

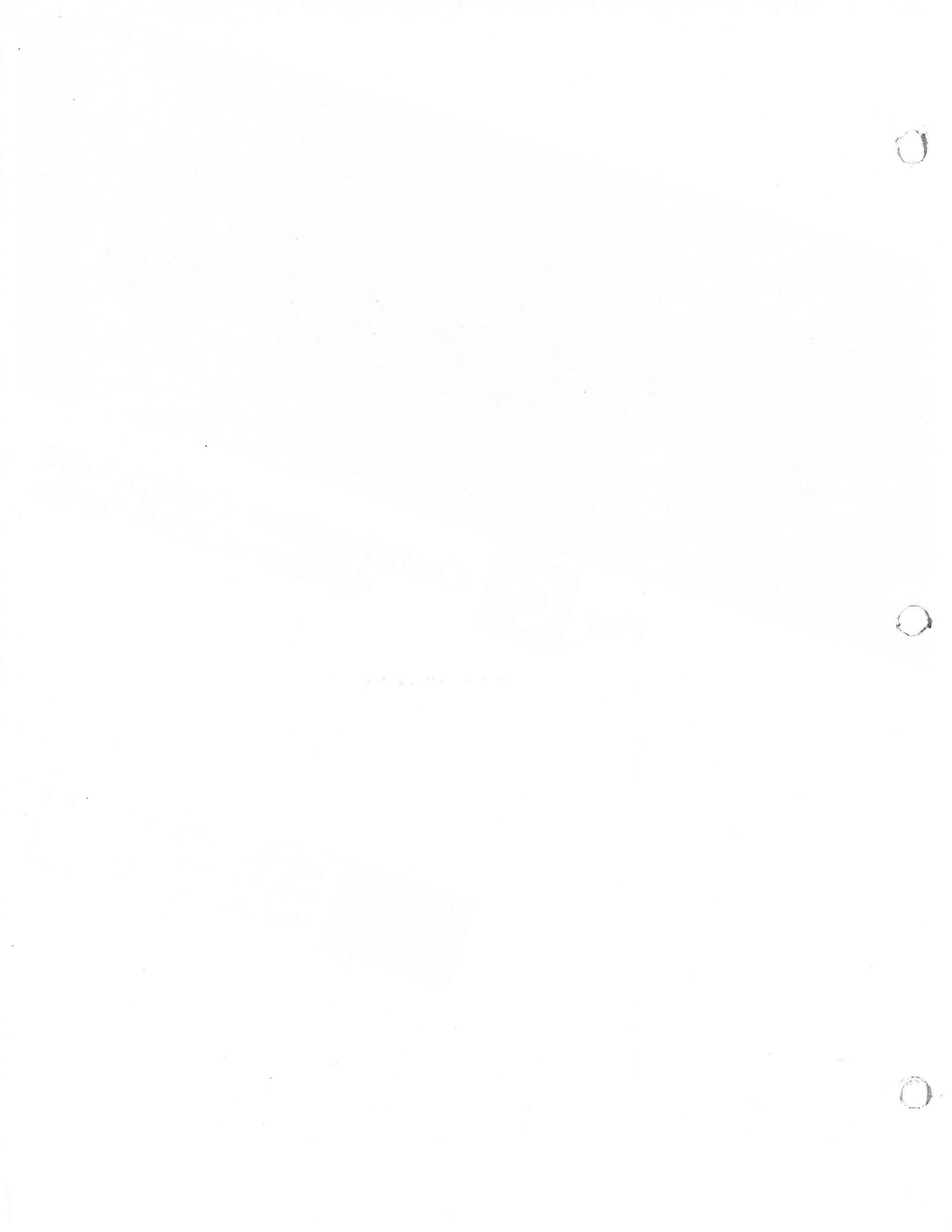
ZRAM™

For 

Commodore Computers
4000 and 8000 Series



Madison Computer
1825 Monroe Street
Madison, WI 53711



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1. INTRODUCTION

1a. About This Manual

This manual is divided into six parts. We suggest that you read each part all the way through before you attempt to carry out the instructions. For a quick summary of all the steps necessary to get CP/M up and running, see section 4m.

Part 1 introduces Z-RAM, describes the equipment you'll need, and gives information on copyrights, warranties, licensing and servicing.

Part 2 gives complete instructions for installing and wiring the Z-RAM hardware in your computer.

Part 3 introduces you to general uses of Z-RAM including instructions for running expanded Visicalc and WordPro 5 Plus. Part 4 introduces CP/M software, tells how to copy your master diskette, explains the Commodore control keys, and gets you started with CP/M for the first time.

Part 5 offers more technical information about Z-RAM, Commodore computers, and CP/M. It's not necessary to understand this section to successfully use CP/M and Z-RAM. We include this information for the use of programmers and service technicians.

Part 6 is a set of manuals on the CP/M Operating System, version 2.2, that are provided by Digital Research. Consult these manuals for specific questions about CP/M.

This manual was written by Stacy Allen. If you have comments or suggestions on improving the Z-RAM board or this manual, contact us at Madison Computer, 1825 Monroe Street, Madison WI 53711 USA (608)255-5552.

1b. Z-RAM Overview

Z-RAM is an add-on circuit board that fits inside Commodore Computers. It was designed by Karl Matzke and Paul Schick of Madison Computer in association with Applied Electronics Consultants of Madison, Wisconsin.

Z-RAM adds 64K of random access memory (RAM) and includes a Z-80A microprocessor. Included with Z-RAM is a copy of the CP/M operating system, version 2.2.

With the addition of CP/M, your Commodore computer will be able to use many of the applications programs currently on the

market that require CP/M. WordStar, SuperCalc, and dBase II are typical examples of software that will now run on the Commodore.

With the addition of the Z-RAM board, Commodore computers will operate with 96K RAM and use both the 6502 and Z-80 processors. Several modes of operations are possible:

1. With Z-RAM installed, all earlier versions of Commodore computers (regardless of memory capacity) can function as normal 32K machines. All current programs will run using 32K of memory and the standard 6502 processor.
2. Z-RAM permits the 6502 to use the full 96K of memory.
3. The Z-80A processor will operate alone in 64K of memory and will run the industry standard CP/M operating system. Z-RAM will make it possible to run other operating systems on the Z-80A in the future.

Z-RAM is supplied as a user installed retrofit or a dealer installed option for all CBM's. The board is installed inside the CBM cabinet and uses the computer's own power supply. A 9511A math processor is available as an option to increase the speed of all mathematical functions by a factor of 10.

Z-RAM Features:

- Expands CBM computers to 96K usable RAM
- Adds Z-80A Microprocessor
- Runs Z-80A and 6502 simultaneously at full speed
- Will operate with currently available CP/M version 2.2
- In memory expansion mode, 32 mappings are available using blocks as small as 8K.
- Software emulates a Hazeltine 1500 to facilitate installation of CP/M software. Versions emulating other terminals can be provided on request.
- Serial port is standard. Software is included to run printers with standard RS-232 interface. PET to RS-232 cable available as option.
- Includes expansion port for addition of future boards.
- Easily installed inside of computer
- Needs no external electrical connections

- Installed by user or dealer in CBM 4000 or 8000 computers
- 9511A math processor available as option

lc. Product Warranty

Madison Computer warrants to the original owner that this product shall be free of defects resulting from faulty manufacture of the product or its components for a period of ninety (90) days from the date of purchase.

Madison Computer makes no other express or implied warranties of any sort, including, but not limited to warranties of merchantability or fitness for a particular purpose. The dealer and user agree that no representations of any sort beyond those included in the manual have been relied on in any case by the user in purchasing this product.

Madison Computer's sole obligation under this warranty is limited to the repair or replacement of a defective product, and Madison Computer shall not, in any event, be liable for any incidental or consequential damages of any kind resulting from use or possession of this product.

ld. Equipment Requirements

To use Z-RAM, you will need one of the following Commodore computers:

- 8032
- 4016 or 4032
- 3000 Series (Europe)

The CP/M operating system can only be used on 32K machines. Z-RAM will not operate with the new SuperPet or the VIC 20. We do not recommend its use on the older 8K PETS (2000 series).

le. Service Information

If during the first 90 days you have any problems with Z-RAM resulting from defects due to manufacture, you are entitled to free repair or replacement of the product.

If your Z-RAM needs servicing, return it with proof of purchase to the computer dealer where you purchased it. If that is not possible, you may return it to Madison Computer. Wrap the product very carefully for shipping. We will not be responsible

for any damages in shipping.

Include a description of the problems you are having and a sales slip for proof of purchase. Send the package, postpaid, to: Madison Computer, 1825 Monroe Street, Madison WI 53711 USA.

1f. Copyright and Licensing Information

All of the software that accompanies Z-RAM is copyrighted and all rights are reserved. CP/M is copyrighted by Digital Research of Pacific Grove, California. All other software is copyrighted by Madison Computer, a division of Microprocessor Systems, Inc. of Madison, Wisconsin.

The distribution and sale of this product are intended only for the use of the original purchaser on a single computer system. Copying, duplicating, selling, or otherwise distributing this product is a violation of the law.

This manual is copyrighted and all rights are reserved. This document may not, in whole or in part, be copied or reproduced without the prior written consent of Madison Computer.

To insure that you receive continuing support for your CP/M operating system, you must fill out, sign, and return the Digital Research end user agreement contained in this manual.

Z-RAM is a trademark of Madison Computer

Commodore is a registered trademark of Commodore Business Machines, Inc.

CP/M is a registered trademark of Digital Research, Inc.

Z-80 is a registered trademark of Zilog, Inc.

Silicon Office is a registered trademark of Bristol Software

WordCraft is a registered trademark of Commodore Business Machines, Inc.

Master is a registered trademark of Canadian Microcomputer Distributors

VisiCalc is a registered trademark of VisiCorp.

2. Z-RAM INSTALLATION

Your Commodore dealer will be happy to assist you in the installation of your new Z-RAM add-on board. The task is not difficult, however, and if you'd like to install it yourself it will probably take about 20 minutes. The only tools you'll need are a screwdriver, a small pocketknife and perhaps a small adjustable wrench. It's a good idea to read these instructions all the way through before starting the installation.

