



COMMODORE 64

CP/M®

OPERATING SYSTEM

USER'S GUIDE



commodore
COMPUTER

USER'S MANUAL STATEMENT

"This equipment generates and uses radio frequency energy and if not installed and used properly, that is, in strict accordance with the manufacturer's instructions, may cause interference to radio and television reception. It has been type tested and found to comply with the limits for a Class B computing device in accordance with the specifications in Subpart J of Part 15 of FCC rules, which are designed to provide reasonable protection against such interference in a residential installation. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- reorient the receiving antenna
- relocate the computer with respect to the receiver
- move the computer away from the receiver
- plug the computer into a different outlet so that computer and receiver are on different branch circuits.

"If necessary, the user should consult the dealer or an experienced radio/television technician for additional suggestions. The user may find the following booklet prepared by the Federal Communications Commission helpful: 'How to Identify and Resolve Radio-TV Interference Problems.' This booklet is available from the U.S. Government Printing Office, Washington, D.C. 20402, Stock No. 004-000-00345-4."

PREELU
M

RY

**COMMODORE 64
CP/M® OPERATING
SYSTEM USER'S
GUIDE**

Published by
Commodore Business Machines, Inc.
and
Howard W. Sams & Co., Inc.

**First Edition—1983
First Printing—1983**

**Copyright © 1983 by Commodore Business
Machines, Inc.
All rights reserved.**

CP/M is a registered trademark of Digital Research
**This manual is copyrighted and contains proprietary
information. No part of this publication may be
reproduced, stored in a retrieval system, or
transmitted in any form or by any means, electronic,
mechanical, photocopying, recording, or otherwise,
without the prior written permission of
COMMODORE BUSINESS MACHINES, Inc.**

Printed in the United States of America

TABLE OF CONTENTS

1. INTRODUCTION TO CP/M ON YOUR COMMODORE 64	7
● 1.1 Overview of CP/M on Your Commodore 64	9
● 1.2 How To Use This Manual.....	10
● 1.3 Digital Research License Information	12
1.3.1 Digital Research License Agreement	12
● 1.4 Registration Information	15
● 1.5 Warranty and Service Information	15
● 1.6 Get More out of Your Commodore Computer.....	16
1.6.1 Power/Play: The Home Computer Magazine	16
1.6.2 Commodore: The Microcomputer Magazine	16
1.6.3 Commodore Information Network: The Paperless User Magazine	17
2. SETTING UP YOUR COMMODORE 64	19
● 2.1 Unpacking and Connecting the Z80 Cartridge	20
● 2.2 Installing the Z80 Cartridge	22
2.2.1 Using the Z80 Cartridge with VIC Peripherals	22

2.2.2	Using the Z80 Cartridge with CBM Series Peripherals.....	22
● 2.3	Connecting Disk Drives	24
2.3.1	Connecting VIC 1541 Disk Drives	24
2.3.2	Connecting CBM Series Disk Drives	24

3. USING YOUR COMMODORE 64 PERIPHERALS FROM CP/M 25

● 3.1	Printer Interface	26
● 3.2	The Commodore 64 Serial Interface	27
● 3.3	The IEEE Interface Cartridge	27
● 3.4	Daisy Chaining Peripherals.....	28
● 3.5	The Commodore 64 User Port	29

4. GETTING STARTED 31

● 4.1	Bringing CP/M onto Your Commodore 64 .	32
4.1.1	Starting CP/M	33
4.1.2	Making Copies of Your CP/M System Disk	34
● 4.2	The COPY Utility	35
4.2.1	Formatting a Disk with the COPY Utility	35
4.2.2	Creating a Disk Backup with the COPY Utility	37
4.2.3	Copying the System Tracks with the COPY Utility	38
● 4.3	The CONFIG Utility	39
4.3.1	Using CONFIG to Change the Number of Disk Drives	40
4.3.2	Using CONFIG to Change the Printer Type	41
4.3.3	Using CONFIG to Change the Initial Caps Mode	41
4.3.4	Using CONFIG to Change the Function Key Assignments	42
4.3.5	Using CONFIG to Change the Key Codes	44

4.3.6 Using CONFIG to Save the New I/O Setup	45
● 4.4 Generating a New CP/M System with SYSGEN	45
4.4.1 Relocating CP/M	46
4.4.2 Saving the New System	47
4.4.3 Using SYSGEN	48
● 4.5 The Commodore 64 Keyboard and Screen with CP/M	49

5. CP/M OPERATION 51

● 5.1 How to Use This Chapter.....	52
● 5.2 CP/M File Naming Conventions.....	52
● 5.3 Input/Output Hardware Conventions	55
5.3.1 Loading Programs from Disk: Single Drive	56
5.3.2 Loading Programs from Disk: Dual Drive	57
● 5.4 CP/M Command Structure	57
● 5.5 CP/M Commands	61
5.5.1 <i>pgm-name</i> (Load and Run a CP/M Program).....	61
5.5.2 <i>x:</i> (Change the Currently Logged Disk)	63
5.5.3 ASM	64
5.5.4 DDT	66
5.5.5 DIR	71
5.5.6 DUMP	73
5.5.7 ED	73
5.5.8 ERA	82
5.5.9 LOAD	83
5.5.10 MOVCPM	83
5.5.11 PIP	85
5.5.12 REN	91
5.5.13 SAVE	92
5.5.14 STAT	93
5.5.15 SUBMIT	97
5.5.16 SYSGEN.....	100
5.5.17 TYPE	102
5.5.18 USER	103
5.5.19 XSUB	104

6. CP/M ON THE COMMODORE 64 107

● 6.1 The Structure of CP/M	108
6.1.1 How CP/M Works on Your Commodore 64	109
6.1.2 6510 Memory Use.....	111
6.1.3 Addresses under CP/M	113
6.1.4 Z80 Memory Use.....	114
● 6.2 The BOOT Programs.....	116
● 6.3 The BIOS Programs	117
● 6.4 CP/M Disk Organization	120
● 6.5 The CP/M BDOS	121
6.5.1 Sample BDOS Function Call	123
● 6.6 Calling a Z80 Program from the 6510....	134
6.6.1 Some Examples	135
● 6.7 Calling a 6510 Program from the Z80	136
6.7.1 Switching on the 6510.....	137
● 6.8 Program Execution under CP/M	139

7. APPENDICES..... 141

● A. Commodore 64 Memory Map	142
● B. Bibliography	144
● C. CP/M Command List	148
● D. ASCII, CHR\$, and Hexadecimal Character Codes	151
● E. BIOS and BOOT Listings (both 6510 and Z80)	155

8. HARDWARE SCHEMATICS .239

- Z80 Schematic
- Commodore 64 Schematic

CHAPTER

INTRODUCTION TO CP/M ON YOUR COMMODORE 64

- Overview of CP/M on Your Commodore 64
- How To Use This Manual
- Digital Research License Information
- Registration Information
- Warranty and Service Information
- Get More out of Your Commodore Computer

Your purchase of the Commodore Z80 add-on microprocessor cartridge puts you in the elite group of owners of a *dual processor home microcomputer*. No one but Commodore—the originator of the home microcomputer—could design and manufacture an inexpensive home or personal computer that accommodates the *two most common microprocessors in the microcomputer industry*:

- the Commodore MOS 6510 (6502 type) microprocessor
- the Z80A microprocessor

The 6510 microprocessor is the main processor on your Commodore 64. The 6510 is a specially designed variation of the widely distributed 6502 microprocessor found in many popular home and office computers. The 6510 runs the same instruction set as the 6502 but includes some special features that make it work more efficiently in your Commodore 64.

It is the 6510 main processor that is active when your Commodore 64 is running in *native mode*. In native mode, your Commodore 64 is controlled by its Commodore 64 Kernal operating system, Screen Editor, and the BASIC V2.2 interpreter. Native mode gives you access to a vast library of Commodore 64 applications packages from Commodore or from one of the many independent Commodore 64 software developers around the world.

When you add your Z80 cartridge to the system and start Digital Research's CP/M® operating system, you open the door to more than **15,000 CP/M-based application programs**. CP/M is the most popular 8-bit operating system and is used for business applications throughout the world.

If you have a special application need, it's very likely that a CP/M package exists to meet it. CP/M applications are available in such areas as:

- financial reporting
- financial analysis
- investment planning
- word processing
- law
- real estate

- farm management
- restaurant management
- data base
- exotic language compilers (PL/I, PASCAL, C)
- and many, many more

1.1 OVERVIEW OF CP/M ON YOUR COMMODORE 64

CP/M on your Commodore 64 can run in a maximum of 48K (1K = 1024 characters) of memory. The rest of memory is occupied by the Commodore 64 Kernal routines that provide input/output support for CP/M.

While you are running CP/M under the Z80 processor, the 6510 main processor acts as an input/output processor. When the 6510 is active, your Commodore 64 is executing in *native mode*. When it's running in native mode, your Commodore 64 "knows" how to handle its keyboard, screen, and peripherals (disks and printer). Rather than duplicate this facility to run under the Z80 processor, CP/M simply calls on the 6510 main processor to perform these tasks.

In addition to CP/M, you get a set of custom utilities that make it easy for you to run CP/M on your Commodore 64. You get:

- The **COPY** utility that formats diskettes in the CP/M format; easily produces backups of CP/M diskettes, even on single-drive systems; and copies the important CP/M system tracks.
- The **CONFIG** utility that makes it easy for you to inform CP/M of changes to your system peripherals, load the Commodore 64 function keys for use under CP/M, and re-define keyboard characters to yield any code you want.
- The **MOVCPM** utility that allows you to create a different sized version of CP/M without the need to learn Z80 Assembler language. MOVCPM relocates *all* of CP/M, including the BOOT and BIOS programs.

You can load anything you like into the **eight Commodore 64 Function Keys**. When CP/M is started, the eight function keys are loaded with the following CP/M commands (<CR> stands for RETURN):

F1 Z DIRXCRZ
F2 Z DIR B:XCRZ
F3 Z STAT *.*XCRZ
F4 Z STAT B:.*XCRZ
F5 Z COPYXCRZ
F6 Z CONFIGXCRZ
F7 Z DDTXCRZ
F8 Z DDT

CP/M on your Commodore 64 supports **upper and lower case characters**. You can toggle between upper case only and upper/lower case using the Commodore (C) key. For special applications, you can **redefine the codes** returned to your CP/M programs from the keyboard or sent to the screen from your programs.

1.2 HOW TO USE THIS MANUAL

The very first thing to do is to read the **Digital Research License Agreement** in Section 1.3. Next, *fill in and mail* the Digital Research CP/M Registration Card at the end of this manual as soon as possible.

With those tasks accomplished, it's time to start running CP/M on your Commodore 64. **Chapter 2 tells you how to use your Z80 cartridge**. Read this chapter before you try to plug it in.

The distribution version of Commodore 64 CP/M assumes that you have a **VIC 1515/1525 printer and a single VIC 1541 disk drive**. If your Commodore 64 is equipped with some other combination, consult **Chapter 3 for information on using your peripherals**.

Chapter 4 is where things really get started. Read this chapter to learn **how to bring up CP/M on your system**. This chapter also tells you about the **Commodore 64 specific CP/M utilities** that you'll need and talks about using the **Commodore 64 keyboard** with CP/M.

IMPORTANT! BE SURE TO MAKE A BACKUP COPY OF YOUR CP/M DISTRIBUTION DISKETTES BEFORE YOU BEGIN PLAYING WITH CP/M. IF YOU DESTROY THESE DISKETTES, YOU LOSE CP/M. SO BE CAREFUL!

ONCE YOU HAVE MADE A COPY OF THE DISTRIBUTION DISKETTES (USE THE FORMAT AND BACKUP FEATURES OF THE COPY UTILITY), PUT THE ORIGINALS IN A COOL, DRY PLACE, AWAY FROM MAGNETIC FIELDS. DON'T USE THEM AGAIN UNLESS YOU ABSOLUTELY HAVE TO (FOR EXAMPLE, IF YOU ACCIDENTALLY DESTROYED ALL OF YOUR OPERATING COPIES!)

The distribution version of CP/M (the one that you get on the distribution diskette) is for a *44K CP/M system*. You should use this version if you have the *IEEE interface cartridge*. If you don't, look in **Chapter 4** to learn how to construct a **48K version** that can take advantage of the additional 4K of RAM available on your system.

Chapter 5 is a reference section which includes descriptions of all of the CP/M commands and utility programs that you need to function in the CP/M environment. Chapter 5 shows you how to execute programs under CP/M and talks about *CP/M files and file naming conventions*.

Chapter 6 is for those of you who want to get involved in the **technical workings of CP/M on your Commodore 64**. You DO NOT have to know any of this material to use CP/M. If interested, you can look into the first few sections of Chapter 6 to get an idea of *how CP/M is implemented on the Commodore 64 and how CP/M itself is structured*.

The balance of Chapter 6 is for the technically sophisticated user. You can learn about the *BOOT and BIOS programs written to support CP/M on the Commodore 64* and you can learn *how to cross-call routines between the two processors*. To understand these sections fully, you should have a strong working knowledge of both 6510 (6502) and Z80 Assembler language.

Chapter 7 provides you with the **engineering details of your Z80 cartridge and your Commodore 64**. If you understand computer hardware, you can look here to see how they did it.

This manual is intended to get you started in CP/M. If you want to *explore the depths of the CP/M operating system*, look in your local bookstore for one (or more) of the

many CP/M books published in the last few years. We've listed some of them in the **Bibliography**, Appendix B. Skim the books to see which one you like best.

Likewise, this manual does not provide a tutorial in the use of the Z80 microprocessor. If you're interested in *programming the Z80 in Assembler*, you'll need detailed references. The **Bibliography** contains a list of some of the Z80 books you can find in your bookstore.

1.3 DIGITAL RESEARCH LICENSE INFORMATION

IMPORTANT: Commodore's license with Digital Research requires that each purchaser of the Commodore 64 CP/M system register with Commodore so that accurate records can be maintained of all CP/M users.

