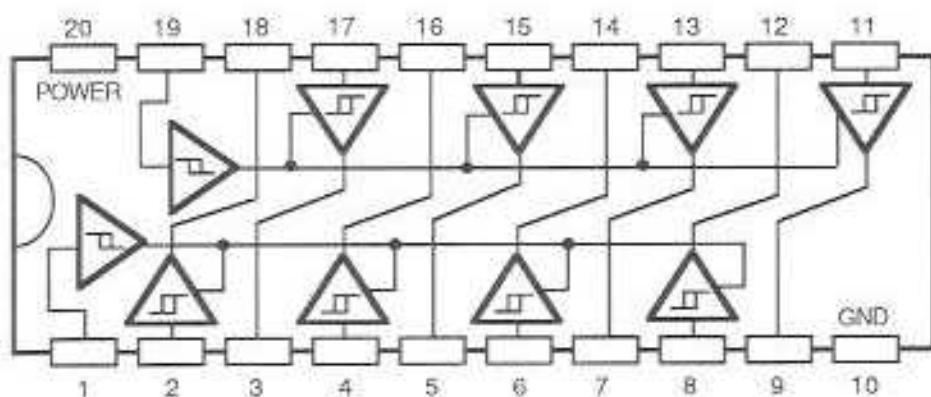
Fig. A-14. 74244 octal buffer/line
drive/line receiver with noninverted 3-state outputs.
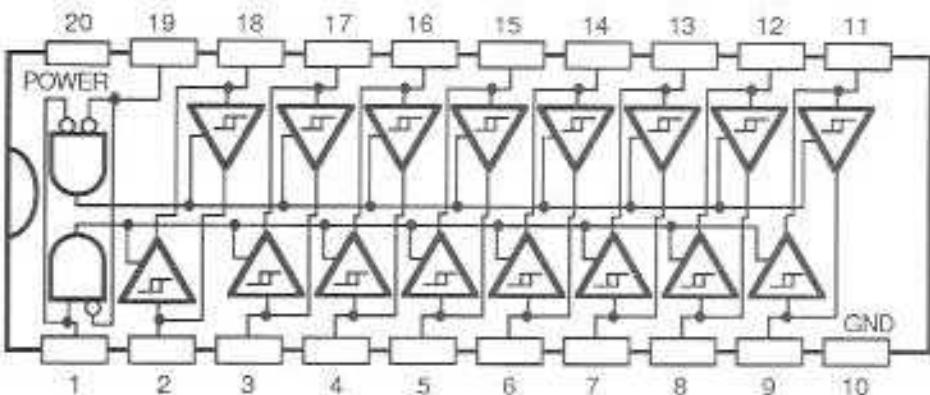
Fig. A-15. 74245 octal bus transceivers with noninverted 3-state outputs.
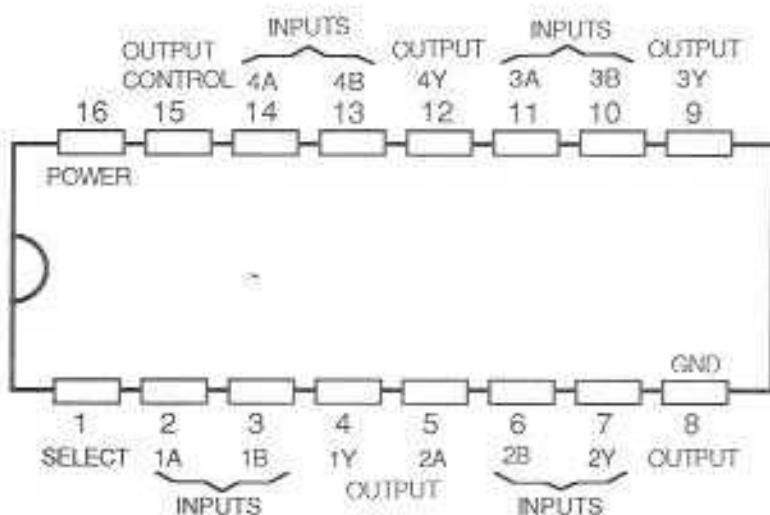
Fig. A-16. 74257 quad 2-line to 1-line data selector/multiplexer with 3-state output.
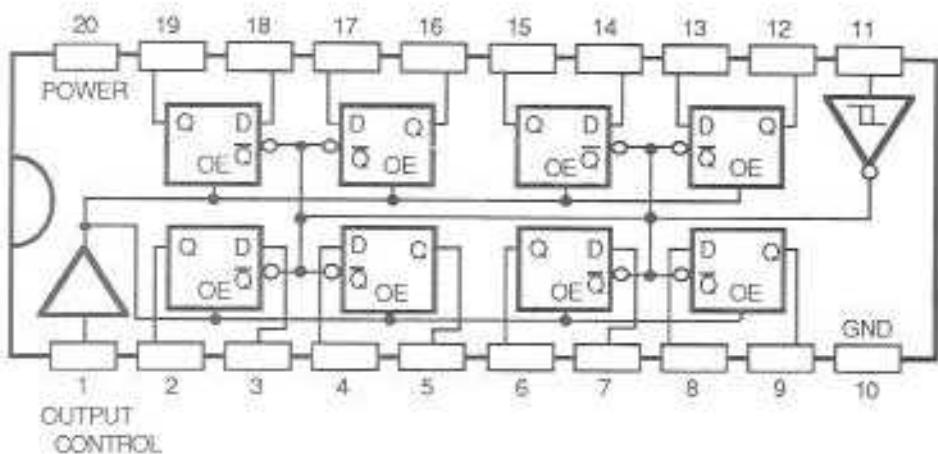
Fig. A-17. 74373 octal D-type latches with 3-state outputs.