2a. How to Mount Z-RAM

First, you should examine your shipping box to make sure you've received all the parts you need to install and use Z-RAM. Find and indentify the following:

- a) one Z-RAM circuit board
- b) four plastic spacers (one inch long cylinders)
- c) four short mounting screws
- d) one 5 1/4" diskette contained in this manual

Now that you're certain you have all the necessary parts, you can install and wire your Z-RAM. Follow these steps carefully and in order:

1. Unplug your computer's power cord.
2. Open the top of the computer. It's hinged on the back and you can lift it from the front, under the keyboard. The entire top, including keyboard and monitor, will lift up. To do this you may have to remove two screws that hold the top down. They're located just under the overhanging white lip of the top, near the front on the right and left sides. See Illustration 1.
3. When you lift the top, be careful not to open it too far. It's possible to bang the back of the monitor on your tabletop. You'll need to prop the top open. Place a solid object about 6" high behind the computer under the back of the monitor. We've found that a closed plastic case for 5 1/4" diskettes works fine. See Illustration 2.
4. Your Z-RAM package includes a set of four spacers. The plastic ones are small six-sided cylinders about one inch long with a hole through the center.

Examine the underside of the top of your open computer. You will see a cut out hole about 7" square that allows you to look into the case containing your monitor's picture tube. Near the edges of this cutout you'll see four nuts or bolt heads. These

are connected to the bolts that hold your monitor on.

a) If you have a 12" monitor, then you'll see four nuts with threaded bolt ends sticking out of them slightly. You will be screwing one plastic spacer onto each of the threaded bolts. You may use either end of the plastic spacer.

These bolts sometimes vary in size, so you may have to push a little harder when first starting to screw them on. The spacers are nylon and will conform to whatever size bolt you have. As soon as the spacer reaches the nut, stop. If you continue to twist it, you'll strip the threads in the spacer. See Illustration 3 for examples of the bolt end and the installed spacer. If you have an 8032 and have completed this step, go to step five.

b) If you have a 9" monitor, then on the underside of your open computer top you'll see the nuts and threaded bolt ends described above in 4a. Install the spacers just like in 4a.

5. Now you can mount your Z-RAM board. Hold up the board so that all of the installed components are facing you and the gray ribbon cable hangs down from the bottom of the board. Look at the lower left hand corner of Z-RAM. There may be a plastic connector with 8 colored wires plugged into the board. If it's plugged in there, carefully unplug it by pulling straight up on the plastic connector, not the wires. Hold Z-RAM up to the spacers you've installed. You may have to pull aside some wires to get it up there.

Some short screws are supplied with Z-RAM. Insert a screw through one of the four holes on your Z-RAM board. This screw is screwed right into one of the plastic or metal spacers that you've installed in your computer. See illustration 4 for a drawing of the correct order of these parts.

It is not necessary to screw them in very tightly, but they should be snug. If, for some reason, you should have difficulty aligning all four holes in the Z-RAM board with the four spacers in your computer, then three screws will be sufficient to hold Z-RAM securely.

2b. How to Wire Z-RAM

1. The next step is to wire Z-RAM. Locate your computer's transformer. It is the large square shaped object in the rear left of your open computer. In front of the transformer is a cylinder called a capacitor.

Several colored wires extend from the transformer and capacitor and are attached to an 8 wire plastic connector. This connector is plugged into the left front corner of the big green circuit board. See Illustration 5.

Carefully unplug this connector from the circuit board by pulling straight up on the plastic part of the connector. Try not to pull on just the wires. Examine the lower left hand corner of your mounted Z-RAM board. You'll find a similar plastic connector which may be plugged into a socket there. If it's plugged in, unplug it in the same way you did the first connector.

Now that both of these connectors are free, simply plug them into the opposite sockets: the connector coming from your computer gets plugged into Z-RAM, and the connector coming from Z-RAM gets plugged into your computer.

When correctly plugged in, the colored wires coming out of the connector plugged into Z-RAM will be pointing down. The colored wires coming out of the connector plugged into the left front corner of your computer board will extend to the left.

When these two plugs are installed, look to see that their wires are not directly on top of the sharp edges of the transformer. It may be necessary to rotate the capacitor (not its holder) slightly to the right so that the wires clear the transformer.

2. Find the gray ribbon cable coming out of the bottom of Z-RAM. It has a forty pin connector on the end. If there is a small piece of styrofoam protecting these pins, remove it. You will also have to remove your computer's 6502 microprocessor chip and insert this Z-RAM connector in its place.

How do you find this 6502 chip? From above, it looks like a black rectangle about 2 x 1/2" with 20 little silver pins on each side. Many are labelled on top: MOS MPS 6502 and another four digit number. This 6502 chip is located in different places, depending on your computer.

a) If you have a 12" monitor, your chip is in slot UB14. The slots are labelled in small white letters on the green circuit board. See Illustration 6. Be careful not to confuse the 6502 with the 6520 in slot UB12

b) If you have a 9" monitor then the 6502 chip is in slot VC4. See Illustration 7.

3. Now that you've located your 6502 chip, you must remove it. This is a fairly delicate operation. If it's never been removed before, the 6502 may fit in its socket very snugly.

There are several different tools that you can use to remove the 6502:

- a) borrow a "chip puller" from your computer dealer. Ask him to explain how to use it.
- b) use a pocket knife with a small blade that's no wider than 1/2" at its widest point.
- c) use a fairly small screwdriver.

The knife or screwdriver will serve as a lever, and you'll need a standard pencil to use as a fulcrum. You will be carefully prying up the 6502 chip.

There are two major risks in removing the chip. First, you could damage your 6502 chip. This is not fatal, however, since you will not be using that chip when Z-RAM is installed. Second, you could damage the socket containing the 6502 chip. This is serious and will require repair. So, follow these instructions closely.

- a) Place the pencil on the large green circuit board that's in the base of your computer. The pencil should be perpendicular to the 6502 chip, to the right of it on 8032s, and in front of it on the 3000-4000 series.
- b) Take your knife blade or screwdriver and insert it in the small slot between the black 6502 chip and the white socket that holds the 6502. Be very careful not to place the blade under the socket, because you will then pry the socket out of the board. You want to pry the chip out of the socket.
- c) Gently push down on the knife or screwdriver handle, using the pencil for leverage. The chip will gradually rise. Then push the blade further under the chip and pry some more. Be careful not to hook it under the socket cross bars. Move the screwdriver and fulcrum to the left side of the 6502 and pry from that side. Go back and forth from side to side until the chip is free. See illustration 8.

Once the chip is free, tape it to the inside of your computer somewhere. You won't need it when using Z-RAM, but you should save it in case you remove Z-RAM in the future.

4. Check Z-RAM's 40 pin connector (on the end of the gray cable) to be sure that all of the pins are straight and parallel. Plug the connector into the socket that held your 6502 chip. Do it gently, taking care not to bend the pins. You may have to push very hard, especially if the 6502 has never been removed before. When the connector is correctly installed in your computer's circuit board, the gray ribbon will point in one

of two directions:

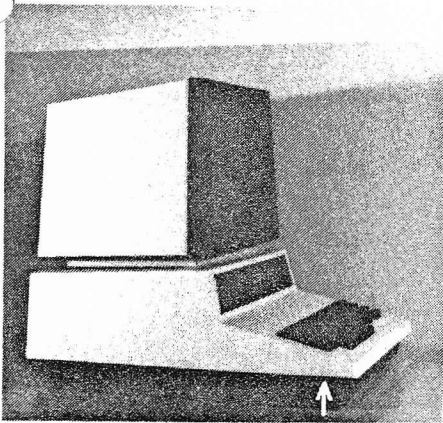
a) In 12" monitor computers, the ribbon cable will extend towards the rear of the computer.

b) In 9" monitor computers, the ribbon will extend to the left once the connector is correctly plugged in.

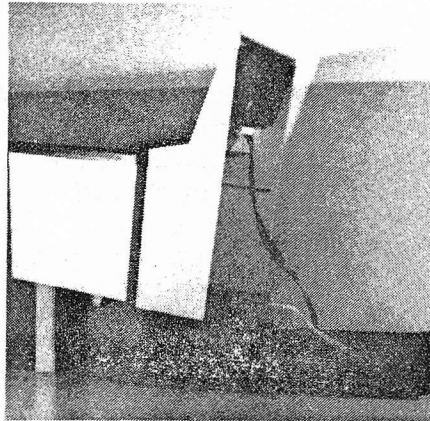
5. Examine Illustration 9. Your final Z-RAM installation on a Commodore 8032 will look like this. Check all of your connections one last time.

6. Close the top of your computer. Turn on the power. You should see the standard start-up display on screen: the Basic level, the number of bytes free, the word "ready" and a cursor. If it's all there then you've successfully installed Z-RAM. If it doesn't work, or you've had other difficulties, then recheck your installation with the instructions. If you still have problems, consult your Commodore dealer.

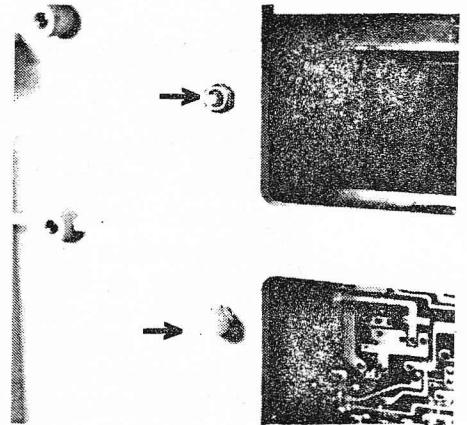
2c. Mounting and Wiring Illustrations



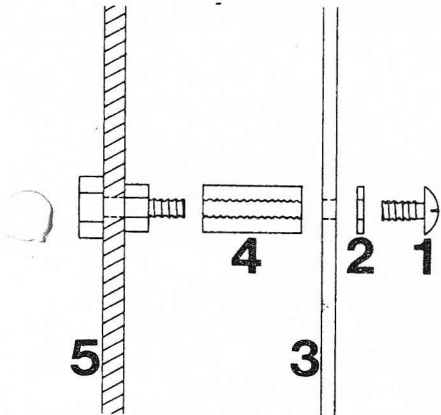
1. Location of screws holding down computer top.



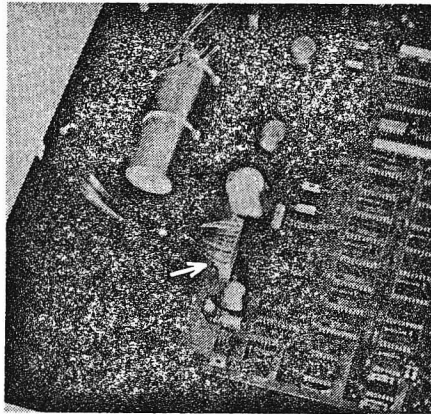
2. Prop open the top.