Because Digital Research requires this information, we have provided a post card for you to fill out and send in. The serial number of your CP/M system disk is stamped on the labels of the disks you receive with your Z80 cartridge and CP/M information. Please fill out the card and send it to us.

READ THE LICENSE AGREEMENT CAREFULLY.

1.3.1 Digital Research License Agreement

DIGITAL RESEARCH
Box 579, Pacific Grove, California 93950
SOFTWARE LICENSE AGREEMENT

IMPORTANT:

All Digital Research programs are sold only on the condition that the purchaser agrees to the following license. **READ THIS LICENSE CAREFULLY.** If you do not agree to the terms contained in this license, return the packaged diskette **UNOPENED** to your dealer and your purchase price will be refunded. If you agree to the terms contained in this license, fill out the **REGISTRATION** information and **RETURN** by mail to Commodore.

DIGITAL RESEARCH agrees to grant and the Customer agrees to accept, on the following terms and conditions, nontransferable and

nonexclusive licenses to use the software program(s) (Licensed Programs) herein delivered with this agreement.

TERM:

This agreement is effective from the date of receipt of the above referenced program(s) and shall remain in force until terminated by the Customer upon one month's prior written notice, or by Digital Research as provided below.

Any license under this Agreement may be discontinued by the Customer at any time upon one month's prior written notice. Digital Research may discontinue any license or terminate this Agreement if the Customer fails to comply with any of the terms and conditions of this Agreement.

LICENSE:

Each program license granted under this Agreement authorizes the Customer to use the Licensed Program(s) in any machine-readable form on any single computer system (referred to as System). A separate license is required for each System on which the Licensed Program(s) will be used.

This Agreement and any of the licenses, programs, or materials to which it applies may not be assigned, sublicensed, or otherwise transferred by the Customer without prior written consent from Digital Research. No right to print or copy, in whole or in part, the Licensed Program(s) is granted except as hereinafter expressly provided.

PERMISSION TO COPY OR MODIFY LICENSED PROGRAMS:

The Customer shall not copy, in whole or in part, any Licensed Programs which are provided by Digital Research in printed form under this Agreement. Additional copies of printed materials may be acquired from Digital Research.

Any Licensed Program which is provided by Digital Research in machine-readable form may be copied, in whole or in part, in printed or machine-readable form in sufficient number for use by the Customer with the designated System, to understand the contents of such machine-readable material, to modify the Licensed Program as provided below, for backup purposes, or for archive purposes, provided, however, that no more than five (5) printed copies will be in existence under any license at any one time without prior written consent from Digital Research. The Customer agrees to maintain appropriate records of the number and location of all such copies of Licensed Programs. The original, and any copies of the Licensed Programs, in whole or in part, which are made by the Customer shall be the property of Digital Research. This does not imply, of course, that

Digital Research owns the media on which the Licensed Programs are recorded. The Customer may modify any machine-readable form of a Licensed Program for his or her own use and merge it into other program material to form an updated work, provided that, upon discontinuance of the license for such Licensed Program, the Licensed Program supplied by Digital Research will be completely removed from the updated work. Any portion of the Licensed Program included in an updated work shall be used only if on the designated System and shall remain subject to all other terms of this Agreement.

The Customer agrees to reproduce and include the copyright notice of Digital Research on all copies, in whole or in part, in any form, including partial copies of modifications, of Licensed Programs made hereunder.

PROTECTION AND SECURITY:

The Customer agrees not to provide or otherwise make available any Licensed Program including but not limited to program listings, object code, and source code, in any form, to any person other than the Customer or Digital Research employees, without prior written consent from Digital Research, except with the Customer's permission for purposes specifically related to the Customer's use of the Licensed Program.

DISCONTINUANCE:

Within one month after the discontinuance of any license under this Agreement, the Customer will furnish to Digital Research a certificate certifying that through his or her best effort, and to the best of his or her knowledge, the original and all copies, in whole or in part, in any form, including partial copies in modifications, of the Licensed Program(s) received from Digital Research or made in connection with such license have been destroyed, except that, upon prior written authorization from Digital Research, the Customer may retain a copy for archive purposes.

DISCLAIMER OF WARRANTY:

Digital Research makes no warranties with respect to the Licensed Programs. The sole obligation of Digital Research shall be to make available all published modifications or updates made by Digital Research to Licensed Programs which are published within one (1) year from date of purchase, provided the Customer has returned the Registration Card delivered with the Licensed Program.

LIMITATION OF LIABILITY:

THE FOREGOING WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING, BUT NOT LIMITED TO,

THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. IN NO EVENT WILL DIGITAL RESEARCH BE LIABLE FOR CONSEQUENTIAL DAMAGES EVEN IF DIGITAL RESEARCH HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

GENERAL:

If any of the provisions, or portions thereof, of the Agreement are invalid under any applicable statute or rule of law, they are to that extent to be deemed omitted.

1.4 REGISTRATION INFORMATION

Please fill out the CP/M Registration Card that is enclosed with your Z80 cartridge and CP/M system. Mail the completed card to:

DIGITAL RESEARCH
P.O. Box 579
Pacific Grove, CA 93950

We need the information on the card to provide information on system updates and to inform you of related new products. The serial number of your CP/M system is the number stamped on the label of the CP/M disks.

1.5 WARRANTY

If your unit is defective when you buy it, return it immediately to the original place of purchase. Your dealer will be able to give you the fastest service if you have problems. You can also send your unit directly to Commodore for replacement. The warranty card enclosed in your unit's package lists addresses for service. Be sure to enclose your receipt and a note explaining the problem. See your warranty card for more information.

1.6 GET MORE OUT OF YOUR COMMODORE COMPUTER

Commodore wants you to know that our support for users only starts with your purchase of a Commodore computer. That's why we've created two publications with Commodore information from around the world, and a "two-way" computer information network with valuable input for users in the U.S. and Canada from coast to coast.

In addition, we wholeheartedly encourage and support the growth of Commodore User's Clubs around the world. They are an excellent source of information for every Commodore computer owner, from the beginner to the most advanced. The magazines and network, which are more fully described below, have the most up-to-date information about how to get involved with the User's Club in your area.

Finally, your local Commodore dealer is a useful source of Commodore support and information.

1.6.1 POWER/PLAY: The Home Computer Magazine

For entertainment, learning at home and practical home applications, **POWER/PLAY** is the prime source of information for Commodore home users. From it you will learn where your nearest user clubs are and what they're doing. You'll also learn about software, games, programming techniques, telecommunications, and new products. **POWER/PLAY** is your personal connection to other Commodore users, outside software and hardware developers, and to Commodore itself. Published quarterly, it sells for \$10.00 a year.

1.6.2 COMMODORE: The Microcomputer Magazine

Widely read by educators, businessmen, and students as well as by home computerists, **COMMODORE Magazine** is our main vehicle for sharing information on the more technical use of Commodore systems. Regular departments cover business, science and education, programming tips, and "excerpts from a technical notebook." There are many other features of interest to anyone who uses or is thinking

about purchasing Commodore equipment for business, scientific, or educational applications. **COMMODORE** is the ideal complement to **POWER/PLAY**. It is published bi-monthly, and subscriptions are \$15.00 a year.

1.6.3 COMMODORE INFORMATION NETWORK: The Paperless User Magazine

This is the magazine of the future. To supplement and enhance your subscriptions to **POWER/PLAY** and **COMMODORE** magazines, the **COMMODORE INFORMATION NETWORK**—our “paperless magazine”—is available now over the telephone using your Commodore computer and modem.

Join our computer club, get help with a computing problem, “talk” to other Commodore friends, or get up-to-the-minute information on new products, software, and educational resources. Soon you will even be able to save yourself the trouble of typing in the program listings you find in **POWER/PLAY** or **COMMODORE** by downloading direct from the Information Network (a new user service planned for early 1983). The best part is that most of the answers are there even before you ask the questions.

To call our electronic magazine, you need only a modem and a subscription to CompuServe™, one of the nation's largest telecommunications networks. (To make it easy for you, Commodore includes a FREE one year subscription to CompuServe™ in each VICMODEM package.)

Just dial your local number for the CompuServe™ data bank and connect your phone to the modem. When the CompuServe™ video text appears on your screen, type G CBM on your computer keyboard. When the **COMMODORE INFORMATION NETWORK** table of contents, or “menu,” appears on your screen, choose from one of our sixteen departments, make yourself comfortable, and enjoy the paperless magazine that other magazines are writing about.

For more information, visit your Commodore dealer or contact CompuServe™ customer service at 800-848-8990 (in Ohio, 614-457-8600).

COMMODORE INFORMATION NETWORK

Main Menu Description	Commodore Dealers
Direct Access Codes	Educational Resources
Special Commands	User Groups
User Questions	Descriptions
Public Bulletin Board	Questions and Answers
Magazines and Newsletters	Software Tips
Products Announced	Technical Tips
Commodore News Direct	Directory Descriptions

CHAPTER

2

SETTING UP YOUR COMMODORE 64

- Unpacking and Connecting the Z80 Cartridge
- Installing the Z80 Cartridge
- Connecting Disk Drives

It's very easy to set up your Commodore 64 to run CP/M. You turn off your computer, plug in the Z80 cartridge, turn on your disks and computer and get started. Follow the directions in this chapter carefully.

**REMEMBER: YOU MUST TURN OFF YOUR COMMODORE 64 BEFORE YOU
INSERT THE Z80 CARTRIDGE IF YOU INSERT THE CARTRIDGE WITH THE
POWER ON, YOU WILL DESTROY THE CARTRIDGE!!**

2.1 UNPACKING AND CONNECTING THE Z80 CARTRIDGE

Before using CP/M on your Commodore 64, you must correctly connect your Commodore 64 to your TV and peripherals. For instructions on connecting your Commodore 64 to your TV, disk, and printer, read the manual that comes with your computer.

When you purchase CP/M for your Commodore 64, you get these items:

1. Z80 cartridge.
2. CP/M system disk.
3. Other disk.
4. User's manual.

Before you can connect your Z80 cartridge, you must know where to connect it. Figure 2.1 shows a diagram of the side and back panel connections for your computer.

Your Commodore 64 has these *side panel* connections:

1. **Power socket.** The free end of the cable from the power supply is attached here to supply power to your Commodore 64.
2. **Power switch.** This turns the power to your Commodore 64 on and off.
3. **Game ports.** These accept a joystick, one or more game controllers, or lightpen equipment. *The lightpen plugs into port 1 only.*

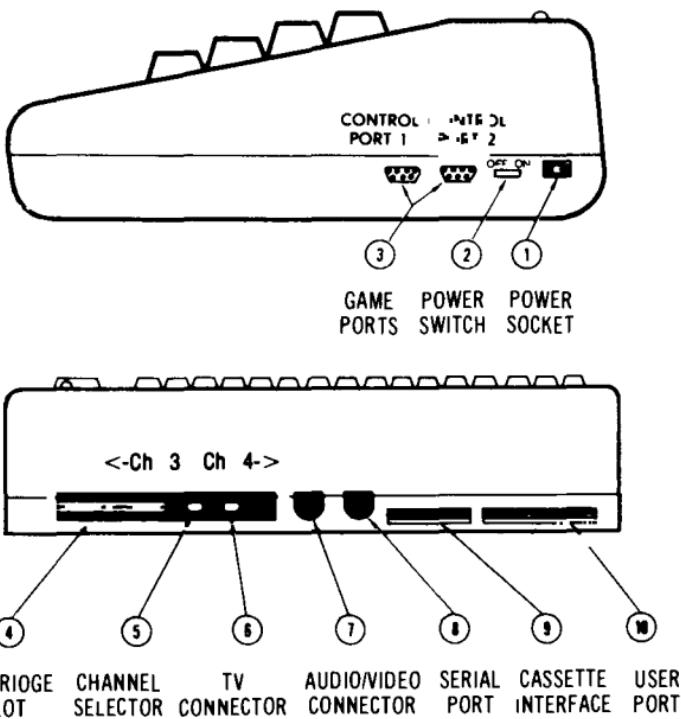


Figure 2.1 Commodore 64 Panel Connections Diagram

Your Commodore 64 has these *back panel connections*:

4. **Cartridge slot.** The rectangular slot to the left accepts program or game cartridges. *This is the connection for your Z80 cartridge.*
5. **Channel selector.** Use this switch to select the TV channel that will display your computer's picture.
6. **TV connector.** This connector supplies the picture and sound to your TV.
7. **Audio & video output.** This connector supplies direct audio (which you connect to your stereo system) and "composite" video (which you connect to a monitor).
8. **Serial port.** This is the connection for your VIC peripherals (1541 drives and 1515/1525 printer). You *must* connect your VIC disk drive to this port and your VIC printer to your VIC disk drive.
9. **Cassette interface.** This is the connection for your DATASSETTE™ recorder.

10. **User port.** This is a port for various interface cartridges such as the VICMODEM or RS-232 communications cartridge.

2.2 INSTALLING THE Z80 CARTRIDGE

Now that you know where your Commodore 64 connections are, you're ready to install your Z80 cartridge. You connect the Z80 cartridge directly to your Commodore 64 if you are using the VIC 1541 disk drive. You connect the Z80 cartridge to an IEEE interface cartridge if you're using the CBM 4040 disk drives or the CBM 4022 printer.

2.2.1 Using the Z80 Cartridge with VIC Peripherals

If you're using *VIC peripherals* like the VIC 1541 disk drives and the VIC 1525 printer, follow these easy steps:

1. TURN OFF THE POWER TO YOUR COMPUTER!
2. Install the Z80 cartridge in the cartridge slot marked 4 in the diagram in Figure 2.1.
3. Turn on your computer and you're ready to start using CP/M on your Commodore 64.

REMEMBER! IF YOU INSERT THE Z80 CARTRIDGE WITH THE POWER TO THE COMPUTER TURNED ON, YOU WILL DAMAGE THE CARTRIDGE!

2.2.2 Using the Z80 Cartridge with CBM Series Peripherals

If you're using *CBM series peripherals* like a CBM 4040 disk drive or a CBM 4022 printer, you follow a slightly different procedure for connecting the Z80 cartridge. Remember, you need to use the IEEE interface cartridge if you're using a CBM peripheral.