Fig. A-18. 8721 programmed logic array (PLA).

```
        PHI 0   1 ▯        ▯ 40  RES
        READY   2 ▯        ▯ 39  R/W
          IRQ   3 ▯        ▯ 38  D0
          NMI   4 ▯        ▯ 37  D1
          AEC   5 ▯        ▯ 36  D2
         Vdd.   6 ▯        ▯ 35  D3
           AO   7 ▯        ▯ 34  D4
           A1   8 ▯        ▯ 33  D5
           A2   9 ▯  8502  ▯ 32  D5
          A3  10 ▯        ▯ 31  D7
          A4  11 ▯        ▯ 30  P0
          A5  12 ▯        ▯ 29  P1
          A6  13 ▯        ▯ 28  P2
          A7  14 ▯        ▯ 27  P3
          A8  15 ▯        ▯ 26  P4
          A9  16 ▯        ▯ 25  P5
         A10  17 ▯        ▯ 24  P6
         A11  18 ▯        ▯ 23  A15
         A12  19 ▯        ▯ 22  A14
         A13  20 ▯        ▯ 21  Vss
```
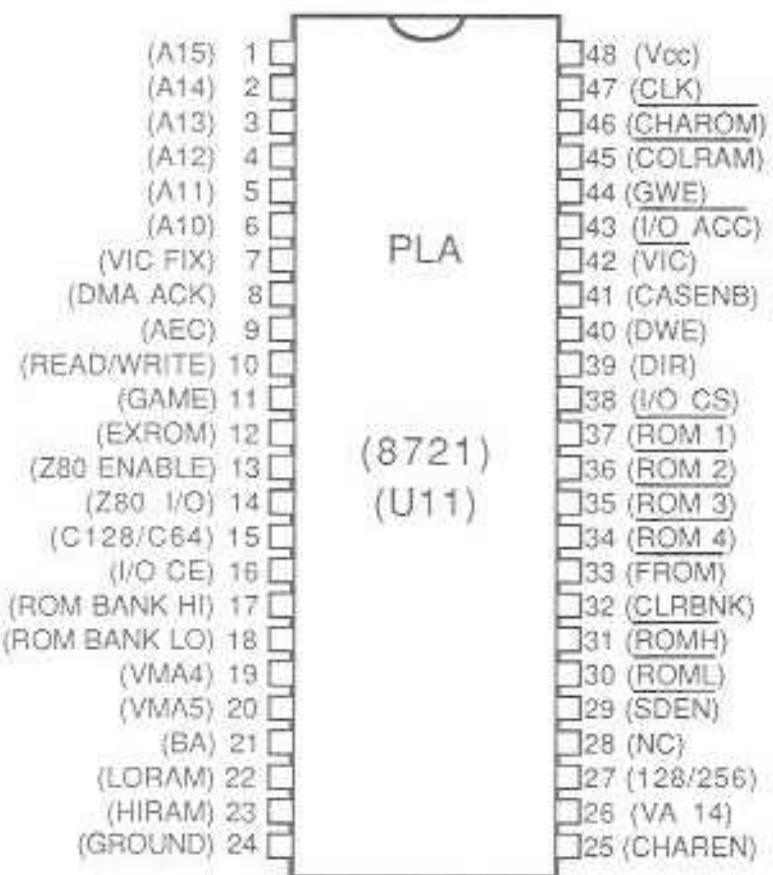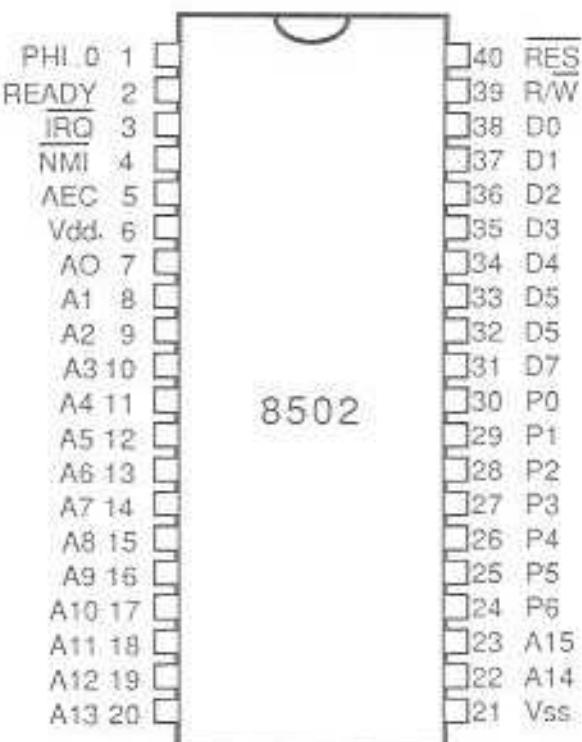
Fig. A-19. 8502 microprocessor.

```
          A11   1 ▯        ▯ 40  A10
          A12   2 ▯        ▯ 39  A9
          A13   3 ▯        ▯ 38  A8
          A14   4 ▯        ▯ 37  A7
          A15   5 ▯        ▯ 36  A6
          PHI   6 ▯        ▯ 35  A5
           D4   7 ▯        ▯ 34  A4
           D3   8 ▯        ▯ 33  A3
           D5   9 ▯        ▯ 32  A2
           D6  10 ▯        ▯ 31  A1
  +5 V POWER   11 ▯  Z80   ▯ 30  A0
           D2  12 ▯        ▯ 29  GROUND
           D7  13 ▯        ▯ 28  REFRESH
           DO  14 ▯        ▯ 27  MI
           D1  15 ▯        ▯ 26  RESET
          INT  16 ▯        ▯ 25  BUS REQUEST
          NMI  17 ▯        ▯ 24  WAIT
         HALT  18 ▯        ▯ 23  BUS ACKNOWLEDGE
       MEMBRO  19 ▯        ▯ 22  WRITE
        I/ORQ  20 ▯        ▯ 21  READ
```
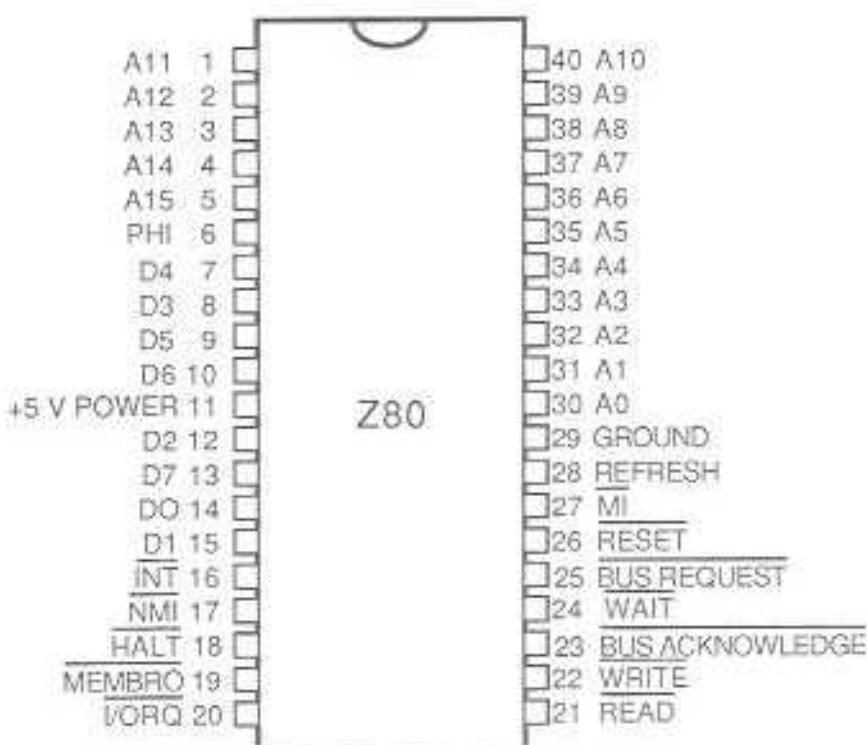
Fig. A-20. Z80 microprocessor.

```
(CAP 1A)   1            28  (Vdd)
(CAP 1B)   2            27  (AUDIO OUT)
(CAP 2A)   3            26  (EXT IN)
(CAP 2B)   4            25  (Vcc)
   (RES)   5            24  (POTX)
    (Q2)   6     SID    23  (POTY)
   (R/W)   7            22  (D7)
    (CS)   8            21  (D6)
    (A0)   9   (6581)   20  (D5)
    (A1)  10            19  (D4)
    (A2)  11            18  (D3)
    (A3)  12            17  (D2)
    (A4)  13            16  (D1)
   (GND)  14            15  (D0)
```