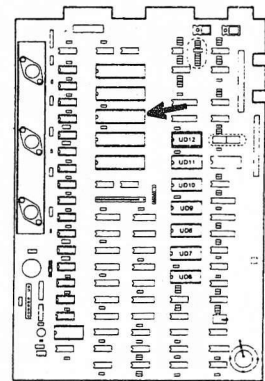
3. Bolt end without spacer and with spacer installed.



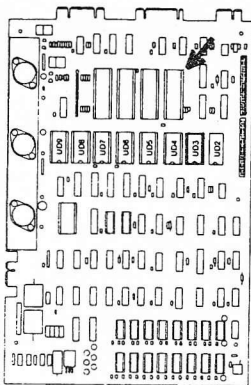
4. Correct order: screw, washer, Z-RAM, spacer, and computer cabinet.



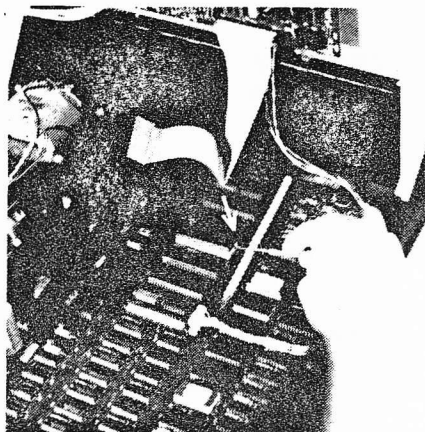
5. Location of wire connector on computer.



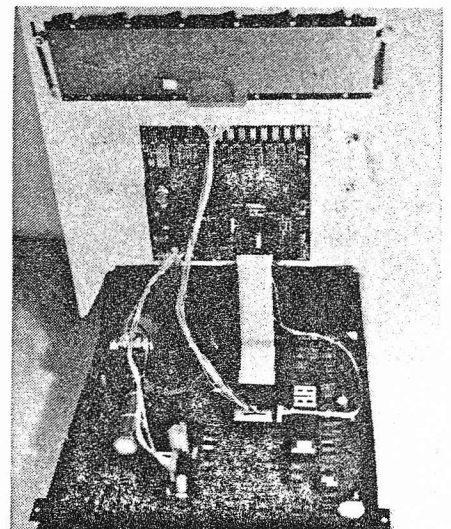
6. Location of 6502 on 12" monitor models.



7. Location of 6502 on monitor models.



8. Removing the 6502 microprocessor



9. Final installation on a Commodore 8032.

3. Using Z-RAM

3a. General Information

With Z-RAM installed, your computer can operate exactly as it did before, but has the potential to do a lot more. All earlier versions of Commodore computers (regardless of their original memory capacity) can function as 32K machines, using the standard 6502 processor. Further, the 6502 can use the full 96K that Z-RAM provides, while the Z-80A processor can operate with 64K of memory.

An important feature of Z-RAM is its ability to bring the CP/M operating system to your Commodore. But you can certainly take advantage of Z-RAM's added memory without using CP/M. An expanded version of VisiCalc is available which allows you to enter more than 7 times as much data as you could on a Commodore without Z-RAM. You can also run WordPro 5 Plus. To run these programs with Z-RAM, two loading programs have been provided on your Z-RAM master disk (see discussion below). Other software which will run on your Commodore with Z-RAM includes Silicon Office, Wordcraft, Master and many others.

3b. Running VisiCalc and WordPro 5 Plus

To run WordPro 5 Plus and expanded VisiCalc (version 1.76a, for the Commodore 8096), two programs are included in your Z-RAM Master disk. "VLOAD" is for VisiCalc and "WLOAD" for running WordPro 5 Plus. To bring up VisiCalc or WordPro on your Commodore, you need only run the appropriate "LOAD" program and have a copy of extended VisiCalc or WordPro 5 Plus in the other drive. However, we suggest that, for ease of operation, you transfer "VLOAD" or "WLOAD" to your master disks containing VisiCalc or WordPro programs, respectively. Instructions for doing this are outlined below.

1. Place your VisiCalc or WordPro program master disk in drive 0 and your Z-RAM master disk in drive 1
2. Check the directory of your program master disk for the exact name of the first file on that disk (referred to below as "firstname").
3. Type: **copy "firstname",d0 to "temp",d0**
4. Type: **sc"firstname",d0**
5. Type: **copy "wload",d1 to "*",d0**
 -or-
 copy "vload*",d1 to "*",d0
6. Type: **Rename "temp",d0 to "firstname",d0**

This procedure copies "vload" or "wload" from your Z-RAM disk and also moves it to be the first file on your program master disk so that you can now run your program using the shifted run/stop key.

4. USING CP/M

4a. What is CP/M?

CP/M stands for Control Program for Microprocessor. It is an operating system that is designed for use with a Z-80 or similar microprocessor.

CP/M consists of several small programs that permit your computer to send data to and receive data from your disk drives. Since CP/M will run on many different computers, it has become an industry standard operating system for microcomputers.

The authors of specialized applications software (such as word processing or accounting software) naturally want to sell as many copies of their programs as they can. For this reason, they often choose to write programs that will function on the most widely used operating system. For microcomputers, that choice is often CP/M.

This has resulted in a large number of available programs. However, in the past Commodore computer owners were not able to use these programs. With the introduction of Z-RAM, you can triple your computer's memory capacity, add a Z-80 microprocessor, and run the CP/M operating system. Consequently, the number of programs available for the Commodore is much larger.

With Z-RAM you have all the advantages of your original Commodore computer, with the added benefits of a CP/M computer.

4b. Using Your Disk Drives

With this manual you have received a 5 1/4" diskette that contains all the CP/M programs. It is marked "Z-RAM Master Disk."

Your Z-RAM diskette is "write-protected." This means that a bit of heavy adhesive tape is applied over the notch on the edge of the diskette. This tells your disk drive unit that the data on this diskette is not to be altered or erased.

This write-protect system works fairly well except in the 8050 disk drive. In this unit there is always the danger that your diskette will be damaged whenever any piece of hardware in your computer system is turned on or off. So, always remove the diskettes from the disk drive before you touch any of the power switches.

Your Z-RAM Master Disk is double sided. One side (the side with the Z-RAM CP/M label) is for use on 8050 disk drives and the other side for 2031 and 4040 disk drives. Determine what kind of disk drive you are using. Whenever you use the Z-RAM diskette, make sure the correct side is facing up.

Insert the diskette into Drive 0 (the right hand drive) of your Commodore disk drive unit. Some care is required to ensure reliable operation, so follow the directions below carefully. Although CBM disk drives are very reliable, they do have some quirks which it is best to scrupulously respect.

The 2031, and 4040 disk drives (Shugart SA390) tend to suffer from errors due to improper seating of the diskette. To minimize this problem, put the diskette in the disk drive like this: lift the door and slide the diskette all the way in (with the oval shaped jacket opening towards the inside of the disk drive).

Close the door slowly until you feel some resistance part way down. Now open the door again. Then gently close the door all the way. This will help seat your diskette properly.

The 8050T disk drive (Tandon) tends to damage the center hole of the diskette, especially if there is no hub ring. Try loading the diskette in the manner just described.

The 8050 and 8250 disk drives (Micropolis) are the simplest. Here it is best to use diskettes without the hub ring. Slide in the diskette in the usual fashion. You will feel and hear a distinct click as it goes all the way in.

Now press the black metal bar down slowly and gently until it clicks and stops. It will stay down once it clicks. You must not slam the bar down or flick it up and down rapidly. For the diskette to be seated properly, push down gently and slowly. (If this description makes no sense at all, you probably have a Tandon drive).

4c. Testing Your Z-RAM Master Disk

Now that you have inserted your Z-RAM Master Disk, you need to load and run it to verify that it works. If you have an 8032, 4032, or other Commodore with 4.0 Basic, press a shift key and

the "RUN-STOP" key at the same time and release them. This will automatically load and run the first program on the disk.

If you have an older PET with 32K of memory and 2.0 Basic, then you'll have to type in the commands to load and run. Each command should start on the far left side of the screen, should be typed in exactly as it's shown here, and should always end with the RETURN key.

So, to load your CP/M program using 2.0 Basic, insert the diskette and type the following:

```
load "mct *",8
```

As you type the keys, the blinking cursor will move along. The quotation marks are part of the command. If you make an error, type the "INST/DEL" key to backspace and erase. Remember to hit the RETURN key to enter the command.

Once you've done this a message will come on saying that the program is loading. After it is properly loaded, the screen will say "ready". Now you should type:

```
run
```

And remember to hit the RETURN key. The program should now be loaded and running.

If there is an error during this process, it will be shown in one of three ways:

1. On the 4040 disk drive a green light between the two disk drives will come on.
2. On the 8050 disk drive that same light will turn red and stay on.
3. On the 2031 disk drive the single light will start blinking as the drive stops.

If you have 2.0 Basic, then in the event of disk error you can get the blinking cursor back by pressing RUN/STOP. If your initial loading attempt was unsuccessful, try the operations once or twice again before giving up.

After the program starts running, a banner message will be displayed while further information is read from the diskette. When this is finished, the screen should clear and a bright line will appear at the top.

On an 80 column display, it will read as follows:

```
A:173          Z-RAM 0.00  (c)1982 Madison Computer
```

The number on the left indicates that you are logged onto drive A which was formatted to contain 173 Kilobytes, or about 174,000 bytes or characters of free space on the diskette for use by CP/M. The number following "Z-RAM" may be different, depending on what version of the program you have. This refers to the Z-RAM version number.

Below the bright status line, this message will appear:

```
Z-RAM from Madison Computer
64K CP/M Version 2.2, (C)DIGITAL RESEARCH
A>
```

The A> will be followed by a flashing cursor. This prompt always appears when you are in the CP/M Command mode. The letter always corresponds to the current logged disk drive: A, B, C or D. Later, once you've loaded a program into CP/M and run it, that prompt will disappear.

Your original Z-RAM Master Disk should never be altered. Copy it, then hold it in reserve, so that you can go back to it if something goes badly awry. However, before copying it, check its contents by typing the following command after the A>:

dir

Remember to hit return. Immediately you should see a list of names on screen followed by another A> and a blinking cursor. This is a list of the contents of the directory in your CP/M files. No need to do anything with it now, just see that it's there.

Now press the RUN/STOP key. The message **Quit CP/M** should appear on the status line, accompanied by a beep if your computer has a built-in beeper. After about two seconds, the message **Are all files closed?** will start blinking

Type a **y** for yes. The line will dim, and after a short time the screen will clear and you will see:

ready.

and a blinking cursor. You are back where you started, in the Commodore Basic mode. Now it's time to learn how to copy your diskettes.