The IEEE interface cartridge has a connector for other

cartridges (like the Z80 cartridge) and also has a connector for the CBM peripherals. Figure 2.2 shows a diagram of the IEEE cartridge connections.

Follow these easy steps to connect your Z80 cartridge to your Commodore 64 when you're using the IEEE Interface cartridge and CBM series peripherals:

1. TURN OFF THE POWER TO YOUR COMPUTER!
2. Install the IEEE interface cartridge in the cartridge slot marked 4 in the diagram in Figure 2.1.
3. Install the Z80 cartridge into the IEEE cartridge slot as shown in the diagram in Figure 2.2.
4. Connect your CBM peripherals to the connector on the IEEE cartridge.
5. Turn on your computer and you're ready to start using CP/M on your Commodore 64.

REMEMBER: IF YOU INSERT THE Z80 CARTRIDGE WITH THE POWER TO THE COMPUTER TURNED ON, YOU WILL DAMAGE THE CARTRIDGE!

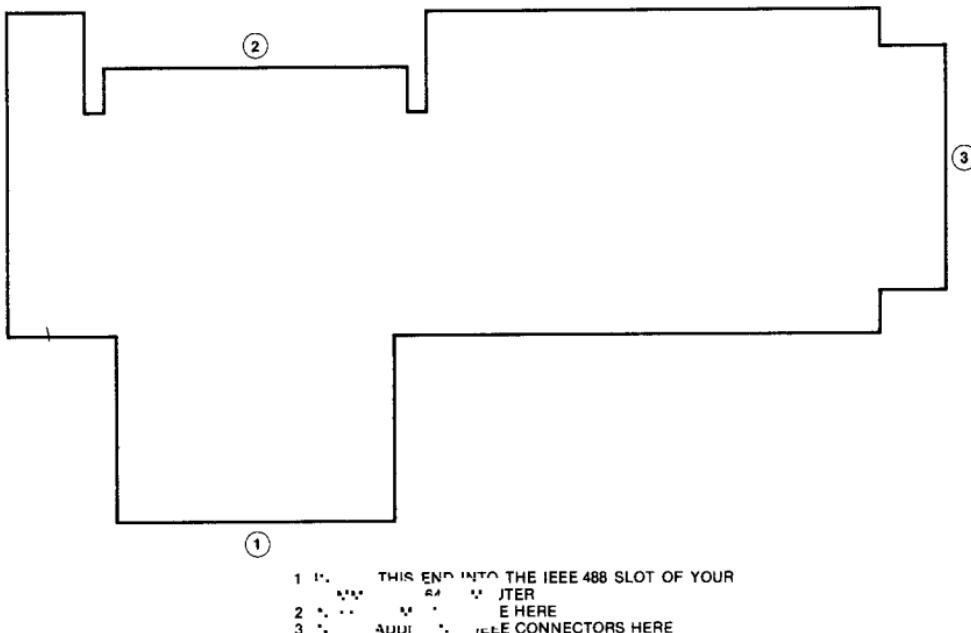


Figure 2.2 IEEE Interface Cartridge Diagram

2.3 CONNECTING DISK DRIVES

The method you use to connect your disk drives depends on the types of drives you use. You can use either a VIC series disk drive (like the 1541) or a CBM series single or dual disk drive (like the 4040) with your Commodore 64.

You don't have to write any special code to use your disk drives under CP/M. The system accesses your disk drives as Drive A and Drive B, regardless of which type of drive you're actually using.

If you use a single disk drive, CP/M uses Drive A and uses a virtual drive for Drive B (CP/M will prompt you to change the physical disk in the drive when you ask for Drive B). If you're using a CBM series dual drive, CP/M uses Drive A and Drive B.

2.3.1 Connecting VIC 1541 Disk Drives

You can use one VIC 1541 disk drive. Like all Commodore peripherals, the VIC 1541 disk drive can be "daisy chained." That is, you can connect your VIC disk drive to a VIC printer.

Connect the single VIC disk drive to the *serial port* (marked 8 in the diagram in Figure 2.1). For full details on connecting a VIC 1541 disk drive to your Commodore 64, see the manual that comes with the drives.

If you're also using a VIC 1525 printer, connect the printer to the connector in the back of your VIC 1541 disk drive.

2.3.2 Connecting CBM Series Disk Drives

When using CBM series peripherals (like the CBM 4040 disk drive or the CBM 4022 printer), you need to connect your peripherals to the IEEE interface cartridge. Figure 2.2 shows a diagram of the IEEE interface cartridge.

You can daisy chain your CBM printer to your CBM disk drive. For more details on connecting your CBM disk drive, see the manual that comes with your IEEE interface cartridge.

CHAPTER 3

USING YOUR COMMODORE 64 PERIPHERALS FROM CP/M

- Printer Interface
- The Commodore 64 Serial Interface
- The IEEE Interface Cartridge
- Daisy Chaining Peripherals
- The Commodore 64 User Port

CP/M, as implemented on your Commodore 64, can access any standard Commodore 64 peripheral (except the RS-232 port and the modem) using standard CP/M device access protocols. This involves calls to the appropriate CP/M BDOS functions. (You can also call the BIOS directly, although this is not recommended.)

The actual peripheral interface drivers reside in the CP/M BIOS. This special BIOS, unique to your Commodore 64, is in two parts. One part executes under the Z80 add-on processor and the other under the 6510 main processor.

Peripheral device access is set up through a series of parameters by the Z80 part of the BIOS. The actual device access is carried out by the 6510 part of the BIOS operating in Commodore 64 native mode.

You must configure CP/M—using the CONFIG utility—so that it knows what kind of printer you have and how many disk drives you have. If you change the type of printer or the number of disk drives on the system, you must use the CONFIG utility to inform CP/M of the change.

3.1 PRINTER INTERFACE

CP/M must know what type of printer you have. Generally you will have a VIC 1515, VIC 1525, or CBM 4022 printer. For purposes of the CONFIG utility, the 1515 and 1525 are the same, and the 4022 represents any CBM series printer.

The VIC 1515 and 1525 printers use the standard Commodore 64 serial bus. The 4022 printer (or any other CBM series printer) requires the optional IEEE interface cartridge.

Once you have properly attached the printer to your Commodore 64 and have run the CONFIG utility under CP/M, you can print using programs that run under CP/M or using standard CP/M BDOS calls from Z80 Assembler language programs.

3.2 THE COMMODORE 64 SERIAL INTERFACE

Your Commodore 64 comes standard with a bit serial interface through which you communicate with the Commodore 64 disk drives and printers. Access to the Commodore 64 serial interface is handled automatically under CP/M.

If you attach a nonstandard device to the Commodore 64 bit serial interface, you must prepare code to handle that device. The actual device handling code must execute in Commodore 64 native mode (under the 6510 main processor). Of course, you also need device handling code to run under the Z80, controlling execution of the native mode device-handling routine.

3.3 THE IEEE INTERFACE CARTRIDGE

If you want to connect your Commodore 64 to IEEE bus compatible devices, you can do that using the *IEEE interface cartridge*.

The IEEE interface cartridge plugs into the cartridge slot on the rear of your Commodore 64. The interface cartridge includes a slot for plugging in your Z80 cartridge. (See the instructions that come with your IEEE interface cartridge.)

The interface cartridge allows you to attach Commodore's own IEEE-compatible peripherals. These more capable, more expensive peripherals are usually available only for Commodore's business computers. The IEEE interface cartridge also provides a link to a multitude of IEEE-bus-based products. For example, many industrial and scientific instruments and devices are controlled using the IEEE bus protocols. With the IEEE interface cartridge, your Commodore 64 can control and collect data from these devices.

NOTE: If you do acquire the IEEE interface cartridge, you will have 44K—NOT 48K—available for CP/M. Be sure to generate a 44K version of CP/M before you install the IEEE interface cartridge.

If you are also installing IEEE bus peripherals, especially disk drives, remember to run the CONFIG utility on your 44K CP/M, informing it of your new peripherals.

3.4 DAISY CHAINING PERIPHERALS

The advanced architecture of the standard Commodore 64 serial bus and of the Commodore IEEE serial bus permits peripherals to be linked to one another in a "daisy chain."

Daisy chaining of peripherals means that you need not buy another interface card or connector every time you add a peripheral to your Commodore 64. The peripherals simply connect to each other to be accessed through a single port on your Commodore 64.

You can daisy chain VIC peripherals on the standard Commodore 64 serial bus or CBM series peripherals through the IEEE interface cartridge, as shown in Figure 3.1.

VIC PERIPHERALS SYSTEM

(Uses Standard Commodore 64 Serial Port)

Computer → VIC Disk Drive → VIC Printer

CBM PERIPHERALS SYSTEM

(Requires IEEE Interface Cartridge)

Computer → CBM Dual Disk Drive → CBM Printer

or

Computer → CBM Printer → CBM Dual Disk Drive

Figure 3.1 Daisy Chaining Peripherals.

NOTE: You can also attach the single drive (2031) version of the CBM 4040 disk drive to the IEEE interface cartridge on your Commodore 64.

3.5 THE COMMODORE 64 USER PORT

Your Commodore 64 user port can accommodate some useful optional devices. Most interesting from CP/M are the VICMODEM and the RS-232 communications cartridge.

If you acquire one of these cartridges and you want to access it from CP/M, you must write the processing code for execution in native mode under the 6510 main processor. This is necessary because these cartridges generate non-maskable interrupts which must be handled by the 6510 processor.

You can gain access to special code for handling these cartridges through BIOS65 function codes 7, 8, or 9. (See the discussion of the CP/M BIOS in Chapter 6 for details on using these function codes.)

In designing this code, you should consider receiving a certain number of characters—say 128 or 256—into a shared buffer. When you have received these characters, inform the device you are communicating with that you are not ready to receive data. You can then safely switch control from the 6510 main processor to the Z80, which can do whatever is required with those characters.

For detailed information on programming for the RS-232 port, see the *Commodore 64 Programmer's Reference Manual*.

13.

CHAPTER

4

GETTING STARTED

- Bringing CP/M onto Your Commodore 64
- The COPY Utility
- The CONFIG Utility
- Generating a New CP/M System with SYSGEN

This chapter tells you how to start using CP/M on your Commodore 64. Read it *carefully*. It's very easy to bring CP/M onto your computer, but you should be sure that you understand the information in this chapter before you start CP/M or run any programs under it.

In this chapter you will learn:

- how to load and run your CP/M system
- how to format new disks and make backup copies of your system
- how to use the special Commodore 64 CP/M utilities
- how to generate a new version of CP/M
- how to use the special Commodore 64 keyboard under CP/M

The distribution 44K version of CP/M assumes that you are using the IEEE interface cartridge. If you don't have the IEEE interface cartridge, you can generate a 48K version of CP/M by following the instructions in Section 4.4.

4.1 BRINGING CP/M ONTO YOUR COMMODORE 64

It is easy to bring CP/M onto your Commodore 64. Before you load CP/M, be sure that you've correctly installed your Z80 cartridge and your disk drive(s) and printer. If you haven't done this, read Chapter 2 for installation instructions.

After installing your Z80 cartridge and peripherals, follow the instructions in Section 4.1.1 to load your CP/M system. Once you've loaded CP/M and made copies of the system disks for backup, you're ready to try any of the commands in Chapter 5.

NOTE: Remember to make copies of your CP/M disks before you do any other processing. You need a backup copy of the disks that you purchased.

4.1.1 Starting CP/M

To bring CP/M onto your Commodore 64 system, you start the computer and load the CP/M system. Just follow these easy steps and *make a backup copy of your system disks right after you get CP/M to start for the first time*:

1. Turn on your equipment (peripherals and computer). Your Commodore 64 will print its usual "sign on" message:

***** COMMODORE 64 BASIC V2 *****

64K RAM SYSTEM 38911 BASIC BYTES FREE

READY.

2. Put the disk marked Commodore CP/M®*V.64 into your disk drive. This disk contains your CP/M system.
3. Your Commodore 64 is in native mode. Type the following:

LOAD "*",8 <CR>

or

LOAD "CPM", 8

4. Your Commodore 64 reads the disk and answers:

SEARCHING FOR * (or CPM instead of *)

LOADING

READY.

5. The Commodore 64 segment of CP/M is now loaded into your computer. To load the Z80 segment and begin executing CP/M, type:

RUN <CR>

6. Your Commodore 64 now reads the disk again to load the CP/M system into your Z80. While it is loading CP/M, your computer will print a row of 27 asterisks (*) across the top of the screen. When CP/M is loaded, your Commodore 64 will print:

COMMODORE 64 nnK CP/M vers 2.2

Copyright © 1979, Digital Research

Copyright © 1982, Commodore

A>

7. Your CP/M system is now loaded and ready to run. Enter the following CP/M command to get a list of the files on your CP/M disk:

DIR <CR>

CAUTION! BEFORE PROCEEDING, MAKE A BACKUP COPY OF YOUR CP/M DISKS!

4.1.2 Making Copies of Your CP/M System Disk

Now that you've started CP/M, you *must* make backup copies of your system disks. It is bad practice to use the disks that you purchased as your standard operating disks. You could accidentally destroy the disk and then you would not be able to run your CP/M system.

So, *make a backup copy and use the copy as your CP/M system disk*. After you make the backup copy, *store your original disk in a cool, dry place, away from magnetic fields*.

To make your backup copy:

1. Use the COPY utility on your CP/M disk to format a new disk. The COPY utility is discussed in detail in Section 4.2.
2. Then use the COPY utility to copy your CP/M disk to the backup disk. The COPY utility prompts you along the way, depending on the number of drives you're using. Just follow its instructions.
3. Store your original disks in a *safe* place, somewhere cool, dry, and away from magnetic fields.

4.2 THE COPY UTILITY

The COPY utility is a special Commodore 64 CP/M utility that allows you to:

- FORMAT a diskette for use with CP/M.
- Make a BACKUP of a CP/M diskette.
- Copy the CP/M SYSTEM TRACKS from one diskette to another.