Fig. A-21. 6521 sound interface device (SID).

```
     D6    1            48  (Vcc)
     D5    2            47  D7
     D4    3            46  D8
     D3    4            45  D9
     D2    5            44  D10
     D1    6            43  D11
     D0    7            42  A10
    IRQ    8            41  A9
     LP    9            40  A8
     BA   10            39  A7
 DMARQST  11            38  A6  (A1)
    AEC   12   8564     37  A5  (A13)
     CS   13            36  A4  (A12)
    R/W   14            35  A3  (A11)
 DMAACK   15            34  A2  (A10)
  COLOR   16            33  A1  (A9)
   SYNC   17            32  A0  (A8)
 1 MHZ    18            31  A11
    RAS   19            30  PH IN
    CAS   20            29  PH CL
    MUX   21            28  K2
 I/O ACC  22            27  K1
 2 MHZ    23            26  K0
    GND   24            25  Z80
```

Fig. A-22. 8564 video interface chip (VIC).

CCLK	1	
DCLK	2	
HSYN	3	
CS	4	
NC	5	
NC	6	
CS	7	
RS	8	
R/W	9	
D7	10	
D6	11	
Vss	12	
D5	13	
D4	14	
D3	15	
D2	16	
D1	17	
D0	18	
DISPEN	19	
VSYNC	20	
DR/W	21	
INIT	22	
RES	23	
TEXT	24	