4d. Copying Your Z-RAM Master Disk

It's very important for you to copy your original Z-RAM Master disk and put it away for safe keeping. If you follow the instructions in the next sections you'll end up with these

diskettes:

- #
1. Original Z-RAM diskette, marked "Z-RAM Master Disk"
2. Exact copy of #1, marked "Z-RAM Master Disk Backup"
3. Modified copy of #2, marked "C/PM System Disk"
4. Exact copy of #3, marked "CP/M System Disk Backup"
5. Modified Copy of #2, marked "Master CP/M Data Disk"
6. Exact Copy of #2, marked "CP/M Working Data Disk #1"

You have #1 already. Let's start by making an exact copy of it which you'll label "Z-RAM Master Disk Backup."

Get either a brand new diskette or a used one in excellent condition that you no longer need. Insert it into drive 1 (the left hand drive) of your disk drive unit according to the previous instructions.

Now examine your master diskette and verify that the write protect tab is covering the notch on the side of the disk. You do not want to copy your blank disk onto your master disk! Then carefully insert the master disk into drive 0.

If you have 4.0 Basic then enter the following:

backup d0 to d1

If you have 2.0 Basic, then enter the following including the quotation marks:

open1,8,15,"d1=0":close1

and in three to ten minutes you will have a copy of your Master Disk.

If there is a disk error, try the procedure again. You should also try copying onto a different blank diskette before you give up. Now, once you've succeeded in making the copy, put away your original diskette! You will use the copy for all further work.

Get a disk label and write on it: "Z-RAM Master Disk Backup". Affix this label to the copy you have just made. You may also wish to attach a write protect tab over the notch on the side of the disk. This will make it impossible to erase information on this disk. Make sure the tab completely covers the notch, front and back.

4e. Setting up for CP/M

Now that you've made a copy called "Z-RAM Master Disk

Backup," you need to set some default definitions in the "mcdefs" file on that disk. On a directory listing, a number will follow the "mcdefs" file name. This refers to the version number of your Z-RAM.

The information in this file determines the disk location assignments of your CP/M disk drives. It also defines the type and baud rate of the printer that you will use with that disk.

These definitions will be used on each CP/M System and Data disk that you format in the future. You should therefore set the default definitions for the equipment that you will use most often. This can be done with the "setup cpm" program. If you desire different defaults on a future disk, you may rerun the "setup cpm" program on that disk. This can be done as often as you like, and each time it will change the defaults on subsequent System disks.

Before we describe how the program operates, you should understand some of the concepts that underlie the default definitions.

The CP/M operating system supports several disk drives which are lettered A, B, C, D, etc. On many computers these correspond to the letters on the actual physical disk drives. This is not always the case with Commodore computers and disk drives. Consequently, we will refer to the CP/M disk drives as "logical drives" and the actual Commodore disk drives where they are located as "physical drives." These physical drives are numbered 0, 1, 2, etc. A lettered CP/M logical drive will be located on a numbered CBM (Commodore) physical drive, and will be given a lettered CBM (Commodore) file name. Finally, each Commodore disk drive unit is given a device number which is usually 8 unless changes are made, or more than one drive unit is in use.

What is the point of all the different designations? Z-RAM has been designed to give you maximum flexibility. You may use any number of single, dual, or hard disk drives. Each device can have a different physical unit number, and you can distribute your CP/M logical drives over several physical drives.

All of this flexibility may be somewhat intimidating. Fortunately, Z-RAM comes already configured with the default definitions that most people will want to use. Read over the following defaults which are contained in the "mcdefs 140" file. If you have no reason to change them, then you do not have to run the "setup cp/m" program.

Side one of your Z-RAM Master Disk Backup is configured for 8050 disk drives that have not been upgraded to 2.7 DOS. These are the defaults:

CP/M Logical Drive	CBM Physical Unit	CBM Physical Drive	CBM File Name
A	8	0	CP/M Drive A
B	8	0	CP/M Drive B
C	8	1	CP/M Drive A
D	8	1	CP/M Drive B

CBM Tractor Printer
 300 Baud
 IEEE Printer Address= Unit 4

Note that there are two CP/M drives on each of the Commodore 8050 physical drives (0 and 1). This is necessary because the information on each of the CP/M drives is stored as a Commodore relative file. A non-upgraded 8050 limits the size of any relative file to 170K, which is less than half of the available disk space on this unit. Therefore, two relative files (corresponding to two CP/M drives) are provided on each Commodore 8050 drive so that you can use more of the storage capacity of your 8050 for CP/M.

If you turn over your Z-RAM Master Disk Backup, it is formatted for the 4040 disk drive. These are the defaults for that side:

CP/M Logical Drive	CBM Physical Unit	CBM Physical Drive	CBM File Name
A	8	0	CP/M Drive A
B	8	1	CP/M Drive A
C	9	0	CP/M Drive A
D	9	1	CP/M Drive A

CBM Tractor Printer
 300 Baud
 IEEE Printer Address= Unit 4

Notice here that only one CP/M logical drive corresponds to each Commodore 4040 disc drive, since the size allowed for a Commodore relative file (as described above) can fill the entire 4040 disk. Drive 0 is CP/M drive A, and Drive 1 is CP/M drive B.

Check the default printer type to be sure it matches yours. If these defaults are acceptable, as they will be to most first time users who have 4040 or standard 8050 drives, you do not need to run the "setup cpm" program. However, if you are using an **upgraded 8050, 8250 or hard disk drive**, the Commodore disk drive that you have can accomodate a relative file size (and therefore CP/M logical drive size) that equals the entire size

of your Commodore disk drive storage capacity. This means that, while your disks are to be formatted in 8050 style, you can configure CP/M logical drives to match the more convenient one-to-one CP/M-Commodore correspondence shown in the table above for the 4040. To do this, or to make any other desired changes in default settings, including printer type, you must run "cpm setup".

Load your Z-RAM Master Disk Backup in drive 0, proper side up (8050 or 4040). Only owners of 4040 drives should use the 4040 side. Type the following:

load"setup cpm",8

and hit return. Your computer should respond with the message that the file is loading.

If your disk drive's error light comes on (or turns red, or blinks, as the case may be), then there was some difficulty in loading. Try typing the above command again. If there's still a problem, remove both diskettes from the drive, turn the computer off, pause a moment, and then turn it back on again. Reinsert the diskettes in the correct drives and try the command again.

Once the program is loaded, your computer will signal **ready**. If you want to create the default definitions on your Z-RAM Master Disk Backup, then leave it in drive 0. All future CP/M system disks will then receive these definitions. If you want to put a new definition file on another previously formatted disk, then insert that disk in drive 0. Now type this command:

run

Your computer's screen will then display a status line that says **CP/M setup (c) Madison Computer**. Below that you will see a series of questions.

To correctly set up the default definitions you must answer these questions. Some of the questions already display an answer. If this is the answer you wish to make, just hit return. If not, enter whatever other answer you wish and hit return.

Here is a list of questions you'll see on screen and an explanation of each.

Read definition file from unit? 8
drive? 0

The answers to these questions tell your computer where to get the "mcdefs" file that will contain your default definitions. You can retrieve it from the Z-RAM Master Disk Backup, in which case it will contain the defaults already

described. Or, you may retrieve the file from some other diskette that has different defaults stored on it.

In either case, tell the computer where you've put the diskette with the file you want to use. That will ordinarily be unit 8 and drive 0. If that's the case, just hit return to accept these answers. If you're using an 8050 disk drive with the standard defaults, you will see the following chart displayed on screen:

cp/m drives are:

a:	unit 8	0:cp/m drive a
b:	unit 8	0:cp/m drive b
c:	unit 8	1:cp/m drive a
d:	unit 8	1:cp/m drive b
e:	unit 9	0:cp/m drive a

Reading left to right on the top row, this means that CP/M logical drive a is located in Commodore physical **unit 8** on drive **0** and stored under the name **cp/m drive a**. The second row refers to CP/M logical drive **b**, and so on down the chart.

any drives? n

If the drives are acceptable as is, just hit return. If you want to change them, type **y** RETURN. **For upgraded 8050, 8250 and hard disk drives, type "y"**. The following question will appear:

To end drive list set unit to 0
A>unit 8,"0:cp/m drive a"

You may now change the unit number of CP/M logical drive **a**. Choose a number and hit return. If you only have one disc drive unit, you should probably not change this, or any of the other items on this line. The cursor will then move to the drive number option. Make a choice and hit return. Finally, the cursor will move to "cp/m drive letter?" This is the name of the Commodore file where the CP/M logical drive will be located. Accept the answer shown, or change it, and hit return.

The cursor will move to the next line and inquire about CP/M logical drive **b**. Again, if you only have one disk drive unit (even if its a dual unit), you should leave **B>** as unit 8. For upgraded 8050 and 8250 drives, you can change the Commodore drive associated with CP/M drive **B>** to 1:cp/m drive a. And, if you have only one disk unit, you need not change any of the other lines and can press "home".

If you are using a hard disk, you must configure both your floppy disk and hard disk units for the number of CP/M logical drives that they can handle. The floppy drive should be configured as shown above, according to the model you have. The

number of CP/M logical drives that must be allocated to your hard disk depends on its memory capacity. The CP/M operating system can handle a disk drive up to 8 megabytes in size. If your hard disk has more memory than this, the disk capacity must be divided among enough cp/m logical drives of 8 Mb each, to fill the hard disk if you do want to use the entire hard disk for CP/M. Obviously you do not have to allocate the entire hard disk to CP/M logical disk drives. Remember that you may want to change unit numbers for the floppy and hard disk drive files to correspond to the unit numbers used in your system to designate the hard and floppy disk unit. Work through the list until you are satisfied that you have provided yourself with the appropriate number of CP/M logical drives for each Commodore drive and that you have assigned them to the appropriate unit number.

When you're done, you'll see this question:

Any more changes to drives? n

If you're satisfied with your answers, hit return. Otherwise, hit **y** return, and you'll start the naming process over.

Next, choose your default printer type:

- 1-> ASCII SERIAL
- 2-> ASCII IEEE
- 3-> CBM 4022/2022
- 4-> CBM 4022P
- 5-> CBM 8023
- 6-> CBM FRICTION

default type? 2

Choose the type of printer you plan to use with this diskette. Choose option 1 if you're using any printer attached to the Commodore user serial port. Choose option 2 if you're using the CBM 8300P or most any other letter quality printer. Choose option 3 if your're using the CBM 2022, 3022, 4022, or 8023P. And choose option 4 if you're using a CBM 2023 or 3033.