You should use this utility to make a backup copy of your CP/M system disks as soon as you get CP/M up and running. Each COPY utility function is described in a separate section below.

To load the COPY utility, enter:

COPY<CR>

CP/M loads the COPY.COM file and writes:

COMMODORE 64 COPY UTILITY 1.0

1. FORMAT DISK
2. BACKUP DISK
3. COPY SYSTEM TRACKS ONLY
4. EXIT

PLEASE CHOOSE FUNCTION (1-4)

You then choose which COPY utility function you want to use and answer the questions that COPY asks.

4.2.1 Formatting a Disk with the COPY Utility

You must *format* a diskette before you can write any information on it. You must format disks that you'll use under CP/M with the COPY utility.

You format disks when:

- You get new disks and you want to prepare them to be used with CP/M.
- You want to *erase all* of the information currently on a disk.

To use the COPY function to format disks, you enter 1 as follows:

...COPY utility messages...

PLEASE CHOOSE FUNCTION (1-4) 1

FORMAT DISK UTILITY

INITIALIZES DISK FOR CP/M

CAUTION! FORMAT ERASES ALL DATA

PLACE DISK TO BE FORMATTED IN

DRIVE 0 AND PRESS ENTER

OR

PRESS SPACEBAR TO RETURN TO MENU

Now, *remove your system disk from the drive* and place the new disk (the one that you want to format) into the drive.

CAUTION! REMEMBER THAT YOU MUST REMOVE YOUR SYSTEM DISK
OR ELSE YOU WILL ERASE YOUR SYSTEM DISK!!

COPY now writes formatting information to your disk. Any information on the disk will be erased and all of the tracks are made available for data. No files remain on the disk after you run COPY's FORMAT. COPY writes these messages during the formatting:

FORMATTING DISK, PLEASE WAIT...

FORMAT COMPLETE

PRESS ANY KEY TO CONTINUE

You can now format another disk, copy information to your newly formatted disk, or exit back to CP/M, depending on your answer. If you want to format another disk, you need to insert the disk to be formatted into the drive. If you want to copy information, follow the instructions from COPY. If you're exiting back to CP/M, you should put your CP/M system disk into the drive.

NOTE: Remember that COPY erases all information from the disk when you use the COPY FORMAT option.

4.2.2 Creating a Disk Backup with the COPY Utility

You can also use the COPY utility to make backup copies of an entire diskette. While making a backup copy, COPY uses a master disk and a slave disk. The *master disk* is the disk that you want to make a copy of (the original disk); the *slave disk* is a formatted disk that will be written to (the copy).

If you are using a single-drive system, the COPY utility will prompt you to insert the master or slave disk into the drive. Be careful when making copies of a disk. Keep track of your master disk so that you don't accidentally copy garbage over your information (and erase your master disk in the process).

To use COPY's BACKUP function, enter a 2 in response to the "choose function" message and follow the instructions from COPY:

PLEASE CHOOSE FUNCTION (1-4) 2
DISK BACKUP UTILITY
THE ENTIRE MASTER DISK IS
COPIED TO THE SLAVE DISK
INSERT MASTER DISK IN DRIVE 0
PRESS RETURN (OR SPACEBAR FOR MENU)

Now insert the disk that you want to copy *from* into the disk drive. If you decide that you don't really want to copy your disk, simply press the **SPACE** bar and COPY returns to its original menu.

Once the master disk is ready, press the **RETURN** key. COPY then reads a number of sectors from the disk into memory and writes:

INSERT SLAVE DISK IN DRIVE 0
PRESS RETURN

Put the disk you want to copy *to* into the drive and press the carriage return. *Be careful to keep the master and slave disks in order.*

COPY now writes the information from memory onto the

slave disk and then asks that the master disk be replaced in the drive. This alternating master/slave disk placement will continue until the entire master disk is copied onto the slave disk. At that time, COPY returns to its main menu.

4.2.3 Copying the System Tracks with the COPY Utility

You can copy the CP/M system tracks to another disk through the COPY system track copy function. This function copies only the system tracks, not any other information, from a master disk to a slave disk.

You need the CP/M system tracks on any disk from which you intend to "warm start" CP/M (start CP/M without having to reinsert the system disk). You may want to copy the system tracks to a disk containing a program that you will run often. That way, when you hit a **CTRL** -C to warm start CP/M, you don't have to replace the disk with your system disk.

To copy the system tracks using COPY, enter 3 for your selection from COPY's main menu. Then follow the instructions:

PLEASE CHOOSE FUNCTION (1-4) 3
SYSTEM TRACK COPY UTILITY
COPIES SYSTEM TRACKS FROM MASTER DISK
TO SLAVE DISK
INSERT MASTER DISK IN DRIVE 0
PRESS RETURN (OR SPACEBAR FOR MENU)

The disk with the COPY utility contains the CP/M system tracks (otherwise, you wouldn't have been able to start your system). Simply press the **RETURN** key or, if you really don't want to make a copy, press the **SPACE** bar.

When you press the **RETURN** key, COPY reads the system tracks into memory and then writes:

INSERT SLAVE DISK IN DRIVE 0
PRESS RETURN

Remove the master disk from the drive and insert the disk on which you want the system tracks copied into the drive. When you press the **RETURN** key, COPY will write the CP/M system tracks (tracks 0 and 1) to the disk in the drive. After the system tracks are written, COPY returns to its main menu.

4.3 THE CONFIG UTILITY

You use the Commodore CP/M CONFIG utility to *change* the current I/O configuration for your CP/M system. Commodore provides the CONFIG utility so that you can add peripherals to your CP/M system quickly and easily.

CP/M needs to know what peripherals you're using. For example, if you're using only a single disk drive, CP/M will prompt you to change the diskette in the drive when you log to another disk. If you're using two drives, a properly configured CP/M will simply use the second physical drive.

NOTE: You CANNOT mix VIC (serial) peripherals and CBM (IEEE interface) peripherals on the same system.

Each of the CONFIG changes is described in a separate section below. To use the CONFIG utility, you enter:

CONFIG <CR>

CP/M then loads the file called CONFIG.COM and writes:

COMMODORE 64 I/O CONFIGURATION UTILITY

THE CURRENT I/O ASSIGNMENTS ARE:

NUMBER OF DRIVES: 1

PRINTER TYPE: 1515

INITIAL CAPS MODE: ON

DO YOU WISH TO:

- 1. CHANGE NUMBER OF DISK DRIVES**
- 2. CHANGE PRINTER TYPE**
- 3. CHANGE INITIAL CAPS MODE**

- 4. CHANGE FUNCTION KEY ASSIGNMENTS**
- 5. CHANGE KEY CODES**
- 6. SAVE CURRENT I/O SETUP ON DISK**
- 7. RETURN TO CP/M**

PLEASE ENTER SELECTION (1-7)

You simply select the type of change that you want to make and answer the questions that CONFIG asks. CONFIG makes all the necessary changes to your CP/M system, for both the Commodore 64 native code and the Z80 code. Adding or changing peripherals to your Commodore 64 CP/M system is as easy as running CONFIG and answering the questions.

4.3.1 Using CONFIG to Change the Number of Disk Drives

The CP/M system that you receive assumes that you are using a single disk drive. You may actually have the CBM 4040 dual disk drives. CONFIG toggles back and forth between one and two disk drives.

To change the number of drives, you run CONFIG like this:

CONFIG<CR>

when the CONFIG Messages are printed, choose selection 1.

CONFIG then processes your answer and changes the number of drives available to CP/M. If you originally had one disk drive, CONFIG prints:

COMMODORE 64 I/O CONFIGURATION UTILITY

THE CURRENT I/O ASSIGNMENTS ARE:

NUMBER OF DRIVES: 2

PRINTER TYPE: 1515

INITIAL CAPS MODE: ON

DO YOU WISH TO:

rest of CONFIG messages...

PLEASE ENTER SELECTION (1-7)

If you had two disk drives when you started CONFIG, you will see this for the number of drives:

NUMBER OF DRIVES: 1

4.3.2 Using CONFIG to Change the Printer Type

Your original CP/M system assumes that you will be using a VIC 1515 or (1525) printer. You may want to add a CBM 4022 (or other CBM) printer. CONFIG toggles back and forth between 1515 and 4022 printer types.

To change the printer type, you run CONFIG like this:

CONFIG<CR>

when the CONFIG Messages are printed, choose selection 2.

CONFIG then processes your answer and changes the printer type. If you originally had a VIC 1515 printer, CONFIG prints:

COMMODORE 64 I/O CONFIGURATION UTILITY

THE CURRENT I/O ASSIGNMENTS ARE:

NUMBER OF DRIVES: 1

PRINTER TYPE: 4022

INITIAL CAPS MODE: ON

DO YOU WISH TO:

rest of CONFIG messages...

PLEASE ENTER SELECTION (1-7)

If you had a CBM 4022 printer when you started CONFIG, you get this for the printer type:

PRINTER TYPE: 1515

4.3.3 Using CONFIG to Change the Initial Caps Mode

Your original CP/M system assumes that you will be using the all caps mode (all upper case letters when you press the

keys). CONFIG toggles back and forth between initial caps ON and OFF.

With initial caps ON, you get only upper case letters. With initial caps OFF, you get upper and lower case letters. Remember that you can also toggle between caps ON and OFF at any time by pressing the **C** key.

To change the initial caps mode, you run CONFIG like this:

CONFIG<CR>

when the CONFIG Messages are printed, choose selection 3.

CONFIG then processes your answer and changes the printer type. If you originally had initial caps ON, CONFIG prints:

COMMODORE 64 I/O CONFIGURATION UTILITY

THE CURRENT I/O ASSIGNMENTS ARE:

NUMBER OF DRIVES: 1

PRINTER TYPE: 1515

INITIAL CAPS MODE: OFF

DO YOU WISH TO:

rest of CONFIG messages...

PLEASE ENTER SELECTION (1-7)

If you had initial caps OFF when you started CONFIG, you will see this:

INITIAL CAPS MODE: OFF

4.3.4 Using CONFIG to Change the Function Key Assignments

Your CP/M system loads initial values into the eight Commodore 64 function keys. You can change any of these function key values through CONFIG.

If you save the new I/O configuration to disk, the new values will be loaded into the function keys when you next start CP/M. If you don't save the new configuration to disk,

the function keys are loaded with the new values but are reset to the original values when you next start CP/M.

To change the function key values, you run CONFIG like this:

CONFIG<CR>

when the CONFIG Messages are printed, choose selection 4.

CONFIG then prints:

F1: "DIR"<CR>
F2: "DIR B:"<CR>
F3: "STAT *.*"<CR>
F4: "STAT B:*.*"<CR>
F5: "COPY"<CR>
F6: "CONFIG"<CR>
F7: "DDT"<CR>
F8: "DDT"

ENTER FUNCTION KEY NUMBER (1-8)

TO CHANGE PRESET VALUES.

ENTER 9 TO LEAVE FUNCTION

KEY UTILITY.

To change function key 8 to "PIP<CR>", use CONFIG like this:

ENTER FUNCTION KEY NUMBER (1-8) 8

TYPE IN TEXT USING "RETURN"

OR "CTRL-Z" AS TERMINATOR

F8: "PIP<RETURN KEY>"

ENTER FUNCTION KEY NUMBER (1-8) 9

This changes the value in function key 8 to PIP<CR> while you are using CP/M.

If you end your new key entry with a **CTRL -Z**, instead of a **RETURN**, the function key is loaded *without a terminating carriage return*.

If you want to save this value as the initial value for function key 8 for the next time you start CP/M, you must also choose CONFIG selection 6 to save the new I/O configuration to disk. Otherwise, the next time you boot CP/M, your function keys will contain the same initial values as they did this time; any changes you made through CONFIG will be lost.

4.3.5 Using CONFIG to Change the Key Codes

Your CP/M system loads a table containing the hexadecimal values for each of the Commodore 64 keyboard keys. You can change any of these function key values through CONFIG. Appendix D contains a table of ASCII characters, hexadecimal values, and the Commodore 64 keyboard characters.

NOTE: Be careful if you change the alphabetic characters. You may not be able to recover if you change characters that you need to run CP/M programs or commands. If you SAVE the character changes on disk (through CONFIG selection 6), you may have trouble recovering at all.

To change the keyboard key values, you run CONFIG like this:

CONFIG<CR>

when the CONFIG Messages are printed, choose selection 5.

CONFIG then prints:

PRESS KEY TO EXAMINE KEY CODE
TO CHANGE KEY CODE, ENTER DATA IN
HEXADECIMAL AFTER "CHANGE TO"
TO EXIT KEY CODE MODE, TYPE "RETURN"
TWICE AFTER "PRESS KEY"
TO KEEP CURRENT KEY CODE, TYPE
"RETURN" AFTER "CHANGE TO"

PRESS KEY (you press the "Q" key)
IS 51 IN CAPS MODE—CHANGE TO 71

You just changed the capital *Q* (hexadecimal value 51) to a lower case *q* (hexadecimal value 71). You won't be able to enter a capital *Q* unless you use CONFIG to change it back again. If you don't want to make any more changes, just press the **RETURN** key twice to return to the CONFIG main menu.

4.3.6 Using CONFIG to Save the New I/O Setup

Once you've made changes to your I/O assignments through CONFIG, you may or may not want to save the new assignments. You will probably want to save the new information if you've changed the disk drive or printer data. You may not want to save the I/O information if you've changed the function key assignments for a special run and don't want the new values to be used the next time you start CP/M.

To save your new I/O assignments to disk, select 6 from the CONFIG menu. CONFIG then writes information to your CP/M system data and the next time you start CP/M, the new information will be used.

Remember, you can make changes that only affect the current CP/M version (the one in memory when you make the changes) if you want some special-purpose alterations. If you don't select CONFIG choice 6, the alterations will not be in effect the next time you load CP/M.