8563

48	CAS	
47	RAS	
46	R	
45	G	
44	B	
43	I	
42	DD7	
41	DD6	
40	DD5	
39	DD4	
38	DD3	
37	Vdd	
36	DD2	
35	DD1	
34	DD0	
33	DA7	
32	DA6	
31	DA5	
30	DA4	
29	DA3	
28	DA2	
27	DA1	
26	DA0	
25	LPEN	
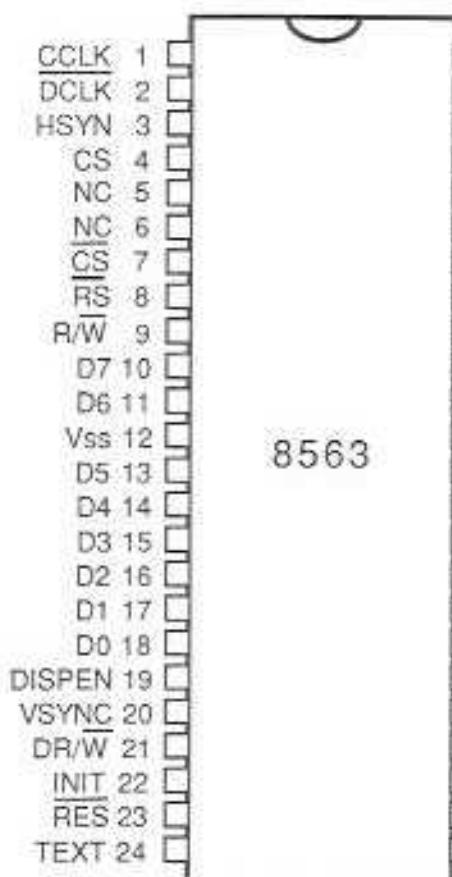
Fig. A-23. 8563 video controller chip.

Vdd	1	
RESET	2	
TA15	3	
TA14	4	
TA13	5	
TA12	6	
TA11	7	
TA10	8	
TA9	9	
TA8	10	
CAS1	11	
CAS0	12	
I/O SEL	13	
ROMBANKHI	14	
ROMBANKLO	15	
AEC	16	
MUX	17	
A0	18	
A1	19	
A2	20	
A3	21	
A4/5	22	
A6/7	23	
A8	24	

MMU

48	SENSE 40	
47	128/64	
46	EXROM	
45	GAME	
44	FSDIR	
43	Z80EN	
42	D7	
41	D6	
40	D5	
39	D4	
38	D3	
37	D2	
36	D1	
35	D0	
34	Vss	
33	PHL_0	
32	R/W	
31	A15	
30	A14	
29	A13	
28	A12	
27	A11	
26	A10	
25	A9	
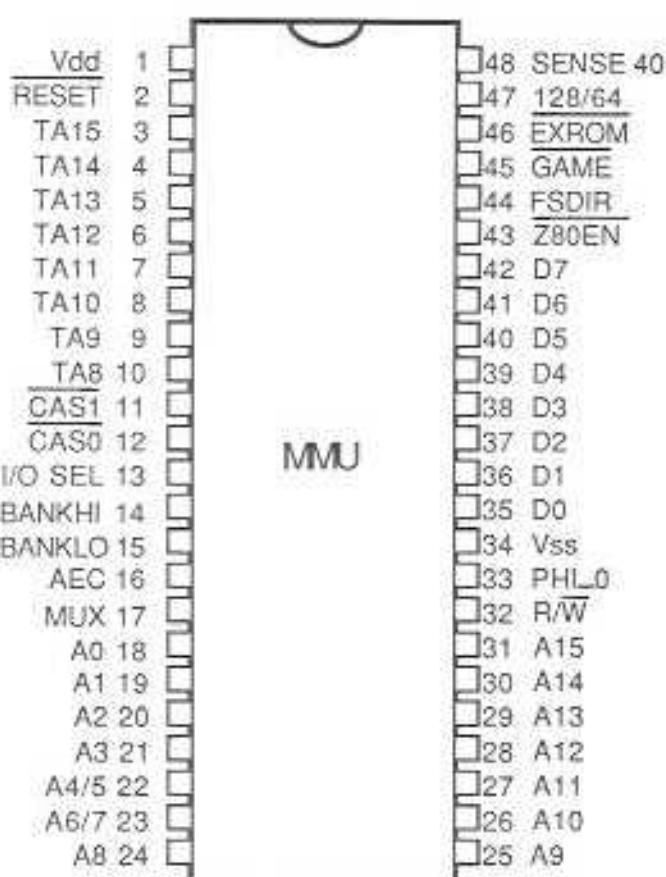
Fig. A-24. 8722R2 memory management unit (MMU).