Choose default serial baud rate

- 1-> 75 4-> 600
 - 2-> 110 5-> 1200
 - 3-> 300 6-> 2400
- current baud rate was 300**
default baud rate? 3

Choose the speed at which your serial printer will communicate. Typically this is 300 baud.

IEEE printer address? 4

If you're using an IEEE printer the device number, or address, is usually 4. You may change this, however.

Edit defaults again? n

If you're satisfied with the default choices you've made, hit return. If you want to make changes, type **y** return. This will bring you back to the beginning of the program.

Save edited defaults? n

If you want to escape from the program, hit return. If you want to save the new defaults you've created, type **y** and then hit return. You will then be asked the unit and drive numbers where you want to store the defaults. This process will save the defaults in the "mcdefs" file on the disk you specify.

4f. Formatting CP/M System and Data Disks

By following the instructions above, you've created an identical copy of your original Z-RAM Master Disk. This copy contains a number of different programs, not all of which you will want on the diskette you're using everyday. The important programs that you need to run CP/M are as follows:

```
mct 1.73      --a Commodore Basic program
cp/m drive a  --the CP/M information (pseudo-disk)
mcpack 140    --machine code programs called on by mct 140
mcdefs 140    --information on drive file locations
```

You should now create a "CP/M System Disk" with these four files on it and at least two logical data files, A and B. But before you can transfer cp/m files to a diskette, it must be prepared or formatted to accept them. The program "format cp/m" has been included on your master disk for this purpose.

There are two operations involved in the "format cp/m" program. One is known as "newing" or the "header" which is the process that initializes a new disk or can reinitialize an old disk that you want to recycle. The newing procedure will destroy the old contents of the disk if you allow it. The second operation performed by "format cp/m" is the preparation of disk space (a whole disk or a fraction of its storage space) to accept cp/m files. The "format cp/m" program performs both of these operations, but gives you the opportunity to use them independently. For the convenience of making a cp/m system disk, "format cp/m" will automatically copy the files listed above if you choose that option. Otherwise the disk space is formatted for cp/m with no files transferred (a data disk).

Once you have a disk that is all or partially formatted for cp/m, you could use "format cp/m" to add more cp/m space to it or add cp/m files, however you will probably not be storing Commodore and cp/m files on the same disk, in which case it is much easier to create newly formatted cp/m disks by copying a master cp/m data disk. The instructions below lead you through the creation of a master cp/m system disk from your Z-RAM master backup and a cp/m master data disk.

Insert a new or good used diskette into drive 1 of your disk drive unit. Make sure you're in the upper/lower case mode. To do this, type this command:

```
poke59468,14
```

and hit return. Now insert your "Z-RAM Master Disk Backup" into drive 0 with the correct side facing up. Type the following command:

```
load "format cpm",8
```

and hit return. Your computer should respond with the message that the file is loading.

If your disk drive's error light comes on (or turns red, or blinks, as the case may be), then there was some difficulty in loading. Try typing the above command again. If there's still a problem, remove both diskettes from the drives, turn the computer off, pause a moment, and then turn it back on. Reinsert the diskettes in the correct drives and try the command again.

Once the program is loaded, your computer will signal **ready** and you should type the command:

run

Your computer's screen will then display a status line that says "**Format CP/M (c) Madison Computer**". Below that you will see a series of questions.

To correctly format your first CP/M system diskette you must answer these questions. Each one already displays an answer. If this is the answer you wish to make, just hit return. If not, enter whatever other answer you wish and hit return.

When first starting out, these instructions have you go through the question and answer process of "format cp/m" four times with four different blank diskettes. When completed, you will have created a CP/M system diskette, a backup CP/M system diskette, a master CP/M data diskette, and a working CP/M data diskette #1.

Here is a list of the questions or requests that you'll see on screen, and an explanation of each:

If you are making system disks, put a master disk into unit 8, drive 0

Put the disk to be formatted in unit 8, drive 1.
then press "return" (or "c" to change units or drives, or "rvs/stop" to quit).

The first thing you'll want to do is to create a cp/m system disk, so follow these directions. If you're working with a Commodore dual disk drive, you need make no changes in the request and can simply press "return" after inserting the disks in their corresponding drives. At this point the computer will read the directory of the disk you have placed in drive 1 for formatting. After the directory is displayed (if one exists already on that disk), you will be asked:

OK to "new" this disk?y

If you have placed a diskette in drive 1 that you don't want to destroy, answer "no" ("n") to this query. At this point, you could still continue in the program to add cp/m files to a disk that has already been "newed" if you desired. However, if you're just starting out and want to "new" another disk, you must exit the program by pressing "rvs/stop", change disks, and run it again. If everything is fine and all disks are correctly located, answer "y", or simply hit "return". The next request is for a disk name and ID:

Enter name for Commodore directory-- " "
Also enter two character disk ID-- " "

Once you have made entries and pressed "return", the newing process will begin and the following message will appear:

new name, ID

The newing takes a minute or two, and when done, will print the name of the disk.

At this point you must indicate whether you are creating a system disk or a data disk by answering "s" or "d" to the question:

System or data disk:s

To make your first system disk, type "s" and "return". If you are simply making a cp/m system disk for everyday use, you should probably answer "n" to the next question, however if you wish, you can include the cp/m setup and format program on your system disk by answering "y".

Include setup and format?:n

The next display indicates the number of blocks available on the disk to format for cp/m files. It is possible to have a portion of your disk formatted for Commodore files and the remainder formatted for cp/m. It is generally not convenient to do this, but if you want to use some disk space for Commodore files, answer "y" to the following question and enter the number of blocks desired. Otherwise answer "n".

That will leave XXXX blocks available for cp/m data and Commodore files
Would you like to reserve any blocks for Commodore files?n
How many?

If you have entered a number of blocks you will be shown how many blocks you have left for cp/m use and asked to confirm your request.

**That leaves XXXX for cp/m data
OK?**

At this point "format cp/m" will create either one or two logical disk drives from the disk space allowed, and will indicate their size. This will take a few minutes, during which the disk drive will be active and you may see the error light come on (you can ignore it).

Although the screen says that the formatting is complete, wait until your disk drive stops spinning before you remove your disk. The entire formatting process will take about three to ten minutes.

Once you have a CP/M system disk, you still need to copy over some CP/M utility programs, such as PIP, which is used to copy files from disk to disk, as the program COPY is used on the normal Commodore operating system. You will actually use the PIP program that is stored under a CP/M logical disk drive file on your Z-RAM master backup to copy other programs from that logical drive over to your system disk. Take the Z-RAM master and your system disk out of their drives and switch them, placing your newly created system disk in 0 and Z-RAM master in 1. This is done so that you load CP/M from your new system disk which has been configured, by "format cpm", to your computer system. To load or "boot" CP/M, type:

load "mct*",8

and hit RETURN. When your computer signals **ready**, type: **run** and hit RETURN. In a moment, you'll see the CP/M display banner and the **A>** prompt. Now you can run the PIP program to copy over the CP/M programs. Type the following after the prompt:

c:PIP a:=c: *.* [ov] for 8050 drives that are not upgraded
-or-
b:PIP a:=b: *.* [ov] for all other drives

and hit RETURN. This entry took the PIP program from CP/M drive C or B (the drive on which your Z-RAM master disk CP/M programs are located) and ran that program to copy all of the files on that drive over to drive A, which is the CP/M drive in which your system disk is located. The bracketed o and v are commands in the PIP program to designate that you are transferring object (non-ASCII, usually non-text) files and the v provides that the transfer is verified. After a few minutes the copying will be completed. For further explanation of the PIP program, consult your Digital Research manuals. Exit CP/M when you're finished by typing the RUN/STOP key, and answering 'yes' to the question "are all files closed?".

Next, create a working system disk by placing another new or

recyclable disk in drive 0 (replacing the Z-RAM master) and using the "backup" program to copy drive 0 to drive 1, as you did for your Z-RAM master backup. One should be labeled "CP/M System Disk" and the other "Backup of CP/M System Disk." Put the latter away in a safe place.

Now run "format cpm" a second time (place Z-RAM master in drive 0, "new" disk in drive 1) choosing the "data" disk option. After you have formatted this disk, back it up as you did your system disk. Then label one diskette "Master CP/M Data Disk" and put a write protect tab over its notch. Put this diskette away in a safe place. Label the other one "CP/M Data Disk #1" or whatever you like. You need not run the PIP program on these data disks.

At long last you have fully formatted CP/M diskettes. You will be using the "CP/M System Disk" to load the CP/M operating system, and you'll be using the "CP/M Data Diskette #1" to record your data.

4g. Quickly Formatting New CP/M Diskettes

Fortunately, your future CP/M diskettes will be much easier to format. You will not need to run the "Format CP/M" program again. Just load a blank disk in drive 1, and put the disk marked "Master CP/M Data Disk" or "CP/M System Disk" in drive 0. If you have 4.0 Basic, type this command:

load "backup",8

and remember to hit return. You must then answer two questions. The first asks for the name you want to give the diskette. The second asks for the two digit ID number you want to assign that disk. Answer these questions and hit return.

In three to five minutes you will have a formatted CP/M data or system diskette which you can label "CP/M Data Disk #2", CP/M System Disk #2, or whatever you like.

4h. CP/M Control Sequences

The CP/M operating system requires the use of a control key on your computer terminal. When you press this key, it disables your terminal keys from sending their usual signals: a letter, number, or punctuation mark. Instead, each key will send a special signal that instructs your computer to do other operations: print, delete line, switch to upper case, etc.

We have used software to convert your Commodore's **OFF/RVS** key to a control key. This key does not need to be held down

while you hit the rest of the control sequence.

The following is a summary of the control characters that you may use while running CP/M on a Commodore. Remember, hold down the **OFF/RVS** key, then type one of these characters:

- 1 =Advances the printer one line.
- 2 =Enters a control P and clears the print buffer.
- 3 =This allows you to choose your printer.
- 4 =Toggles between upper and lower case.
- 0 =Reverses the status line
- : =Reverses the status line, compress the screen, and exchanges foreground and background.
- = =Alternately compresses and expands the screen.

To learn about other control sequences, consult your CP/M manuals.

If you want to exit the CP/M operating system so that you can use your Commodore for some other purpose, type the **RUN/STOP** key. The message ***** Quit CP/M ***** will appear on the status line, and a beep will sound.