4.4. GENERATING A NEW CP/M SYSTEM WITH SYSGEN

You can generate CP/M on your Commodore 64 to run in any memory size from 20K to 48K. If you are using the standard Commodore 64 serial bus to attach your peripherals—disk and printer—you should use a 48K version of CP/M. If you acquire the IEEE interface cartridge, you must

use a 44K version of CP/M. You may also want to generate a smaller version of CP/M if you need space to load a 6510 routine that you are invoking from a CP/M program.

NOTE: If you don't intend to save the new CP/M on an existing CP/M disk, the first step in generating a new version of CP/M is to format a disk. Disk formatting is discussed in detail in Chapter 4 under the COPY utility

Once you have the disk formatted for CP/M, you must use the COPY utility to copy the System tracks from one of your existing CP/M disks to the new disk. This operation places the 6510 loader into its proper place

Once you have properly initialized your disk, you use a series of CP/M utility programs to generate the new version of CP/M and save it on your disk. These utilities are:

- MOVCPM
- SAVE
- SYSGEN

These utilities have a number of options on their use. In the following discussions, we consider only the most frequently used options. A more detailed exploration of all the utility options is found in Chapter 5.

In general, you will be generating either a 44K or a 48K version of CP/M on your Commodore 64. We'll use generating a 48K version as an example. Other versions are generated in exactly the same way but with a different memory size specified.

4.4.1 Relocating CP/M

MOVCPM is a system utility that *relocates* the CP/M operating system to execute in any memory size you specify.

To generate a 48K version of CP/M, you enter:

MOVCP.48 *

where:

48 is the memory size

* instructs MOVCPM to leave the relocated CP/M image in memory.

MOVCPM responds with:

CONSTRUCTING 48K CP/M vers 2.2
READY FOR "SYSGEN" OR
"SAVE 37 CPM48.COM"

This is the end of MOVCPM execution. You follow this by running either the SYSGEN or the SAVE utility. Normally, you use the SYSGEN utility. Use the SAVE utility if you want to "patch" the operating system.

NOTE: Your Commodore 64 version of MOVCPM properly adjusts all of the CP/M code, including the BOOT80 and BIOS80 programs. You do NOT have to reassemble these programs and use DDT to patch them into the new version of the operating system as you do on less capable CP/M systems.

Execution of MOVCPM as shown above leaves a copy of the relocated CP/M operating system, including BOOT80, CCP, BDOS, and BIOS80, in the Transient Program Area (TPA) ready to be saved as a file on your disk or written directly to the system tracks. (To learn more about CP/M structure, read Chapter 6.)

If you choose to save a copy, you can SYSGEN it later.

4.4.2 Saving the New System

The SAVE built-in command writes the content of the TPA (in this case, a copy of your newly relocated CP/M) to the specified disk file. The MOVCPM command tells you how many 256-byte pages to save. MOVCPM on your Commodore 64 always tells you to save 37 pages.

To save your relocated verion of CP/M, enter:

SAVE 37 CPM48.COM

This command will write the relocated CP/M to a file named "CPM48.COM". This is a full copy of a 48K version of the CP/M operating system. You can use the saved copy of CP/M in subsequent SYSGEN commands or for direct alteration under DDT.

4.4.3 Using SYSGEN

A version of CP/M that you have saved in a disk file cannot be directly executed. You must first SYSGEN it to the system tracks of a CP/M disk.

SYSGEN writes the specified version of the CP/M operating system to the proper locations on the system tracks of a CP/M disk. SYSGEN can read a version of the operating system from one of two places:

- The system tracks of diskette.
- A memory image of CP/M loaded into the TPA by the MOVCPM or DDT programs.

If you are using a file containing a SAVED version of CP/M, you must first bring it into memory with the DDT program. In our example, you enter:

DDT CPM48.COM

then exit from DDT with a G0 command.

If your source for the new version of CP/M is the system tracks of your disk or a memory resident image, you simply enter:

SYSGEN

and SYSGEN responds with:

**SOURCE DRIVE NAME
(OR RETURN TO SKIP)**

At this point you can specify the drive (A or B) whose system tracks you want read. If you simply hit the **RETURN** key, SYSGEN assumes that a copy of CP/M is already loaded into the TPA.

Whatever way you get the CP/M version loaded into memory, SYSGEN will ask you:

**DESTINATION DRIVE NAME
(OR RETURN TO REBOOT)**

If you respond with a destination drive name (A or B), SYSGEN will write CP/M to the system tracks of that drive.

If you simply hit the **RETURN** key, SYSGEN will reboot from whatever disk is currently in Drive A.

NOTE: IF you SYSGEN a CP/M system that is different in size from the one you ran the SYSGEN under, DO NOT try to reboot from a disk containing the new system. This will cause the operating system to crash. Re-insert the disk from which you loaded SYSGEN before you tell it to reboot

To test a newly SYSGENed version of CP/M, you'll have to start it from native mode on your Commodore 64.

4.5 THE COMMODORE 64 KEYBOARD AND SCREEN WITH CP/M

The Commodore 64 has a full typewriter-style keyboard that behaves as such when you are running CP/M. All of the CP/M **CTRL** shifted control codes operate as they are supposed to. In addition, the **STOP/RUN** key on your Commodore 64 keyboard acts like a **CTRL**-C to produce a warm boot of the CP/M operating system.

In the Commodore 64 version of CP/M, you have the option of using only upper case or both upper and lower case. You *toggle* between them using the Commodore **C** key on the keyboard. You can use the CONFIG utility to tell CP/M to start with upper only or with upper/lower case enabled.

Table 5.3 contains a complete list of the **special CP/M control keys**. These are identical to those defined for CP/M, with a few additional functions taken from your Commodore 64 keyboard.

The Commodore 64 graphics characters and screen color control are not generally available to CP/M. But there is no reason that you can't store values into your Commodore 64 6567 Video Interface Chip's control registers just as you do when running in native mode. To arrive at the proper addresses for the control registers, examine Section 6.1.3, which explains the address mapping between the Z80 and 6510 processors.

The control values that you insert into the registers are the same as those you use in native mode. As an example, suppose you want to use your Commodore 64 graphics character set. Running in native mode, you simply touch the graphics key to switch on the graphics character set. From a CP/M program running under the Z80, you have to control it directly through a store into the appropriate 6567 control register.

The character set selection control register is at

6510 address 53,272 decimal or \$D018 hexadecimal

which converts to the Z80 address base:

Z80 address 49,176 decimal or \$C018 hexadecimal

The character set control register normally contains a \$17. To invoke the graphics character set, you must store a \$15 in the register:

```
MVI A,15H      ;LOAD THE CONTROL VALUE IN A  
STA 0C018H      ;STORE $15 IN THE 6567 CONTROL REGISTER
```

Once you've executed this code, the graphics character set is available to you. This operation *does not* change the character codes reaching your CP/M programs from the keyboard—only the display is changed.

You can use the same technique to alter colors, activate Sprites, or even play music through your Commodore 64 6581 Sound Interface Device. If you want to store characters directly into the screen matrix, remember to store Commodore 64 screen codes, *not* ASCII codes.

To use the dynamic features of your Commodore 64 from CP/M, all you have to do is remember that the 6510 addresses for the control registers must be reduced by \$1000 (4096) in your CP/M programs.

CHAPTER 5

CP/M OPERATION

- How to Use This Chapter
- CP/M File Naming Conventions
- Input/Output Hardware Conventions
- CP/M Command Structure
- CP/M Commands

This chapter tells you how to use CP/M on your Commodore 64. It is *not* a detailed lesson on CP/M and its internal workings. It is an introduction to CP/M's conventions and notations, and an introduction to the commands that you can use under CP/M.

If you want detailed information on the internal workings of CP/M, get one of the many fine books listed in Appendix B, the Bibliography. That level of detail is far beyond the scope of this book.

5.1 HOW TO USE THIS CHAPTER

Section 5.2 describes the CP/M file naming conventions. You should follow some reasonable conventions for naming your own files so that you can easily identify their contents.

Section 5.3 discusses the CP/M disk identification conventions. CP/M uses disk A and disk B; your Commodore 64 identifies these disks as disk 0 and disk 1. Section 5.3 also tells you how CP/M differs when you use the VIC 1541 or the CBM 4040 drive.

Section 5.4 describes the CP/M command structure and gives a table of all the CP/M commands that you get with your Commodore 64 CP/M system.

Section 5.5 provides *brief* descriptions of the CP/M commands. If you need more detail, see one or more of the CP/M books listed in Appendix B. Some books are more technical than others, so find the one with the amount of detail you are most comfortable with.

5.2 CP/M FILE NAMING CONVENTIONS

When you are using CP/M on your Commodore 64, you should follow the CP/M file naming conventions. CP/M files have the general format:

[DISK-ID:] FILENAME [.TYPE]

where:

DISK-ID is an optional disk drive identifier (such as A or B) that is needed when you want to use a file not on the currently logged disk.

FILENAME is a one- to eight-character name used to identify your file to CP/M.

TYPE is an optional one- to three-character name used to further identify your file.

Some examples of CP/M filenames are:

A:SAMPLE.BAS	A BASIC sample program stored on the disk on Drive A.
MY.TXT	A text file.
PROGRAM.COM	A program that is executable.
10/25/82.DRY	A diary entry.

CP/M lets you use any alphabetic or numeric character in your file names, as well as some special characters. CP/M reserves a few of the special characters for its own use. You *cannot* use the following characters in a CP/M file name:

< > . , ; : = ? * []

With some software packages, files must be named with specific types, such as SUB for a SUBMIT file or ASM for an Assembly Language source file. Read the information with your software packages to see if you need to follow any naming conventions for that package's files.

Even if you don't have to follow any specific rules in naming your files, you should try to use reasonable naming conventions. In this way, when you get a directory listing (a list of all the files on a disk), you will have some idea of what's in the files.

A file named MORTGAGE.BAS is easier to recognize as the set of source statements for a BASIC program that calculates mortgage rates than a file named X127GY9.123. In other words, it makes sense to name your data files in ways that represent their contents. For example, a file named

01/15/83.DTA could contain the data you collected on January 15, 1983.

Since there are so many CP/M users (over 500,000 to date), certain standard filename types have been adopted. The most commonly used types are shown in Table 5.1.

Table 5.1 Commonly Used CP/M File Types

TYPE	FUNCTION OR CONTENTS
*.ASM	Assembly language source file
.BAK	Backup file
.BAS	BASIC program source file (for some BASIC interpreters like CBASIC)
*.COM	Directly executable transient program
.DAT	Data file
.DOC	Document or text file (required by some word processing packages)
*.HEX	File containing data in hexadecimal format; an Intel HEX format object code file
.INT	Output file from some compilers (CBASIC, JRT PASCAL) that contains intermediate code
*.LIB	Library file
.LST	Program listing (usually output from a language processor like a compiler, interpreter, or assembler)
.PRN	Print file (usually output from an assembler or compiler)
.PRT	Print file (usually output from an interpreter or compiler)

Table 5.1 Commonly Used CP/M File Types

TYPE	FUNCTION OR CONTENTS
.SRC	Source file from the CP/M User's Group
*.SUB	Command file for a SUBMIT run
.SYM	Symbol table file (generated by some compilers, assemblers, and interpreters)
.TEX	Text file (required by some word processors)
.TXT	Text file (required by some word processors)
*.\$\$\$	Either a temporary file or an improperly saved (and unusable) file

NOTE: Those filename types marked with an asterisk (*) must be adopted if you want to use associated software packages or system functions. That is, all CP/M directly executable programs must be named "filename.COM."

5.3 INPUT/OUTPUT HARDWARE CONVENTIONS

CP/M has certain conventions that must be followed when you are reading files from a disk or writing files to a disk.

The first disk drive physically attached to the system is called drive A. The next is drive B. When you are using a single 1541 disk drive, your Commodore 64 CP/M uses a slightly different way of telling which disk is in the drive (this is described in some detail below).

When you begin CP/M, you will be "logged" to drive A and you will see the prompt "A>" on your screen. This means that if you specify a filename in a command and you don't

specify a disk-id before the filename, the disk on drive A will be searched for the file.

You can log to drive B by entering the command:

B:

After entering the B: command, any filename that you specify without a disk-id preceding the filename will be read from or written to drive B.

You can change back and forth between drive A and drive B by simply entering the above command. You can tell which drive you're currently accessing by looking at the prompt: it will be **A>** when you're using drive A or **B>** when you're using drive B.

Your Commodore 64 CP/M can use either the VIC 1541 single disk drive or the CBM 4040 dual disk drive. Read the sections below that cover the type of disk drive you have attached to your Commodore 64.

5.3.1 Loading Programs from Disk: Single Drive

It is easy to load and run a CP/M program. You first place the program disk into your disk drive and then enter the filename followed by a carriage return, for example:

MYPROG <CR>

CP/M then goes to the currently logged disk and looks for the file called MYPROG.COM. If CP/M finds this file, the data in the file are read into the computer's memory and CP/M begins executing those instructions.

If the file is not found on the disk, then CP/M prints the filename followed by a question mark:

MYPROG?

In such cases, check to see if you have the correct disk in the drive, log to the correct disk, or correct the program name.

For a single-drive system, if you are logged to drive A and your program is on drive B, then remove disk A from the drive, insert disk B, and enter:

B:OTHERPGM <CR>

CP/M will first ask that the appropriate disk be placed in the drive by writing:

INSERT DISK B INTO DRIVE 0, PRESS RETURN

You should put the appropriate disk into the drive and press the **RETURN** key. CP/M will then search the disk for the file called OTHERPGM.COM, load the file, and run it.

5.3.2 Loading Programs from Disk: Dual Drive

When using the CBM 4040 dual disk drive, you don't have to physically change the disk in the drive when you want to log to another disk. Since there are two drives, you can insert two disks into the drive: disk A and disk B.

When you enter the B> command to log to disk B, CP/M will not ask you to insert a disk into the drive. Instead, CP/M will use the disk already in drive B.

If you want to change which disk is in a drive, you should change the disk and then tell CP/M that a different disk is in the drive by entering a **CTRL-C** command. This makes CP/M read the directory from the disk and keeps you from writing over information that you want to keep.