B

Board Layout
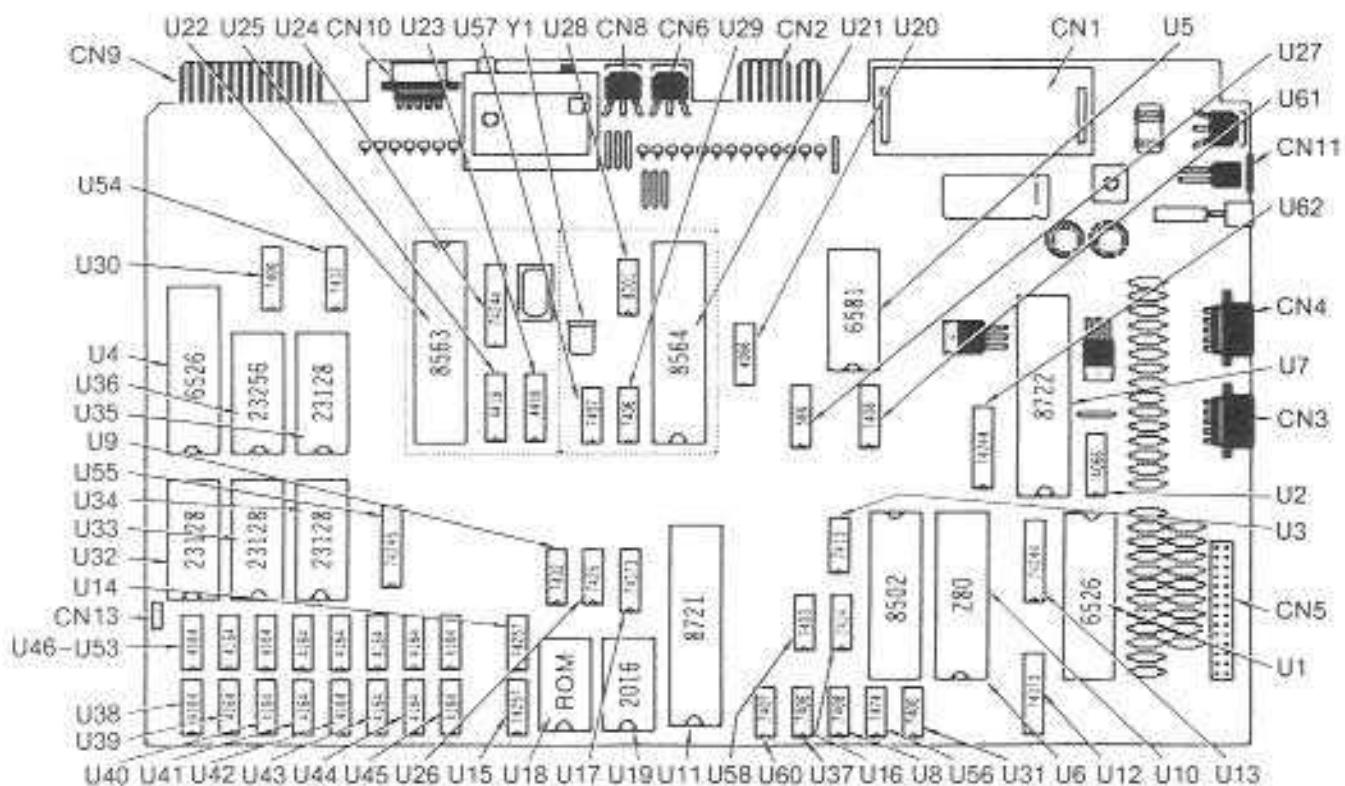
Fig. B-1. Commodore 128 board layout with chip locations.

C

Input/Output Ports

1: GND	7: SP2	A: GND	H: PB4
2: +5	8: PC2	B: FL2	J: PB5
3: RST	9: SAI	C: PB0	K PB6
4: CTI	10: 9 V	D: PB1	L: PB7
5: SPI	11: 9 V	E: PB2	M: PA2
6: CT2	12: GND	F: PB3	N: GND

Fig. C-1. User port.

1: GND	6: INT
2: GND	7: MON
3: RED	8: HSY
4: GRN	9: VSY
5: BLU	
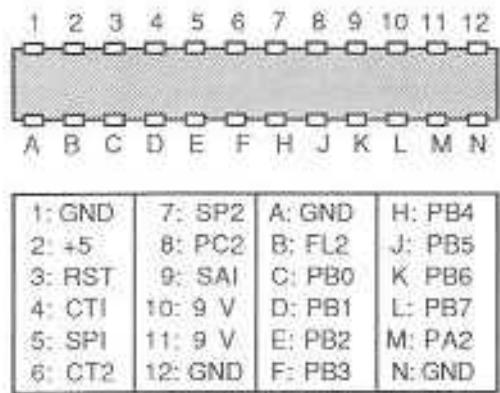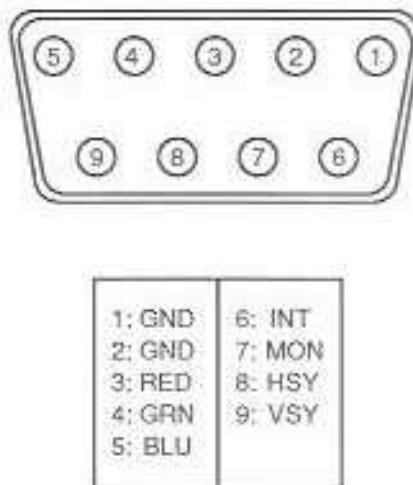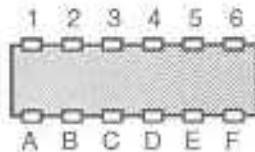
Fig. C-2. RGBI connector.

1: LUM/SYNC	5: AUDIO IN
2: GROUND	6: COLOR OUT
3: AUDIO OUT	7: NC
4: VIDEO OUT	8: NC
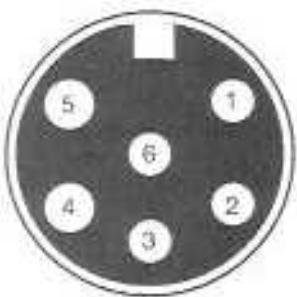
Fig. C-3. Composite video port.
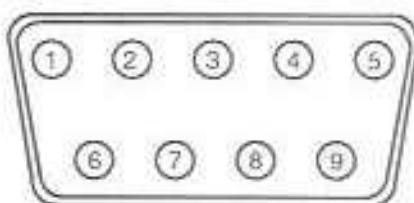
1: GROUND
2: +5 VOLTS
3: CASSETTE MTR
4: CASSETTE READ
5: CASSETTE WRT
6: CASSETTE SENS

Fig. C-5. Cassette interface.

1: SERIAL SRQIN	4: SERIAL CLOCK I/O
2: GROUND	5: SERIAL DATA I/O
3: SERIAL ATN I/O	6: RESET

Fig. C-4. Serial Port.

1: JOY DATA 0	6: FIRE BUTTON
2: JOY DATA 1	7: +5 VOLTS
3: JOY DATA 2	8: GROUND
4: JOY DATA 3	9: PADDLE X
5: PADDLE Y	

Fig. C-6. Game connector.