To give you time to react, the computer will not accept any keys for a few seconds. The beep will sound again, and the message **Are all files closed?** will start to blink. Type a **y** if all of your files are closed. This is the case when you're in the **A>** mode. If your files are not closed, type any letter except **y**, and you'll return to exactly where you were.

4i. Status Line Messages

When you're using CP/M on a Commodore computer you'll sometimes see special messages appear on the top status line. Here are some typical messages.

A common message is **warm start**. This will appear when you type **OFF/RVS C** in response to the **A>** prompt. It means your system is rebooting.

Whenever data is being recorded on your diskette, the message **writing to disk** will appear. To preserve the integrity of your data, whenever this message is shown you should not remove the diskette, turn off the printer or disk drives, or create any other disturbance. Your **RUN/STOP** key will be ignored

during disk writing because your files must be closed before you exit CP/M.

If a disk error occurs, a Commodore error message will flash on the status line. Press any key to acknowledge the message. At that time a further error message from CP/M will usually appear.

You may then type **OFF/RVS R**, which will sometimes try the operation again. Typically, however, a warm start will follow the pressing of any key. This leaves you in the command mode and destroys your work-in-progress. This is characteristic of any CP/M system.

4j. Changing Commodore files to CP/M files

Now that you're working with CP/M and the software that runs on it, there may be files, such as text or data files, that you want to convert from Commodore format to CP/M format so that you can use them with your CP/M programs. To make this conversion, your CP/M system disk contains a program called "CBMREAD.COM". To enter a change, the following format is used:

CBMREAD CP/M drive#:CP/M filename=unit#:drive#:CBM filename

An example would be "CBMREAD A:CP/Mfile=8:0:CBMfile". The Commodore unit number will default to 8 if omitted. Be aware that any Commodore file name should not contain graphics characters or punctuation except "-" or "()". We suggest that you examine your Commodore directory and change file names to lower case. For changing text files, the Commodore source file must be stored as a WordPro print-to-disk file for compatibility with CP/M wordprocessors such as WordStar. Note that the program cannot be used in the reverse direction: to read CP/M files to the Commodore format. Typing "CBMREAD HELP" after the A> will display a short explanation of how to use the program for copying files over.

CBMREAD can also be used to list out a Commodore file on the screen while in CP/M for review before copying. Type:

CBMREAD CON:=0:CBMfilename

Where 0 is the drive number that the Commodore file is on (use 1: if CBM file is on drive 1). While listing out the program, a "CONTROL - S" can be used to pause and a "CONTROL - C" to stop the listing.

4k. Using Your IEEE Printer with CP/M

There are a few special things you should know about using a printer when you run CP/M on your Commodore equipment.

1. Don't turn your printer's power on or off while a program is running in your computer. The electrical surge may stop the program, and you'll lose all of your work-in-progress. If it's an IEEE printer and you turn it off, your disk drives may be reset, making it impossible to save your work.

2. Make sure that every IEEE device attached to your printer has its power turned on when you begin to use your computer. For example, don't run a program if your printer is turned off. If you do, the IEEE bus may become overloaded and garble the data going over it. You may lose all of your work.

3. If you must turn your printer off while you're in CP/M, save your work to disk first. Exit the program you're running, and then type **OFF/RVS** and then **c**. You'll see the message **warm start** appear on the status line.

Turn off the printer and do whatever you needed to do. Then turn the printer on and type **OFF/RVS c** again. If the system hasn't stopped, you can go back into your program. If it has stopped, reset the Commodore computer by turning it off, pausing for a moment, turning it back on, and reloading CP/M.

4. When you ran the "setup cpm" program, you set defaults for the type of printer you are using. If you'd like to change that while in CP/M, you can do it easily as follows.

Type **OFF/RVS 3**. The status line will show two flashing diagonal squares with the following words between them:

print: cbm tractor

If this is the type of printer you want to use, just hit return. If it's not, each time you hit the space bar a different printer type will appear in the space: **cbm friction**, **cbm 4023**, **cbm 8023**, **ascii serial**, **ascii IEEE**. You may scan through these more than once by simply hitting the space bar. When you see the one you are going to use, hit return. You may use the **OFF/RVS 3** sequence whenever you want to change printers.

5. To send your printer a line feed, type **OFF/RVS 1**.

6. Programs which run under CP/M often use the "control P" command to stop the printer. This leaves characters in the computer and the printer. These will then be printed out the next time you start the printer. This sometimes happens on the top of what was meant to be a fresh page.

To overcome this problem, do not use "control P" when you're running CP/M on Z-RAM. Instead, type **OFF/RVS 2**. This issues a control P, clears the buffer and issues an extra carriage return and line feed to the printer.

4l. Using the CP/M RS-232 serial port

Under CP/M, Z-RAM gives you a fully bidirectional RS-232 serial port which you can use to run a printer, or, by using what is referred to as the "reader" and "punch", you can configure the port to accept a modem, plotter or other peripheral that is not supported in the standard CP/M system. In addition, Z-RAM provides you with a reader and punch status feature which allows you to use this port in a greater variety of applications (see discussion below of UPET1.Z80). The port can be accessed by typing "control l" (OFF/RVS then l) or by setting up a default device number using the program "cpm setup" (see section 4e). It can be configured to provide the proper link to the peripheral used by running the CP/M program BAUD. This simple program allows you to choose baud rate, parity and word length settings for any device you wish to hook up. Type **BAUD HELP** to view a summary of the BAUD program and its use. In addition to selecting port settings, you can run BAUD to find out what the present settings on the port are, regardless of what type of peripheral is attached to it.

Another CP/M program that you will find on your master system disk (that you PIP'ed over from the Z-RAM master) is **UPET1.Z80**; an example of a specific application of the serial port. This machine language program uses the punch and reader, plus the status feature, to run BSTAM, a program that transfers files between computers. Typing **TYPE UPET1.Z80** produces a source listing of this program so that you can see how the port and its features are used.

4m. Z-RAM Summary

Typical installation in CBM computer with 4.0 Basic

1. Read through the manual.
2. Sign and return the Digital Research User Agreements.
3. Check to see that all parts are in the Z-RAM box.
4. Install plastic spacers in computer.
5. Mount Z-RAM with screws and washers.
6. Plug Z-RAM's plastic connector into your computer and vice versa.
7. Remove computer's 6502 chip and plug in Z-RAM's 40 pin connector.

8. Load Z-RAM Master Disk and test it.
9. Copy your Master Disk.
10. Load and run "setup cp/m" program if you want to change location of logical drives, or the type and baud rate of your printer.
11. Load "format cp/m" program from Master Disk Backup and run it twice to create Master System Disk and Master Data Disk.
12. Load CP/M by putting System Disk in drive 0 and pressing SHIFT RUN.
13. On the newly formatted System Disk run the PIP program to copy over the CP/M programs.
14. Exit CP/M, then run "backup" program to create additional system and data disks.

5. TECHNICAL INFORMATION

5a. Overview

Z-RAM is a complete Z-80 microcomputer board with 64K of dynamic memory and expansion port. It plugs into the 6502 socket in a CBM/PET. The Z-80 runs at a full 4 MHz clock speed without wait states.

On the 6502 side, Z-RAM appears as a set of control ports at \$fff0 which perform two distinct functions. The first is to provide communication between the Z-80 and the 6502 when both processors are running at the same time.

The second function is to provide selection of memory banks so that the 64K can be accessed by the 6502 when the Z-80 is shut down. It is possible to have extended versions of regular CBM/PET programs which make use of this memory.

Z-RAM has been carefully designed to be as simple as possible, consistent with operating flexibility, to provide years of reliable operation.

5b. Memory Maps

The memory address space of a 32K CBM is divided into general functional blocks (for BASIC, I/O, working storage, etc.) and one big 32K block of RAM, available to the user (figure 5b-1). The locations of these address spaces in memory are identified by hexadecimal numbers or pointers. The Z-RAM memory is broken up into 8 blocks or 8K each (figure 5b-2) which can be slipped into the 6502 address space of the Commodore (figure 5b-1) in a variety of ways, to expand either the user RAM or the address spaces used in the CBM for other functions. The allocation of Z-RAM blocks to specific address spaces in the CBM is determined by the selection of a memory map. Because Z-RAM's memory is broken down into 8K blocks (as opposed to the 16K blocks of the CBM RAM card; figure 5b-3), there are 32 available memory maps, offering you greater flexibility in your use of Z-RAM's memory. The map number, 0-31, is poked into location \$fff0 (65520). Note that if the Z-80 is running, map #0 should be in use (extra memory allocated entirely to the Z-80). With each set of eight 8K blocks numbered 0 to 7, the mappings are as follows:

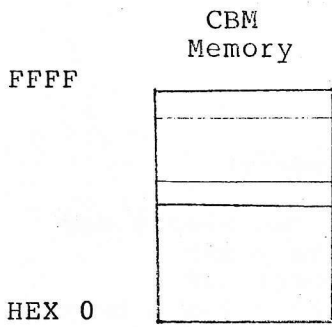
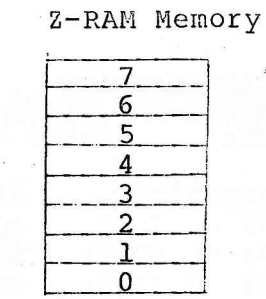
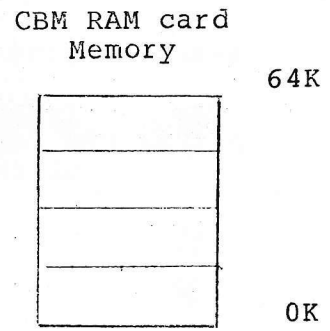


figure 5b-1



8 K Blocks

figure 5b-2



16 K Blocks

figure 5b-3

Z-RAM Mappings:

<u>Map</u> <u>number</u>	<u>Z-RAM Overlay Mapping</u> CBM reference block number	<-Z-RAM block number	comment		
0	No Expansion		Standard CBM Memory Map		
1	(0-7)	<- (0-7)	All 64K is Z-RAM		
2	(0-3)	<- (0-3)	Switch lower 32K		
3	(0-3)	<- (4-7)	Switch top Z-RAM & bottom CBM		
4	(4-7)	<- (0-3)	Switch lower 32K Z-RAM with top CBM		
5	(4-7)	<- (4-7)	Switch top 32K		
6	No Expansion				
7	No Expansion				
8	3	<- 0			
9	3	<- 1			
10	3	<- 2	Z-RAM or CBM	reference	
11	3	<- 3	address	block	
12	3	<- 4	range	number	
13	3	<- 5			
14	3	<- 6	\$0-1FFF	0	
15	3	<- 7	\$2000-3FFF	1	
16	4	<- 0	\$4000-5FFF	2	
17	4	<- 1	\$6000-7FFF	3	
18	4	<- 2	\$8000-9FFF	4	
19	4	<- 3	\$A000-BFFF	5	
20	4	<- 4	\$C000-DFFF	6	
21	4	<- 5	\$E000-FFFF	7	
22	4	<- 6			
23	4	<- 7			
24	(2-3)	<- (0-1)			
25	(2-3)	<- (2-3)			
26	(2-3)	<- (4-5)			
27	(2-3)	<- (4-5)			
28	No Expansion				
29	No Expansion				
30	(4-5)	<- (0-1)			
	and (6-7)	<- (6-7)			
31	(4-5)	<- (4-5)			
	and (6-7)	<- (2-3)			

Add 32 to the memory map numbers to get PEEK THROUGH.