You must have the Commodore 64 IEEE interface cartridge when you use the CBM 4040 dual disk drive. You cannot plug the dual disk drive into the Commodore 64 without the interface cartridge.

5.4 CP/M COMMAND STRUCTURE

Your Commodore 64 CP/M system includes a Console Command Processor (CCP) through which you interact with CP/M. The CCP reads and interprets the commands you enter at the keyboard.

The CP/M commands are listed in Table 5.2 and described in some detail later in this chapter.

In general, the CP/M commands are of two types:

- *Built-in commands* which are a part of the CCP itself. Being part of the CP/M operating system, built-in commands are included whenever you load CP/M.
- *Transient commands* which are loaded into the Transient Program Area (TPA) from a disk and then executed. Transient commands reside on the disk as COM files.

Table 5.2 CP/M Commands

COMMAND NAME	BUILT-IN (B) or TRANSIENT (T)	COMMAND FUNCTION
<i>pgm-name</i>	T	Load and execute the program stored on the disk as file <i>pgm-name.COM</i> .
<i>x:</i>	B	Change the currently logged disk to disk <i>x</i> .
ASM	T	Load the CP/M assembler and assemble the specified program from the disk.
DDT	T	Load the CP/M debugger (DDT) and begin executing the debugger.
DIR	B	List the filenames in the disk directory.
DUMP	T	Dump the contents of the specified file to the screen in hexadecimal format.
ED	T	Load and execute the CP/M text editor program.
ERA	B	Erase the specified file(s) from the disk.

Table 5.2 (Continued)

COMMAND NAME	BUILT-IN (B) or TRANSIENT (T)	COMMAND FUNCTION
LOAD	T	Produce an executable (COM) file from an assembled (HEX) file.
MOVCPM	T	Recreate the CP/M system for the specified memory size.
PIP	T	Copy specified file(s).
REN	B	Rename the specified file.
SAVE	B	Save the contents of memory as the specified file on the disk.
STAT	T	Provide status information about specified files, no file, or all files, and list the number of available bytes remaining on the disk.
SUBMIT	T	Read the specified file and execute the commands in a batch processing mode.
SYSGEN	T	Create a new CP/M system diskette.
TYPE	B	Type the contents of the specified file onto the screen.
USER	B	Change the currently logged user number to the specified value.
XSUB	T	Allow the entering of data as well as CP/M commands in a SUBMIT file.

In addition to the commands listed in Table 5.2, your CP/M system includes a number of built-in *line editing*

commands. The CP/M line editing commands, shown in Table 5.3, have the general form:

CTRL -x

where:

CTRL means hold down the CONTROL key on your Commodore 64.

x is one of the keys on your Commodore 64 keyboard.

Table 5.3 CP/M Built-in Line Editing Commands

COMMAND	FUNCTION
CTRL -C or	Perform a CP/M <i>warm-start</i> .
RUN/STOP	
CTRL -E	Move to the beginning of the next line.
CTRL -H or	Delete one character and erase it from the screen.
DEL	
CTRL -J	Perform a carriage return and line feed.
CTRL -M or	Perform a carriage return.
RETURN	
CTRL -P	Toggle printer/console output. On first use, send all screen messages to the printer; on next use, send all screen messages to the screen.
CTRL -R	Repeat the current command line.
CTRL -S	Temporarily halt listing of data on the screen. Press any key to continue listing.
CTRL -U or	Cancel current command line.
CTRL -X	
C	Toggle between all upper case and upper/lower case letters. C is the Commodore key.

5.5 CP/M COMMANDS

This section gives you a brief description of the Commodore 64 CP/M commands. It is *not* intended to be a detailed description of how CP/M commands operate, nor does it attempt to describe every possible way you can use the CP/M commands.

If you need to learn how CP/M works or if you need more detail on how the commands work, you should purchase one or more of the excellent CP/M teaching texts on the market. Skim these books and pick those that present the information in a way that you can easily understand.

The following notation is used in describing the CP/M commands:

- *Underlined* words show arguments (parameters) which you replace with your own values.
- **BOLDFACE** keywords must be entered *exactly* as shown.
- A *vertical bar* (|) separates arguments where you may select any one of the list of arguments.
- *Square brackets* ([]) are used to show *optional arguments*. You select any or none of the arguments listed, depending on your needs.
- *Braces* ({ }) show that you *must* choose one of the arguments.

5.5.1 *pgm-name* (Load and Run a CP/M Program)

Format: [disk-id:]filename<CR>

where:

disk-id is an optional disk identifier.

filename is the name of the file containing the program to be loaded and run. Programs must be stored in files named *filename.COM*.

Description:

CP/M programs are stored in files named *filename.COM*. When you type the name of one of

these program files and hit the carriage return key, CP/M does the following:

1. Searches the currently logged disk or the disk specified by *disk-id* for the program file *filename.COM*.
2. Loads the program file into memory.
3. Begins executing the instructions in the program.

If the file is not found on the disk, CP/M prints a message like this:

FILENAME?

When you get this message, make sure you have the correct disk in the disk drive, that you've spelled the program filename correctly, and that the program is stored in a COM file.

Example 1:

To load and execute your program which is stored in the file MYPROG.COM, enter:

MYPROG <CR>

CP/M searches the currently logged disk for the file MYPROG.COM, loads the file, and begins executing the instructions. If the file is not on the disk, you will see the error message:

MYPROG?

Example 2:

You have a single drive system and are currently logged to disk A. You want to load and run the program XYZ from disk B. Enter the CP/M command:

B:XYZ <CR>

CP/M then responds with:

PLACE DISK B INTO THE DISK DRIVE AND HIT RETURN

Put the appropriate disk into the disk drive and press the **RETURN** key. Then, CP/M searches for the file named XYZ.COM, loads the file, and begins executing its instructions.

5.5.2 *x:* (Change the Currently Logged Disk)

Format: *disk-id:*

where:

disk-id is the disk identifier

Description:

Under CP/M, you are always "logged" to a disk. You can tell which disk CP/M is using by looking at the prompt message. If it's "A>", you're logged to disk A; if it's "B>", you're logged to disk B.

You can change the logged disk by entering:

DISK-ID:

CP/M then asks you to insert the appropriate disk into the disk drive and hit the carriage return. CP/M remembers which disk you're currently logged to and will request another disk if you ask for a file or program and use the *disk-id* qualifier.

Example:

You have a single drive system and are currently logged to disk A. You want to log to disk B. To do this, you would enter:

B: <CR>

CP/M then writes:

INSERT DISK B INTO DRIVE 0, PRESS RETURN

When you insert the disk into the drive and hit the carriage return, CP/M is logged to that disk. The CP/M prompt will now be:

B>

5.5.3 ASM

Format: **ASM** *filename* [.*parms*]

where:

filename is the name of the file containing the program to be assembled. The file *must* be named *filename.ASM*.

parms contains up to three characters specifying the drive(s) for the source file, HEX file, and PRN file.

Description:

The ASM command loads and executes the CP/M Assembler which processes 8080 instructions. The CP/M Assembler:

1. Assembles the assembly language statements contained in the file *filename.ASM*.
2. Generates an object file in hexadecimal format and places the object file in *filename.HEX*.
3. Produces a print file in *filename.PRN*.

The *parms* string is an optional character string which tells the assembler where to read and write its files. You can specify up to three characters in *parms*. Each character position has a special meaning:

- Position 1: The source drive for the file containing the assembly language statements.
- Position 2: The destination drive for the object (HEX) file.
- Position 3: The destination drive for the print (PRN) file.

If you specify a "Z" for positions 2 and/or 3, the assembler will not generate a HEX (position 2) or PRN (position 3) file. If you specify an "X" for position 3, the listing will appear on your screen instead of in a file. Table 5.4 lists the ASM error messages.

NOTE: CP/M was written for the Intel 8080 microprocessor. The Z80 processor in your Commodore 64 is compatible with the 8080 processor but offers a much larger instruction set, more internal registers, and other advantages.

If you want to use the full Z80 instruction set, you'll have to get an assembler that recognizes the Z80 instructions.

Table 5.4 ASM Error Messages

ERROR CODE	MEANING
D	Data error. The data element cannot be placed into the specified data area. For example, you cannot put the value 500 in a one-byte area.
E	Expression error. The assembler could not evaluate the expression.
L	Label error. The label is used out of context. This could be a duplicate label.
N	Not implemented. You tried to use a feature that is not implemented, such as using macros.
O	Overflow. The expression is too complicated to evaluate.
P	Phase error. A label's value changed between passes of the assembler.
R	Register error. The value specified as a register does not match the value needed by the op code.
S	Syntax error. The statement contains a syntax error and could not be evaluated.
U	Undefined label. You used a label which does not exist in the program.
V	Value error. There is an improperly formed operand in the expression.

Examples:

- ASM APROG.BBB Assemble the assembly language program contained in the file B:APROG.ASM and put the object file in B:APROG.HEX and the print file in B:APROG.PRN.
- ASM PGM2.BZZ Assemble the assembly language program contained in the file B:PGM2.ASM. Do not generate either the object (HEX) file or the print (PRN) file.
- ASM PGMFOR.AAX Assemble the assembly language program contained in the file A:PGMFOR.ASM. Put the object file (PGMFOR.HEX) onto Disk A. Print the listing on the screen.

5.5.4 DDT

Format: DDT [[disk-id:]filename[.type]]

where:

disk-id is an optional disk identifier.

filename.type is a valid CP/M filename for the file containing the information to be loaded and processed by DDT.

Description:

DDT is the CP/M Dynamic Debugging Tool which you can use to interactively test and debug programs. You can load *any* file into memory using DDT. If you load an executable file, you can directly control its execution from your console.

NOTE: You can also use DDT to look at a file in both ASCII and hexadecimal format.

DDT loads the file into the TPA (Transient Program Area) in memory. You can then use the commands shown in Table 5.5 to operate on the information in the TPA.

You must know 8080 assembly language instructions to use DDT. If you don't know the assembly language instructions, don't try to use DDT. Appendix B gives a list of some of the currently available Z80 assembly language books.

NOTE: DDT recognizes only the subset of Z80 instructions that is identical to the Intel 8080 microprocessor instruction set.

Table 5.5 DDT Commands

COMMAND	MEANING
As	Assemble. Begin entering assembly language instructions at address s.
D[s[,f]]	Display. Display the contents of memory in both hexadecimal and ASCII formats. Begin at address s and end at address f. If you don't specify f, 16 display lines are shown. If you don't specify s, the starting address is the current display address.
Fs,f,c	Fill memory. Fill memory with the hexadecimal byte c. Begin storing the byte c at location s and end at location f. You use the F command to fill a block of memory with one value, for example, all zeros or blanks.
G[s] [,b1[,b2]]	Go. Begin executing the instructions at location s with optional breakpoints at locations b1 and

Table 5.5 (Continued)

COMMAND	MEANING
	b2. If you don't specify location s, execution begins at the current address.
Hc1,c2	Hexadecimal sum/difference. Add (or subtract, depending on the signs) the hexadecimal constants c1 and c2.
Ifilename [.type]	Input. Insert the filename <i>filename.type</i> into the default file control block for the TPA. You must use an R command to actually read the file.
L[s[f]]	List. List the assembly language mnemonics beginning at address s and ending at address f. If you don't specify a value for s, the listing begins at the current address. If you don't specify a value for f, 12 lines are listed.
Ms,f,d	Move a block of information. Move the contents of a block of memory. Begin moving data from address s and end at address f. Move the information to address d.
R[o]	Read a disk file. Read the file whose filename and type are in the file control block into the program area beginning at offset o. You use an I command to set the file information in the file control block. If you don't specify an offset value, the file is read into memory beginning at address 100H.

Table 5.5 (Continued)

COMMAND	MEANING
Ss	Examine and modify memory values. DDT begins processing at location s. All addresses and their contents are listed. If you hit a carriage return, the contents are not changed. If you want to change the value, enter a new value before you hit the carriage return. To stop the listing, hit a period (.).
T[n]	Trace program execution. DDT traces execution and displays registers and flags for n steps. n may be 1 through 65535. If you don't specify a value for n, DDT executes and traces one statement.
U[n]	Untrace. This performs the same processing as the T command except that the registers and flags are not displayed for each step.
X[r]	Examine and modify CPU registers. The examine command lets you examine and optionally modify the contents of the CPU registers shown in Table 5.6. If you don't specify a value for r, all of the CPU registers are displayed in the format shown in Table 5.7.

Table 5.6 DDT CPU Registers/Status Flags

NAME	MEANING	VALUE
STATUS FLAGS:		
C	Carry flag	0/1
Z	Zero flag	0/1
M	Minus flag	0/1

Table 5.6 (Continued)

NAME	MEANING	VALUE
STATUS FLAGS:		
E	Even parity flag	0/1
I	Interdigit carry	0/1
REGISTERS:		
A	Accumulator	0-FF
B	BC register pair	0-FFFF
D	DE register pair	0-FFFF
H	HL register pair	0-FFFF
S	Stack pointer	0-FFFF
P	Program counter	0-FFFF

Examples:

DDT Loads DDT and waits for you to enter commands.

DDT PROG.COM Loads DDT and reads the file PROG.COM into the TPA (address 100H). DDT then waits for you to enter commands.

Table 5.7 DDT CPU Register/Flag Display Format

**CfZfMfEfIf A=bb B=dddd D=dddd H=dddd S=dddd
P=dddd inst**

where:

C, Z, M, E, and I are processor status flags shown in Table 5.6

A, B, D, H, S, and P are the registers shown in Table 5.6

f is a 0 or 1 flag value

bb is a byte value (0 through 255)

dddd is a double byte value

inst is the disassembled 8080 instruction at the location addressed by program counter (P)

5.5.5 DIR

Format: **DIR** [*disk-id:*] [*filename.type*]

where:

disk-id is an optional disk identifier.

filename is an optional valid one- to eight-character CP/M filename.

type is a valid one- to three-character CP/M file type. You need to specify a *type* if you use the *filename* parameter.