D

System Specfications

Voltage Inputs: 5-volts dc at 4.3 amperes
9-volts ac at 1 ampere

Operating Speed(s): 8502—1.02 MHz/2.04 MHz
Z80—2.04 MHz

I/O Ports: 2 Game Ports (compatable with)
Joystick(s)
Paddle(s)
Light Pen
Mouse
Board-Type Pointing Devices
Expansion Port (Full Bus)
Cassette Port
Serial Port
RGBI Display Port
Modulated Video Port
Standard Video Port
User (Parallel) Port

Microprocessors: 8502 and Z80

Memory Devices: 23128 (128K ROM)
23256 (256K ROM)
4464 (Dynamic RAM)
4164 (Dynamic RAM)

Video Display Circuits: 8564 (VIC Chip, for 40-column display)
8563 (for 80-column display)

Audio Processor: 6581 SID Chip

I/O Processors/Timers: 6526

Other Devices: 8921 PLA (Programmed Logic Array—Custom circuit)

E

Keyboard Codes

| 0/ₖ₁ | 3/ₖ₀ | 0/ₖ₂ | Dir | | 0/ₖ₀ | 3/ₖ₁ | Dir | 7/ₖ₂ | | 3/ₖ₂ | 4/ₖ₂ | 5/ₖ₂ | 6/ₖ₂ | | 3/0 | 4/0 | 5/0 | 6/0 |

| 1/7 | 0/7 | 3/7 | 0/1 | 3/1 | 0/2 | 3/2 | 0/3 | 3/3 | 0/4 | 3/4 | 0/5 | 3/5 | 0/6 | 3/6 | Q/0 | | 6/ₖ₀ | 1/ₖ₀ | 6/ₖ₁ | 1/ₖ₂ |

| 2/7 | 6/7 | 1/1 | 6/1 | 1/2 | 6/2 | 1/3 | 6/3 | 1/4 | 6/4 | 1/5 | 6/5 | 1/6 | 6/6 | DIRECT | | 5/ₖ₀ | 2/ₖ₀ | 5/ₖ₁ | 2/ₖ₁ |

| 7/7 | Dir | 2/1 | 5/1 | 2/2 | 5/2 | 2/3 | 5/3 | 2/4 | 5/4 | 2/5 | 5/5 | 2/6 | 5/6 | 1/0 | | 7/ₖ₀ | 4/ₖ₀ | 7/ₖ₁ | 4/ₖ₁ |

| 5/7 | 7/1 | 4/1 | 7/2 | 4/2 | 7/3 | 4/3 | 7/4 | 4/4 | 7/5 | 4/5 | 7/6 | 4/6 | 2/0 | 7/0 | | 1/ₖ₃ | 2/ₖ₂ |

| 4/7 |
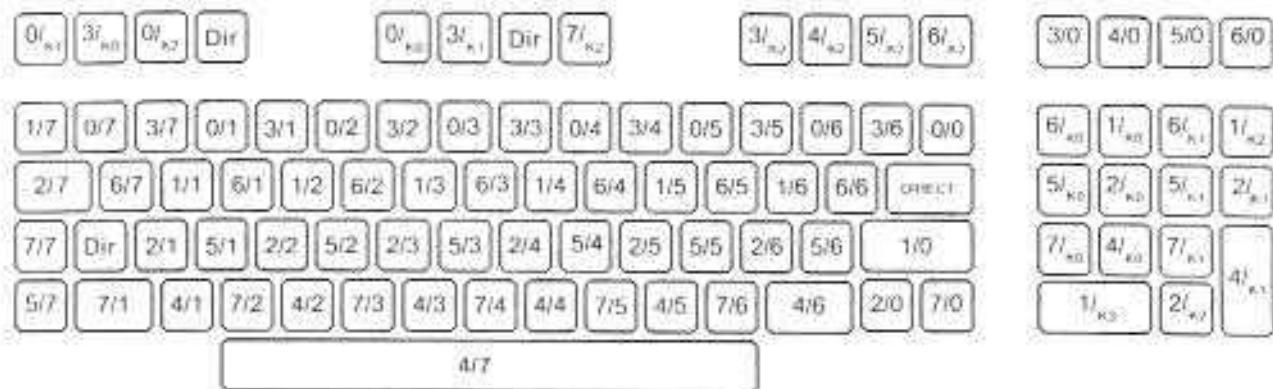
Fig. E-1. Commodore 128 row and column keyboard addresses.

	C0	C1	C2	C3	C4	C5	C6	C7	K0	K1	K2
R0	INST DEL	# 3	% 5	' 7	(9	+	1b	£ 1	HELP	ESC	ALT
R1	RETURN	W	R	Y	I	P	*	←	8	+	0
R2	↑↓	A	D	G	J	L	¦	CONTROL	5	−	·
R3	F8 F7	$ 4	& 6	< 8	0	−	CLR HOME	' 2	TAB	LINE FEED	↑
R4	F2 F1	Z	C	B	M	> .	RIGHT SHIFT	SPACE BAR	2	ENTER	↓
R5	F4 F3	S	F	H	K	[:	=		4	5	←
R6	F6 F5	E	T	U	O	@	π ∧	Q	7	9	→
R7	←→	LEFT SHIFT	X	U	N	< ,	? /	RUN STOP	1	3	NO SCROLL

Fig. E-2. Keyboard matrix.