Window Mappings (peek through)

Z-RAM Video	8000-8FFF
I/O	E800-EBFF
Zero Page	0-3FF
CBM RAM Card Video	8000-8FFF
I/O	E800-EFFF

CBM RAM Card Mappings for comparison

<u>CBM Ram Card Memory Map</u>	<u>CBM RAM Card Overlays</u>	<u>Corresponding Z-RAM Memory Map</u>
128	(4-7) <- (0-3)	4
132	(4-5) <- (4-5)	31
	and (6-7) <- (2-3)	
136	(4-5) <- (0-1)	30
	and (6-7) <- (6-7)	
140	(4-7) <- (4-7)	5

In the SuperPet: Any of the sixteen 4K blocks can be mapped into 9000-9FFF.

From this comparison, Z-RAM memory maps can emulate those used with the CBM RAM card. However, it should be noted that with Z-RAM's mapping, you cannot manipulate the CBM I/O and video memory spaces independently. See sample program in 4f to control switching of memory maps.

5c. Z-80 Port Maps

Unlike the 6502, the Z-80 uses special addresses called "port" addresses for input/output. Thus, the math chip and the communication chip which is tied back to the 6502 both appear as port addresses. The port addresses in use are:

Z-80 PIO Port A

00H Communication to 6520 (data)
01H Communication (control, math direction, etc.)

Z-80 PIO Port B

02H Misc. (data, 6520 CB2, math chip end line, etc.)
03H Misc. Control (data direction, etc.)

Optional

04H AM9511 Math Chip (stack access data)
05H AM9511 Math Chip (status, commands)

Bit 7 at Z-80 Port 02H is tied to bit 7 at 6520 port \$FFF0 (65520). Bit 1 is tied to 6520 CB2 line, which is the control line of the 6520 port which appears at \$FFF0 (not at \$FFF2). Bit 0 is tied to the AM9511 "end" line and may be read to determine whether the AM9511 is done with an operation, or may be used to create an interrupt.

When running under CP/M, port 02H is operated in bit mode. This should not be changed. This port should be used under CP/M only by AM9511 drivers to read the "end" line and is set up appropriately to do so. It is possible to set up appropriate masks to create an interrupt when the end line changes state. At present this would not interfere with CP/M if done properly. We cannot guarantee this for all future revisions of CP/M.

The I/O expansion connector (P1) contains the following control lines through which 16 I/O Ports can be accessed:

	<u>Pins</u>		
ZD3	1	2	ZD4
ZD6	3	4	ZD5
ZD2	5	6	ZD7
ZD0	7	8	ZD1
ZIORQ	9	10	GND
ZMA6	11	12	GND
ZMA5	13	14	GND
ZMA4	15	16	+5V
ZMA1	17	18	+5V
ZMA0	19	20	ZMA7
ZRD	21	22	IEO
4MHz	23	24	INT
ZMI	25	26	+12v

For more detailed technical information on instruction sets, ports, PIO architecture, programming, and signal definitions, consult manufacturer's technical data sheets from Zilog, SGS, or Mostek.

5d. 6502 Port Maps

The 6502 ports are memory mapped and appear at addresses \$FFF0 through \$FFF3. These four bytes always show.

```

$FFF3  Z-80 communication (data)
$FFF2  Z-80 communication (data direction and control)
$FFF1  Memory map, Z-80 start/stop, extra flag bit
$FFF0  Data direction and control for $FFF2

```

Bits 0 through 4 control the selection of one of 32 memory maps as outlined in the Memory Map section.

Bit 5 has a value of 32 when set on. It controls page 0 and video "peek through," which is a modification of the memory map. With bit 5 set to 0, the maps are exactly as given. With bit 5 set to 1, pages 0 through 3 (\$0000 through \$03FF) and the 4K video address space \$8000 through \$8FFF are not mapped out even if the map calls for them to be. The I/O mappings are E800-EFFF.

You may substitute the added memory for all or part the existing memory while leaving the screen and the 6502 page 0 and stack access intact. If the screen space is mapped out while bit 5 is set to 0, then any printing to the screen done from Basic will go to an "invisible screen," that is to the mapped memory.

Bit 6 has a value of 64 when set on. It turns the Z-80 on and off. With bit 6 set to 0, the Z-80 is put into a "halt" state, with a "HALT" instruction forced into it. In this condition, it runs cycles which refresh the 64K memory in

synchronism with the clock cycles of the 6502. The 6502 can read and write to memory if it is appropriately mapped.

When bit 6 is set to 1, the Z-80 is reset and then allowed to run. In this condition, the Z-80 cycles are not synchronized to the 6502 clock cycles, and memory map 0 (no mapping) must be in use for proper operation.

Bit 7 has a value of 128 when set on. It is tied to bit 7 of the Z-80 port 02H. It is used by CP/M as an extra flag or handshake bit.

Z-RAM uses four memory locations in the 6502, either FFF0-FFF3 or FFF4-FFF7 (jumper selectable). The interface used is a 6520 with ports assigned as follows. Note that A and B ports are inverted. Following is the 6502 memory address using the base selected by J2. The default is \$FFF0. If J2 is in the B position, then add 4 to each address.

		<u>7</u>	<u>6</u>	<u>5</u>	<u>4</u>	<u>3</u>	<u>2</u>	<u>1</u>	<u>0</u>	=bits
65523	FFF3	Port 2 Control								=port A
65522	FFF2	Data to Z-80								
65521	FFF1	Port 0 Control								=port B
65520	FFF0	Memory Map								
		└─ Window								
		└─ Z-80 Reset and hold								
		└─ To Z-80 PI/O bit 7 port B								

See program in 4f to control switching of memory maps. For further technical information on the 6502 or the 6520 consult data sheets available from Commodore or Rockwell. For information on the 6821 consult Motorola.

5e. On Board Jumper Options

J1	Jumper for 2 or 4 MHz clock 9511
	A 4 MHz
	B 2 MHz
J2	Board Address
	A FFF4-FFF7
	B FFF0-FFF3

5f. Memory Map Switching Program

This program initializes port B of the 6821(6520). With it you can exchange memory maps under control of a Basic or machine language program. It is stored as "bank memory" on your Master Disk.

```

10 poke 65521,4:REM Access output register, controls map
20 poke 65520,0:REM Set to 0 (default map)
30 poke 65521,0:REM Access data direction register
40 poke 65520,255:REM Set to output
50 poke 65521,4:REM Access output register
60 poke 65520,0:REM Make sure data set to 0
70 poke 63,96:CLR:REM Set top of memory down to $6000 and
reset Basic
80 print"THIS PROGRAM SHOWS BANK SWITCHING FROM BASIC. THE
FIRST BYTE OF EACH"
90 print"BANK IS LOADED WITH A NUMBER FROM YOU AND THEN
READ BACK.":print
100 print"DATA FOR CBM RAM (NUMBER BETWEEN 0 AND
255)";:inputj
110 ifj<0 orj>255 then print "USE NUMBER BETWEEN 0 AND 255
[cursor up twice]":gotol100
120 poke24576,j
130 for i=0 to 7 :REM put data in first byte of each
140 poke65520,8+i:REM of the eight blocks
150 print"DATA FOR BANK "I" (NUMBER BETWEEN 0 AND
255)":inputj
160 if j<0orj>255then print "USE NUMBER BETWEEN 0 AND 255
[cursor up twice]":gotol150
170 poke24576,j:next i
180 poke 65520,0 :REM Reset cbm to all cbm ram
190 print:print"data in cbm ram is "peek(24576)
200 for i=0 to 7
210 poke65520,8+i:print"DATA IN BANK" I "IS" peek(24576)
220 next i
230 poke 65520,0 :REM reset cbm to all ram

```

5g. Memory Upgrade Program

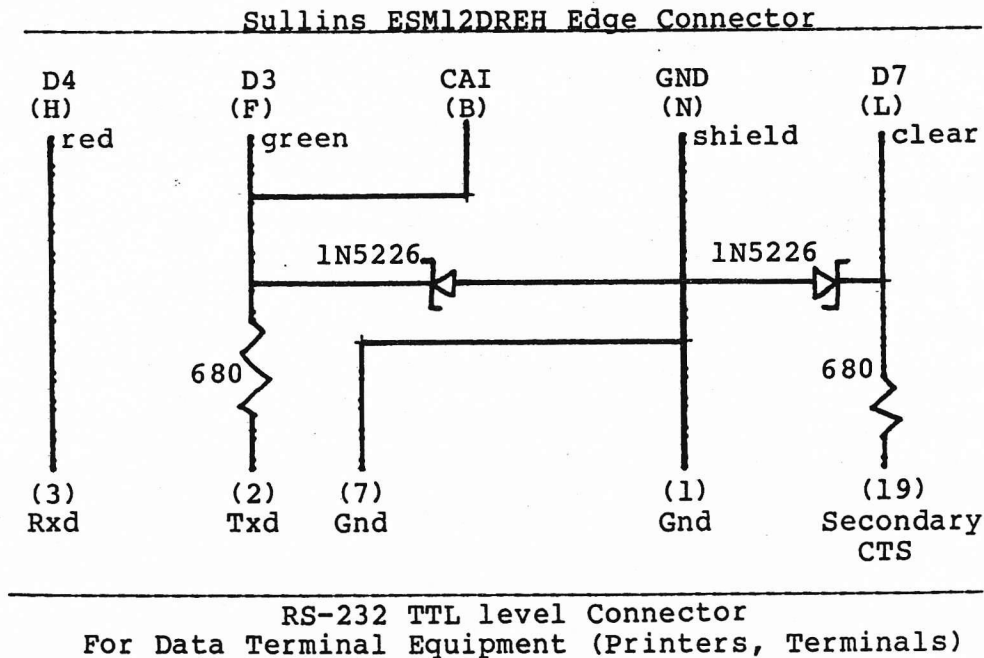
This program is stored on your Master Disk as "**upgrade memory**". You may run it to convert a Commodore 16K computer to a 32K computer. You will not be able to use CP/M on it, however.

```
10 poke 65521,4
20 poke 65520,0
30 poke 65521,0
40 poke 65520,255
50 poke 65521,4
60 poke 65520,0
70 print"[screen clear]This program changes any pet to 32K
ram by use of z-ram.
80 print"Now type the return key on the sys command line.
90 a=peek(65520+12):b=peek(65520+13)
100 print:print:print"sys "b*256+a;"[home]"
110 poke65520,2+32
```