Description:

You use a **DIR** command to display the directory of files on a certain disk *disk-id*. If you don't supply a *disk-id* parameter, DIR lists the directory of the disk in the drive currently logged to the system.

You can use the CP/M wildcard (*) and (?) characters in your *filename* and *type* parameters. These characters are acted upon as follows:

- **question mark (?)**

Use a question mark (?) to represent a *single* character in a filename or type. DIR will use the ? to match on *any* character that occupies that position in the filename or type. For example,

DIR PGM?.COM

will display all files that have the first three characters PGM, any fourth character and the type COM. This format will match only files with names PGMy.COM. It will *not* match PGMyxx.COM.

- **asterisk (*)**

Use an asterisk (*) to represent an *entire* filename or type or the *remainder* of a filename or type. DIR will match on *any* characters in the positions indicated by the *. For example,

DIR PGM*.COM

will display all files that have the first three characters PGM, regardless of the length of the filename, and the type COM.

If you use a *disk-id* value, DIR will display only those files on the indicated disk. If you omit the *disk-id* value, DIR displays the files on the currently logged disk.

Examples:

DIR	Display the directory of the currently logged disk. The names of all files on the disk are shown.
DIR B:	Display the directory of Disk B.
DIR B:TEST.COM	Display the directory information for file TEST.COM on Disk B. You can use this form of the DIR command to check whether the file you want is on that disk.
DIR *.BAK	Display the information from the currently logged disk for all files which are of the type BAK.
DIR TEST*.BAK	Display the information from the currently logged disk for all files that are of the type BAK and whose filenames contain the first four characters TEST. This will display the files TEST.BAK, TEST1.BAK, TESTXXX.BAK, TEST1234.BAK, or any other file with the first four characters TEST and type BAK.
DIR TEST???.BAK	Display the information from the currently logged disk for all files that are of type BAK and have a four- to six-character filename beginning with the letters TEST. This will display the files TEST.BAK, TEST1.BAK, or TESTXX.BAK but will not display the file TEST1234.BAK.

5.5.6 DUMP

Format: **DUMP [disk-id:]filename.type**

where:

disk-id is an optional disk identifier.

filename is valid CP/M filename of the file whose contents are to be displayed.

type is a valid one- to three-character CP/M file type.

Description:

You use a **DUMP** command to display the contents of a file in hexadecimal format. The file information is shown on the screen.

Examples:

DUMP A:DATA.TST Dump the contents of the DATA.TST file on Drive A to the screen. The file information is shown in hexadecimal format.

DUMP MY.DTA Dump the contents of the MY.DTA file, which is on the currently logged disk, to the screen.

5.5.7 ED

Format: **ED [disk-id:]filename[.type] [[disk-id2:] [filename2[.type2]]]**

where:

disk-id is an optional disk identifier.

filename is the name of the file containing the data to be edited.

type is a valid CP/M file type for the file containing the data to be edited.

disk-id2 is an optional disk identifier needed when you want the edited file to be written to a disk other than the disk being edited.

filename2 is the name of the output file when you want the edited filename to differ from the original filename.

type2 is the type for the output file when you want the edited file to have a different type than the original file.

Description:

You use the **ED** command to run the CP/M context editor to create or change CP/M source language, data, and text files. ED works on the data in its buffer, using a character pointer to keep track of its current position. Be sure that you understand how to use ED; you could lose your edited file if you're not careful!

If the file exists when you enter the ED command, CP/M opens it and prepares to operate on it. If the file does not exist, CP/M creates a new file with the specified name. CP/M names its temporary file *filename.\$\$\$* while you are editing the information.

When you are finished editing the file, CP/M changes the name of the original file to *filename.BAK* and writes the edited information to the file named *filename.type* when you tell ED to write the data. If you don't tell ED to write the edited information to the file, you will lose the edited data. You must tell ED *everything*!

If you want to write the edited file to a disk other than the one containing the original file, specify a *disk-id2* parameter.

If the file that you are editing is too large to fit in memory, you must tell CP/M's ED processor when to swap information to its work files. The amount of data that can be processed without swapping depends on the size of your CP/M system. The standard Commodore 64 CP/M system is a 44K version.

You use the control characters shown in table 5.8 and the commands shown in table 5.9 when you are editing a file using ED.

Remember that the CP/M ED editor is not a very complex editor. It works in its buffers, and you must tell it *everything*. After you enter the command that tells ED what file to edit, you must tell ED to read in a specified number of lines from the file. In the same way, after you have finished editing, you must be sure to close the processing with an E command to save your edited data.

NOTE: Some ED commands (F, I, N, and S) when entered in upper case, automatically translate all subsequent lower case entries to upper case. If you enter these commands in lower case (f, i, n, s), the automatic translation to upper case is not done, and data can be entered in both upper and lower case

Table 5.8 CP/M ED Control Characters

CHARACTER	MEANING
CTRL -L	Used as a logical carriage return/line feed within a string.
CTRL -X	Line delete.
CTRL -Z	String terminator/separator.
DELETE	Delete the previous character.

Table 5.9 CP/M ED Commands*

COMMAND	FUNCTION
n:	Move the character pointer to the beginning of line n.
[+/-]n	Move the character pointer up (-) or down (+) n lines and type the line.
nA	Append n lines from the original file <i>filename</i> to the buffer in memory.

Table 5.9 (Continued)

COMMAND	FUNCTION
0A	Append enough lines from the file to half fill the buffer.
#A	Append enough lines from the file to fill the buffer or reach the end of file.
[+/-]B	Move to the top (B) or bottom (-) of the buffer.
[+/-]nC	Move the buffer character pointer forward (+) or backward (-) <i>n</i> characters in the buffer.
[+/-]nD	Delete <i>n</i> characters from the buffer. Delete the characters before (-1) or after (+) the character pointer.
E	End the ED session. Rename the original file to <i>filename.BAK</i> . Close the files and save the new file.
nF <i>string</i> [^Z]	Find the character string <i>string</i> <i>n</i> times. If you don't supply a value for <i>n</i> , the <i>string</i> is found only once. You use the CTRL -Z (^Z) to end the <i>string</i> when you want to enter another ED command on the same line as the F command. This command performs an automatic translation to upper case. To find a character string that includes lower case letters, use the f form of this command.
H	Save the new (edited) file. Rename the original file to <i>filename.BAK</i> .

Table 5.9 (Continued)

COMMAND	FUNCTION
	Re-edit the file using the new file as the original file. This is the same as entering an E (end edit) command and then running the ED editor again on the newly saved file.
I<CR>	Enter insert mode. You must enter a CTRL -Z (^Z) to end insert mode. When you use an I command, you can enter only upper-case characters. The character pointer is moved to the end of the inserted text when you enter the CTRL -Z. To enter both upper-case and lower-case information, use the I command described below.
Istring(^Z)	Insert the character string <i>string</i> at the position in the buffer pointed to by the character pointer. The CTRL -Z marks the end of the string to be inserted. The character pointer is moved to the end of the inserted string. You can enter only upper-case characters with the I command. To insert both upper-case and lower-case information, use the <i>istring</i> command described below.
i<CR>	Enter insert mode. You must enter a CTRL -Z (^Z) to end insert mode. When you use an i command, you can enter both upper-case and lower-case characters. The character pointer is moved to

Table 5.9 (Continued)

COMMAND	FUNCTION
	the end of the inserted text when you enter the CTRL -Z.
i <i>string</i> [^Z]	Insert the character string <i>string</i> at the position in the buffer pointed to by the character pointer. The CTRL -Z marks the end of the string to be inserted. The character pointer is moved to the end of the inserted string. You can enter both upper- and lower-case characters with the i command.
nJ <i>string1</i> ^Z <i>string2</i> ^Z <i>string3</i> [^Z]	Juxtapose strings. Find <i>string1</i> . Add <i>string2</i> to the end of <i>string1</i> and delete all characters from the end of <i>string2</i> up to but not including the first character of <i>string3</i> . You use the optional final CTRL -Z (^Z) when you want to enter another ED command on the same line.
[+/-]nK	Delete the following (+) or previous (-) <i>n</i> lines.
[+/-]nL	Move the character pointer up (-) or down (+) <i>n</i> lines. If <i>n</i> is zero (0), move the character pointer to the beginning of the current line.
nM <i>commands</i> [^Z]	Execute the ED commands <i>n</i> times. If <i>n</i> is zero (0) or one (1), repeat the ED commands until an error occurs. You use the terminating CTRL -Z (^Z) to enter an-

Table 5.9 (Continued)

COMMAND	FUNCTION
	other ED command on the same line. Any ED commands after the ^Z are executed only once and are not treated as part of the M command.
nNstring [^Z]	Find the <i>n</i> th occurrence of the character string <i>string</i> . You use the optional terminating CTRL -Z (^Z) when you want to enter another ED command on the same line. The N command performs an automatic translation from lower case to upper case. If you want to find a string containing lower-case letters, use the n form of this command.
O	End the ED session and keep the original file. Do not apply any of the changes made during the session.
[+/-]nP	Display <i>n</i> pages. Each page is 24 lines. Display the <i>n</i> pages before (-) or after (+) the current position of the character pointer. If you supply a zero (0) for <i>n</i> , the current line and the next 23 lines are listed.
Q	Abandon the editing session. Do not save the new (edited) file. Return to CP/M.
R[filename]	Read the file and insert the text into the buffer. Move the character pointer to the end of the inserted

Table 5.9 (Continued)

COMMAND	FUNCTION
	text. If you supply a <i>filename</i> , ED reads the file <i>filename.LIB</i> . If you don't supply a value for <i>filename</i> , ED reads the file X\$\$\$\$\$.LIB.
nS <i>string1</i> ^ Z <i>string2</i> [^Z]	Find <i>string1</i> and replace it with <i>string2</i> . Repeat this substitution <i>n</i> times. If you do not supply a value for <i>n</i> , the substitution is performed once. You use the terminating CTRL -Z (^Z) when you want to enter another ED command on the same line. The S command performs an automatic translation from lower case to upper case. If you want to use lower-case letters in your strings, use the s form of this command.
[+/-] nT	Display the previous (-) or following (+) <i>n</i> lines. If <i>n</i> is zero (0), or if <i>n</i> is not supplied, display the current line. B#T displays the entire buffer.
[+/-] JU	Translate all characters in the buffer to upper case. Plus (+) turns on the translation. Minus (-) turns off the translation.
[+/-] OJV	Turn on (+) or off (-) the line number display. The O displays the amount of free buffer space in bytes and the total buffer size.
[n]W	Write the following <i>n</i> lines to the temporary output file

Table 5.9 (Continued)

COMMAND	FUNCTION
	<i>filename.</i> \$\$. If you do not specify a value for <i>n</i> , only the current line is written to the file.
[n]X	Write the following <i>n</i> lines to the temporary file X\$\$\$\$\$.LIB. You can retrieve these lines with an R command (this is an easy way to move a block of lines). If <i>n</i> is zero (0), ED will DELETE the X\$\$\$\$\$.LIB file.
nZ	Wait <i>n</i> seconds before resuming ED processing.

*NOTES: You can use the operand *n1::n2* for any *n* or *n* operand in the ED commands shown in this table. If you use the *n1::n2* form, the ED processor will operate on the lines *n1* through *n2*. If you use this form and omit either *n1* or *n2*, ED assumes the current line for the missing operand.

You can use a # for *n* in the ED commands. # means to use the largest possible value (65535) for *n*.

Many of the ED commands show a +/- form. You do not need to specify the plus (+) sign. You do need to specify the minus (-) sign if you want to move backward in the file.

The F, I, N, and S commands perform an automatic translation to upper case. If you want to enter both upper and lower case data, use the commands f, i, n, and s.

Example:

ED PGMTST.ASM Edit the file PGMTST.ASM. If the file exists, you must remember to read in the data with an A command before attempting to edit it.

5.5.8 ERA

Format: **ERA [disk-id:]filename.type**

where:

disk-id is an optional disk identifier.

filename is a valid CP/M filename.

type is a valid CP/M file type.

Description:

You use an **ERA** command to erase one or more files from your disk. If you don't specify a *disk-id* parameter, the file is erased from the currently logged disk.

ERA accepts the wildcard (*) notation for the *filename* and *type* parameters. This allows you to erase a group of files with a single command. Be careful that you don't erase files that you want to keep when you use the wildcard notation.

Examples:

ERA TEST.DTA	Erase the file TEST.DTA from the currently logged disk.
ERA B:MY.PGM	Erase the file MY.PGM from disk B.
ERA *.BAK	Erase all files with a type BAK from the currently logged disk.
ERA A:*.*	CAUTION. Erase <i>all</i> files from disk A. (CP/M asks you whether you really want to erase all files from the disk.)
ERA TEST.*	Erase all files with the filename TEST from the currently logged disk. This would erase, for example, TEST.DTA, TEST.PGM, TEST.ASM, TEST.BAK, TEST.xxx.

5.5.9 LOAD

Format: **LOAD [disk-id:]filename**

where:

disk-id is an optional disk identifier.

filename is the name of the file containing output from the assembler.

Description:

You use a **LOAD** command to process the output from the assembler (see the description of the **ASM** command) and produce an executable program file. The input file must be named *filename*.HEX. The output file is named *filename*.COM.

You run the output from the **LOAD** processor by entering the *filename* and hitting a carriage return (see the description on loading and executing a CP/M program in Section 5.5.1).

Example:

LOAD ASMPGM2 Process the file ASMPGM2.HEX (which was created by the assembler) and produce an executable program in the file ASMPGM2.COM.

5.5.10 MOVCPM

Format: **MOVCPM [{ * | size }] [*]**

where:

the first * tells CP/M to calculate the amount of memory available for its use.

size is a two-digit number from 20 through 48 which is the maximum amount of memory available for CP/M in your Commodore 64. You use 44 for a 44K version of CP/M.

the second * tells CP/M to leave the new version in memory for later SYSGEN or SAVE command processing.