Glossary

ac Abbreviation for Alternating Current. The type supply voltage provided by a standard home power outlet.

alphanumeric Text consisting of both letters and numbers.

amperage (Also called amps) The amount of electrical current.

amplitude The maximum voltage level of a signal, peak to peak.

AND A logic function in which two or more input signals are examined and a true output is produced if all of the inputs are true.

antistatic A Material designed to prevent static voltage charges from building up by conduction.

anode The positive electrode of a bipolar device (a device having two electrical poles, positive and negative).

architecture The internal design of an electronic circuit.

ASCII (American Standard Code for Information Interchange) The numeric code to used by the computer to represent every character used by the computer.

asynchronous Event based timing used on microcomputers. In asynchronous systems, each logical event triggers the next event instead of the events being triggered by a separate timing device or signal.

ball element Ball-shaped character element used by some printers and typewriters.

bank switching Switching from one block of main memory to another. This allows a computer with a limited memory address range to utilize memory beyond that address range. For example, the 8502 microprocessor in the C128 can address 64K bytes of memory directly. By switching banks it can read and write to any number of separate 64K "banks," one at a time.

BASIC The programming language built into the Commodore 128.

bidirectional Printing from left to right and from right to left.

binary The numeric system based upon two digits, typically 0 and 1.

bipolar One of the fundamental processes for producing ICs. A bipolar IC is made up of layers of silicon with different electrical characteristics. It is a different circuit process than for NMOS or CMOS.

bit The smallest logical unit. There are eight bits in a computer word for the Commodore 128 (byte).

booting The process of starting or restarting the computer.

buffer The logic device used to manipulate the current, voltage, or timing of a signal without altering its logical condition.

bus A combination of logic lines inside the computer (there are two primary busses inside the C128—the address bus and the data bus).

byte A computer word. A combination of several bits into a single unit with a unique meaning to the computer. The Commodore 128 uses eight-bit bytes because of its internal circuitry. Other microcomputers may use 4-bit, 16-bit, or 32-bit words (bytes).

capacitance The measure of a device's (usually a capacitor) ability to store a static charge. Usually measured in microfarads or picofarads.

capacitor A passive electronic device used to store an electrical charge.

carriage The mechanism that supports and moves the print head assembly.

CASS Abbreviation for cassette. Refers to the cassette port on the back of the C128.

cassette A data storage device which uses audio tape as the storage medium.

cathode The negative electrode of a bipolar device (a device having two electrical poles, positive and negative).

characters The letters, numbers, or symbols printed or displayed by a computer. Includes alphanumeric, mathematical, and graphic symbols.

chip A common term for an integrated circuit. The small, rectangular piece of a silicon wafer that holds an individual integrated circuit.

CIA Abbreviation for Complex Interface Adaptor (6526). Used as an interface device and timer in the C128.

CLK Abbreviation for Clock. One of several timing signals used by the microprocessors to synchronize their activities.

clock The evenly spaced timing signal used to synchronize events within the C128. (There are several different clocks used within the C128.)

CMOS Abbreviation for Complementary Metal Oxide Semiconductor. A type of integrated circuit. A family of circuit types which have low power consumption.

coil An electronic device used primarily to add an ac resistance (impedance) to a circuit or to tune (with capacitance) an ac circuit to a specific frequency.

color code Colored bands on certain electronic devices, such as resistors, used to identify their values.

component In the context of this book, any electronic device assembly or subassembly in the C128.

composite video An analog video signal which includes image, sound, and synchronization information.

conductor Any material which provides little or no resistance to electricity.

conductance The inverse of resistance. A measurement of a device's ability to transfer electricity.

coprocessing Having or using more than one microprocessor. The C128, for example, uses both the 8502 and Z80 microprocessors and is therefore a coprocessing system.

corona wire A device used in photocopiers and laser printers to produce or remove a magnetic charge.

CPU Abbreviation for Central Processing Unit. Another name for a microprocessor.

CR Abbreviation for Carriage Return.

cradle The paper guide that lies underneath the platen in a printer. It supports several of the "pinch" or "pressure" rollers that are used to hold the paper tightly against the platen (the large rubber roller) which moves the paper through the printer in nontractor drive systems.

crystal A device used to set and hold the system clock(s) to a precise frequency.

cursor The flashing box on the screen that shows the position of the next character to be printed.

D-type flip flop A memory/logic device used as a building block in digital circuits.

daisy chaining The connecting peripheral devices for the Commodore 128 by way of serial cables (in one device, out the other).

daisy wheel A daisy-shaped character element used in some printers and typewriters. Each 'petal' holds one or more characters, depending upon the printer type.

Datasette Commodore's digital cassette data storage device. It resembles a cassette tape recorder, but has a digital output circuit instead of an audio output circuit.

dc Abbreviation for direct current. The type of voltage provided by a battery.

decibel The unit of measurement for audible sound levels.

desolder The act of removing the solder from a joint by heating the joint with a soldering iron and sucking the solder away.

diode An electronic device that allows current flow through it in one direction only.

disk A circular magnetic data storage medium.

diskette See *disk*.

dot-matrix A printer type that produces characters by printing patterns of dots.

DPI Abbreviation for Dots-Per-Inch. It typically is used to refer to the resolution of a printer. The higher the DPI, the sharper the image.

drop-on-demand A type of process used to generate dots on an ink-jet printer. It produces drops of ink as they are needed instead of continuously.

dynamic Concerning or depending on a condition that changes as a function of time. In this book it refers to dynamic RAMs. which are memory devices that will hold a memory image for a limited amount of time, requiring a "refresh" cycle at repeated intervals (typically 60 times a second).

electrolyte A liquid or semiliquid used to conduct electrons in a battery or electrical cell. Its primary function is to produce an environment in which electron movement generates a dc voltage.

emitter One of the elements of a bipolar transistor.