5h. Memory Diagnostic

This program is a memory diagnostic for the Z-80 and 6502 microprocessors. It is stored on your master disk as "**memtest.**"

5i. Serial Port Wiring Diagram

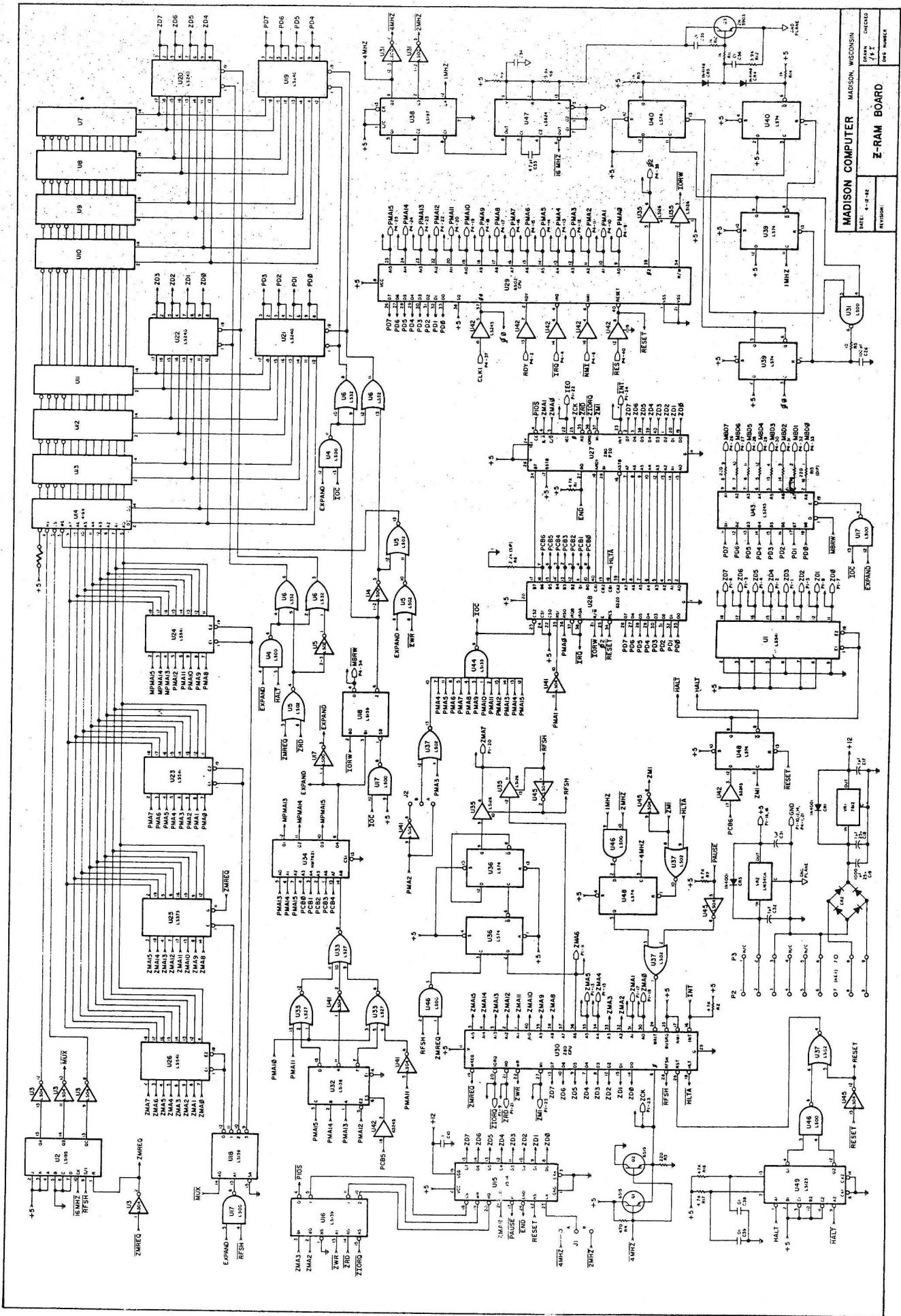


D3=input to Z-RAM
D4=output from Z-RAM

4j. SUMMARY OF REMOTE COMMANDS

REMOTE COMMANDS	LEAD-IN* REQD (X)	KEY STROKE	ASCII CODE	DECIMAL
Home Cursor	X	Control-R	DC2	18
Up Cursor	X	Shift-Line Feed	FF	12
Down Cursor	X	Control-K	VT	11
Left Cursor		Back Space	BS	8
Right Cursor		Shift-Backspace	DLE	16
Address Cursor	X	Control-Q	DC1,X,Y	17,X,Y
Read Cursor Address	X	Control-E	ENQ	5
Clear Screen	X	Control/Shift-L	FS	28
Clear Foreground	X	Control/Shift-M	GS	29
Clear to End-of-Line	X	Control-O	SI	15
Clear to End-of-Screen	X	Control-X	CAN	24
Clear to End-of-Screen - background spaces	X	Control-W	ETB	23
Background Follows	X	Control-Y	EM	25
Foreground Follows	X	Control/Shift-O	US	31
Delete Line	X	Control-S	DC3	19
Insert Line	X	Control-Z	SUB	26
Keyboard Lock	X	Control-U	NAK	21
Keyboard Unlock	X	Control-F	ACK	6
Audible Alarm		Control-G	BEL	7
Tab		Tab	HT	9

*Lead-in Code = ASCII ~, Decimal 126



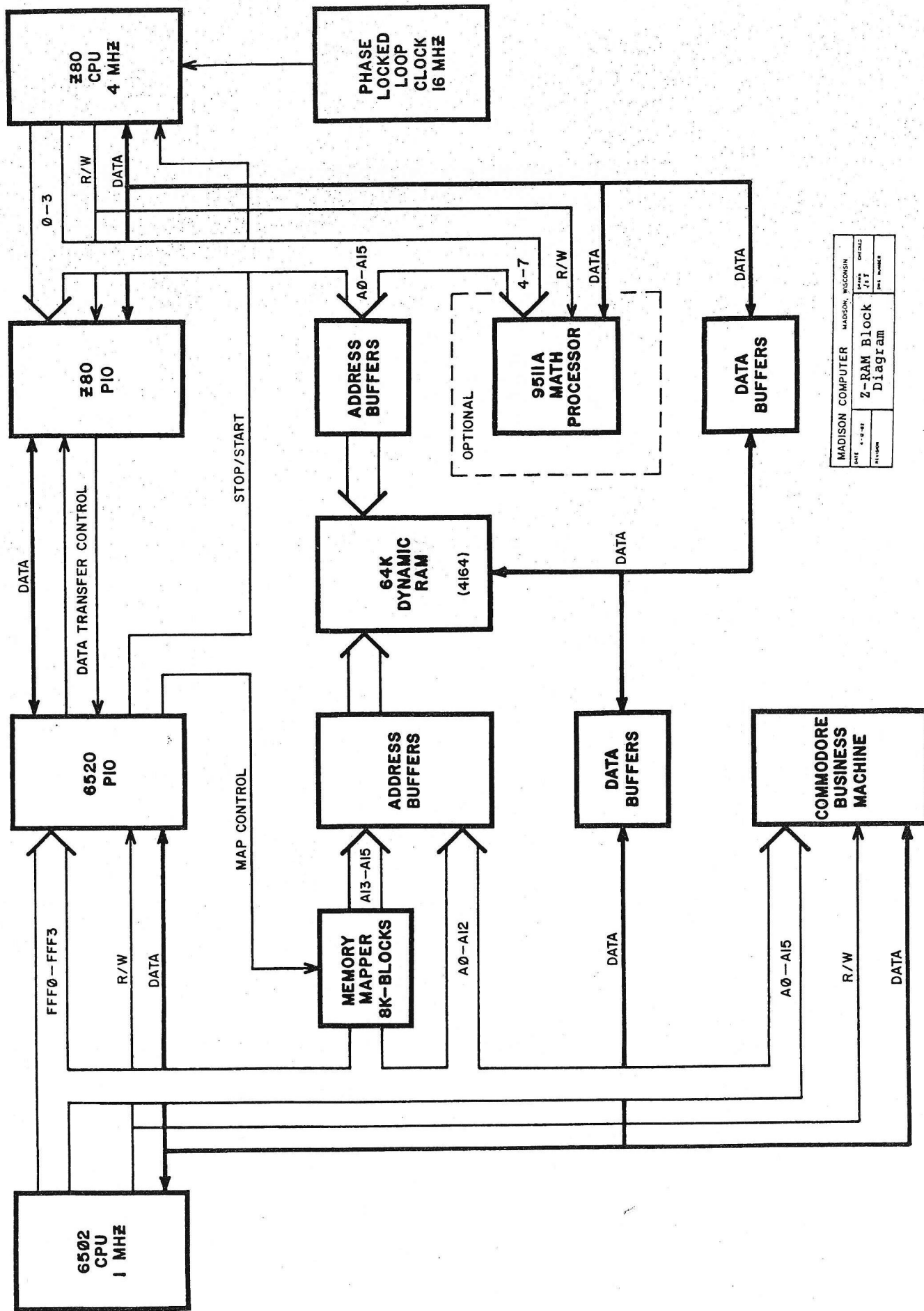
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 DATE: 1-1-62
 REVISION: 1
 FILE: 100
 SHEET NUMBER: 1

Z-RAM BOARD

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MADISON COMPUTER MADISON, WISCONSIN
 DATE 4-18-81 FILE 0112
 DRAWING Z-RAM Block Diagram

1

2

3