EPROM Abbreviation for Eraseable, Programmable, Read Only Memory. Used in the C128 as permanent, unchanging memory such as the character set or the boot-up routines.

fan fold A type of paper that is supplied as folded, connected sheets which may be separated into individual pages by tearing along perforations.

fan out Describes the number of devices that may be connected to a logic circuit. Typical fan out of a bipolar device is about 10 meaning that the output of any logic device in the circuit may drive as many as ten other logic circuits.

farad The unit of measurement for capacitance. Since a farad is such a large value, most capacitive devices (typically capacitors) are measured in microfarads ($^1/_{1,000,000}$ of a farad) or picofarads ($^1/_{1,000,000,000,000}$ of a farad).

ferrous Made of, or containing iron.

flip flop A memory/logic device used as building block in digital circuits. The most common flip flops are the D-type, and the J-K type.

friction feed A paper transport mechanism that pulls the paper by dragging it between a platen and pinch (or pressure) rollers.

fuse An electronic component designed to protect electronic circuits by self destructing.

impedance The measurement of ac resistance, expressed in ohms.

inductor An electronic component such as a coil that introduces inductance in a circuit.

inverter A logic device that switches a logic signal from one polarity to the other (i.e., positive to negative).

joystick A control device that connects to the game port.

jumper A wire with two connectors (one at each end) used to make a temporary electronic connection.

kernal ROM(s) that contain the start up program and primary operating system for the C128.

kilo The metric prefix for one thousand.

laser A electronic device that produces a coherent light beam.

LED Abbreviation for Light Emitting Diode.

mega The metric prefix meaning one million.

MHz Abbreviation for Megahertz; a measurement of signal frequency meaning one million cycles per second

micro The metric prefix for one millionth (abbreviated μ).

microfarad Measurement of capacitance meaning one millionth of a farad.

microprocessor A logic device capable of being programmed and performing a myriad of logical functions based upon those programs. Also called the CPU or processor.

microsecond One millionth ($^1/_{1,000,000}$) of a second

MMU Abbreviation for Memory Management Unit. A special logic device used in the C128 to control data going to, from, and between the memory and memory control circuits.

multimeter An electronic instrument used to measure a variety of electronic quantities, including voltage, current, and resistance.

NAND Negative AND logic gate.

NLQ Abbreviation for Near Letter Quality. It refers to the output of certain high quality dot-matrix printers.

NOR A logic function in which two or more input signals are examined and a false output is produced if any of the inputs are true.

ohm The unit of measurement for resistance.

OR A logic function in which two or more input signals are examined and a true output is produced if any of the inputs are true.

pF Abbreviation for Picofarad ($^1/_{1,000,000,000,000}$ of a farad).

photosensitive Sensitive to light.

pico The metric prefix for $^1/_{1,000,000,000,000}$.

picofarad $^1/_{1,000,000,000,000}$ of a farad.

piezoelectric A material which produces electricity when a mechanical force is applied to it.

pixel An individual dot in a video display.

PLA Abbreviation for Programmed Logic Array.

platen The large rubber roller used as the primary paper guide and printing surface for impact-type printers.

potentiometer A variable resistance device with a sliding tap that may be moved to select a portion of the voltage connected across the two ends or between one end and the tap.

RAM Abbreviation for Random Access Memory. Also known as read/write memory.

raster The video display scan pattern used on most standard televisions and video monitors. It consists of multiple horizontal scan lines and a single vertical scan for each frame image.

rectifier An electronic device that allows current flow in one direction only. Used to convert ac to dc.

regulator An electronic device that controls the current or voltage (or both) in a power supply.

resistance The measurement of the opposition of a circuit or circuit device to the flow of electrons. Measured in ohms. Resistance is the opposite of conductance.

resistor An electronic device designed to introduce a specific amount of resistance into a circuit.

ROM Abbreviation for Read Only Memory. A memory device that is preprogrammed for a specific purpose (usually when a product is manufactured) and maintains that memory for the life of the product.

semiconductor A material with a conductivity between that of a conductor and an insulator and used in the manufacture of transistors, ICs, and microprocessors.

SID Abbreviation for Sound Interface Device. The integrated circuit that produces and controls all of the sound functions of the C128.

solenoid An electromagnetic device that moves a plunger up and down (or in and out) based upon an input voltage.

thimblewheel A thimble-shaped character element used in some printers and typewriters. Similar to a daisy wheel.

tolerance The range of accuracy to the specified value. The term is used in the specification of electronic characteristics for circuit components.

toner The black or colored powder used to produce images in photocopiers and laser printers.

transistor A semiconductor device that controls electrical output based upon an input electrical signal.

VIC Abbreviation for Video Interface Chip. Used in the C128 to control the 40-column display and an assortment of peripheral functions such as the light pen and some keyboard functions.

voltmeter A test instrument used to measure voltage in an electronic circuit.

Z80 The microprocessor used for controlling CP/M functions in the C128.

zener diode A special type of diode that conducts electricity backwards at a specified voltage. Used for voltage regulation.

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John Heilborn is the president of ThinkWorks, a computer consulting firm in the San Francisco Bay Area, and is a highly experienced computer-book author. He also writes the nationally syndicated newspaper columns "Ask Dr. John" and "ComputerTalk" and has written for such publications as PC World, BYTE, Commodore, Power Play, and The Washington Post.

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