Description:

You use a MOVCPM command to configure (prepare) a new copy of your CP/M system. Changing CP/M to expect a different memory size is called "moving" the system. The MOVCPM command operates in either of these ways, depending on which parameters you use:

1. "Move" CP/M and immediately execute the new, different sized system. Do not save it on disk.
2. "Move" CP/M and prepare the new system to be saved to disk by a later SYSGEN or SAVE command. *The new CP/M system is NOT written to the disk. You must use a SYSGEN or SAVE command to actually write out the new version of the system.*

If you do not specify any parameters and use a MOVCPM command like this:

MOVCPM <CR>

CP/M will determine how much memory is available, create a new system, and immediately use the new system.

If you specify the first parameter, you can tell CP/M how much memory it can use by:

- Using the * which tells CP/M to use all available memory.
- Using the *size* parameter which tells CP/M to use *sizeK* bytes of memory.

You can use any decimal integer between 20 and 48 for the *size* value.

If you want to save the new version of CP/M on a disk, you must use the second * parameter and you must supply a first parameter (either *size* or *). You can use this type of command:

MOVCPM * * <CR>

**CAUTION: MOVCPM WILL ONLY CREATE A NEW VERSION OF CP/M.
THE NEW VERSION IS NOT SAVED TO A DISK UNTIL YOU USE A SAVE
OR SYSGEN COMMAND!**

Examples:

- | | |
|-------------|---|
| MOVCPM | Create a new version of CP/M, use all available memory, and immediately execute the new version. Do not save this version. |
| MOVCPM 40 * | Create a new version of CP/M using 40K of memory. Do not execute the version but prepare it to be saved to disk through a SAVE or SYSGEN command. |
| MOVCPM 28 | Create a 28K version of CP/M and execute it. Do not save this version. |

5.5.11 PIP

Format: **PIP**

or

PIP destination=source[parameter]

where:

destination tells where you want to copy the file to.
destination is in the form:

[disk-id:]filename.type

source tells which file to copy. *source* has the same format as *destination*.

parameter is one or more valid PIP parameters separated by zero or more blanks and enclosed in square brackets [].

Description:

You use PIP, CP/M's *Peripheral Interchange Program*, to copy files. It doesn't matter what's in the file. PIP

simply copies from the destination file to the source file. The source and destination files can be on the same disk or can be on different disks.

You can specify only the *disk-id* for the *destination* when the file is to be copied to a file with the same *filename.type* on another disk. You can use the wildcard (*) notation for any part of the *source filename* and/or *type*.

You use the *parameters*, or PIP commands, shown in Table 5.10 to have PIP perform some operations on the file during the copy process.

You can use PIP in two different ways:

1. Invoking PIP as a program by entering:

PIP <CR>

In this use, PIP is loaded and returns an * on the next line. You can then enter PIP commands, one per line, until you have finished copying all the files you want to copy. You end the PIP session by hitting a carriage return when PIP prints its * prompt message.

2. Invoking PIP with a command string, by entering:

PIP A:NEW.DTA=B:OLD.DTA <CR>

In this use, PIP is loaded and copies the file B:OLD.DTA to the new file A:NEW.DTA. After the copying is complete, PIP reboots CP/M and returns control to CP/M.

PIP can also copy from device to device. For this type of operation, you can use any of the devices shown in Table 5.11. PIP also uses some "devices" to perform special operations. These are shown in Table 5.12.

You can use PIP to copy the contents of several files to one file (concatenate several files). You do this by specifying the source filenames, separated by commas. For example, to copy files FILE1.DTA, FILE2.DTA, and FILE3.DTA to the single file ALLDATA.BAK, you use the command:

PIP ALLDATA.BAK=FILE1.DTA,FILE2.DTA,FILE3.DTA

In the above example, the entire contents of FILE1.DTA are copied to ALLDATA.BAK. Next, PIP copies the entire con-

tents of FILE2.DTA to ALldata.BAK, beginning the copy at the end of the current contents of ALldata.BAK (the end of the copied FILE1.DTA). FILE3.DTA is then copied at the end of the FILE2.DTA data in ALldata.BAK.

NOTE: Be careful when concatenating ASCII files. ASCII files end with a ^ Z (**CTRL** -Z) that PIP copies, along with the data, into your output file. This produces a file with multiple end-of-file markers embedded in it. Many programs will stop reading the file at the first ^ Z.

Table 5.10 PIP Command Parameters

COMMAND	FUNCTION
Dn	Delete all characters after the <i>n</i> th column. Use this when you want to send data to your printer and the data are longer than your printer's carriage. You get only the first <i>n</i> characters.
E	Echo the characters to the console during the copy operation.
F	Remove form feed characters during the copy operation. Form feed characters are ASCII value 0CH or CTRL -L (^L).
Gn	Get the file from a different user area. The <i>n</i> can be any decimal integer between 0 and 15.
H	Check the files for correct Intel Hexadecimal format records.
I	Ignore any null records when transferring Intel Hexadecimal records. Null records are those that contain only 00H.

Table 5.10 (Continued)

COMMAND	FUNCTION
L	Convert all upper-case letters to lower-case letters during the copy operation. Only the letters A-Z are converted to a-z. All other characters are unchanged.
N	Append a line number to the beginning of each copied line. A line is a record that ends in an ASCII CR/LF (carriage return/ line feed), which you usually insert when you press the RETURN key. The line numbers begin at one (1) and are incremented by one (1).
O	Copy object files and non-ASCII files. Treat the CTRL -Z (^Z; end-of-file marker as any other character.
Pn	Add a page feed (form feed) every n lines copied. The ASCII form feed character is CTRL -L (^L) or OCH. You use this when you are copying from a file to your printer.
Qs ^ Z	Copy only a section of the file. Stop the copy operation when PIP finds the string s. The CTRL -Z (^Z) marks the end of the string to be found. The characters in string s are converted to upper case <i>only</i> when you specify the destination and source parameters when you invoke PIP. The conversion to upper case is <i>not</i> done when you load PIP into memory and enter several commands to PIP's prompt of *.

Table 5.10 (Continued)

COMMAND	FUNCTION
R	Copy system files. System files have the SYS attribute.
Ss^Z	Copy only a section of the file beginning with the first occurrence of the string s. The CTRL -Z (^ Z) marks the end of the string s. See the description of lower- to uppercase conversion for the s string in the Q command description.
Tn	Set tab stops at every n column. This is useful when you are sending output to your printer from a file. The ASCII tab character is 09H or CTRL -I (^ I)
V	Verify the copy operation by comparing the source and destination files after the copy is complete.
W	Override the read only attribute and copy into a read only (R/O) file.
Z	Zero the parity bit (8th bit) on ASCII characters.

Examples:**PIP A:FIRST.DTA=B:TEST.DTA**

Copy the file from disk B called TEST.DTA to the file on disk A called FIRST.DTA.

PIP B:=A:*.*

Copy all files from disk A to disk B.

PIP CHAPT1.BAK=CHAPT.ONE

Copy the file CHAPT.ONE to the file CHAPT1.BAK. Both files are on the same disk.

PIP CON:=TEST.DTA

Print the file TEST.DTA on the console.

PIP B:BACKUP.PGM=A:PROG234.COM[R]

Copy the system file PROG234.COM on disk A to BACKUP.PGM on disk B.

PIP X.Y=A.B,C.D Copy the two files A.B and C.D to the file X.Y.

PIP

***B:=A:SYSFILE.XXX[R]**

***A:=B:WORDPROG.COM**

***B:=A:*.BAK**

***<CR>** Copy several files. First, copy the system file SYSFILE.XXX from disk A to disk B. Then copy the program WORDPROG.COM to disk A. Finally, copy all files that have the type BAK from disk A to disk B.

Table 5.11 PIP Logical Devices

NAME	DEVICE
CON:	Console display as PIP output. Keyboard as PIP input.
LST:	The CP/M list device (printer) for PIP output.
PRN:	A special form of the CP/M LST device. PRN handles tabs, determines page breaks, and number lines.

Table 5.12 Special PIP Devices

NAME	DEVICE
NUL:	Send 40 null characters (ASCII value is zero) to the file or device.
EOF:	Send an end-of-file mark (ASCII value is 1AH) or ^Z (CTRL-Z) to the ASCII (not binary) file or device.

5.5.12 REN

Format: **REN**

Format: **REN[*disk-id*:]*new-file*=*old-file***

where:

disk-id is an optional disk identifier.

new-file is the *new* filename. This must be a valid CP/M filename of the form *filename*[.*type*].

old-file is the current filename. This must be a valid CP/M filename of the form *filename*[.*type*].

Description:

You use a **REN** command to change the name of an existing file. The current filename *old-file* is changed to the new filename *new-file*. You *cannot* use the wildcard form of a CP/M filename when you use the **REN** command. You must specify a valid CP/M filename, but you can specify a blank *type*.

If you are renaming a file that is on the currently logged disk, you don't need to specify the *disk-id* parameter. You *cannot* specify two *disk-id* parameters. **REN** changes the name of the file on the same disk on which the file resides; it does *not* copy the file to another disk. If you want to change the filename and also move the file to another disk, use the **PIP** command.

Examples:

REN A:PRODPGM.COM=TESTPGM.COM

Change the name of the file

TESTPGM.COM on disk A to
PRODPGM.COM.

REN DATA.ARC=DATA.182

Change the name of the file DATA.182 on the currently logged disk to DATA.ARC.

REN B:DATAFILE=TEST.DTA

Change the name of the file TEST.DTA on disk B to DATAFILE.

5.5.13 SAVE

Format: **SAVE page-num [disk-id:]filename[.type]**

where:

page-num is the number of 256-byte pages from the TPA to save to the specified file.

disk-id is an optional disk identifier.

filename.type is the name of the file to which CP/M will write the *page-num**256 bytes.

Description:

You use a **SAVE** command to save *page-num* pages (where 1 page = 256K bytes) to the specified file. CP/M copies the information from the TPA which begins at location 100H. You also use the **SAVE** command when you use the **MOVCPM** command to create a new version of CP/M.

You must calculate the number of pages to be saved by dividing the amount of data by 256. You can use DDT to determine the size of your program. When you load a program into the TPA using DDT, DDT will tell you the size of the loaded data. Then, calculate the number of 256-byte pages that this represents.

For example, if you want to save the information from location 100H through 4FFH into the file NEWPGM.CM, you would use the command:

You use the *disk-id* parameter when you want to save the information to a disk that is not the currently logged disk.

Examples:

SAVE 1 A.B Save the contents of memory locations 100H through 1FFH to the file A.B.

SAVE 10 B:PGM.TST Save the contents of memory locations 100H through AFFH to the file PGM.TST on disk B.

SAVE 5X Save the contents of memory locations 100H through 5FFH to the file X on the currently logged disk.

5.5.14 STAT

Format: **STAT**

or

STAT *command*

where:

command is a valid STAT command as described below.

Description:

You use a **STAT** command to display or change status information for a CP/M disk, file, group of files, device, or user number.

To display status information, you use one of these forms of the STAT command:

- **STAT** [*disk-id*:]

This shows the number of bytes remaining on disk *disk-id*. If you omit *disk-id*, STAT provides the in-

formation on the currently logged disk. The STAT message is (see Table 5.13 for the valid options):

disk-id: Option, Space: nnK

- **STAT [disk-id:]DSK:**

This shows the drive characteristics for disk *disk-id*. If you omit *disk-id*, STAT provides information related to the currently logged disk. The STAT information is:

<i>disk-id:</i>	Drive Characteristics
1088:	128 Byte Record Capacity
136:	Kilobyte Drive Capacity
64:	32 Byte Directory Entries
64:	Checked Directory Entries
128:	Records / Extent
8:	Records / Block
34:	Sectors / Track
2:	Reserved Tracks

- **STAT [disk-id:]filename[.type]**

This shows the characteristics of the file(s) specified. You can use the wildcard (*) notation for the *filename* and/or *type* parameters. If you don't specify a *disk-id* parameter, STAT uses the currently logged disk.

The STAT information for the specified file(s) is shown as:

Recs Bytes Ext Acc
nnn nK e Options disk-id:filename.type

...for each file specified...

Bytes Remaining on *disk-id*: *nnK*

where:

nnn is the number of 128-byte records for the file.

nK shows the file size in 1024-byte blocks.

e shows the number of extents used for the file.

Options shows a valid STAT option from Table 5.13.

disk-id:filename.type shows the filename.

If you specify a file which is not on the disk, STAT returns an error message:

FILE NOT FOUND

- **STAT {DEV: | VAL: | USR:}**

This shows the information for the CP/M devices (DEV:), STAT commands and external peripheral options (VAL:), or user numbers (USR:). This function refers to the I/O byte, which is not implemented and always returns the default device assignments.

Table 5.13 STAT Command Options

OPTION	MEANING
DSK:	Show the characteristics of the specified drive.
DEV:	Show the characteristics of the CP/M system devices.
USR:	Show the files related to each USER number on the specified disk.
VAL:	Show the possible STAT commands and devices.

NOTE: The DEV: and VAL: options refer to the I/O byte, which is not implemented in the Commodore 64 BIOS.

To change status information, you use one of these forms of the STAT command (valid STAT attributes are shown in Table 5.14):

- **STAT *disk-id*:=R/O**

This changes the disk *disk-id* to a temporary read only mode (R/O).

- **STAT [disk-id:]filename[.type]=\\$x**
where x is {R/O | R/W | SYS | DIR}

This changes the specified file(s) to read only (R/O), read/write (R/W), system (SYS), or nonsystem (DIR). You can use the wildcard (*) notation for the *filename* and/or *type* parameters. To change all your program files on disk A to read only, you enter the command:

STAT A:*.COM \$R/O

Table 5.4 STAT Command Attributes

ATTRIBUTE	MEANING
DIR	Set the non-SYSTEM attribute for the file(s).
R/O	Set the file or disk to read only.
R/W	Set the file to read/write.
S	Show the size(s) of the file(s) based on the file last record number(s).
SYS	Set the SYSTEM attribute for the file(s).

Examples:

- STAT *.*** Show the statistical information for all files on the currently logged disk.
- STAT A.B** Show the statistical information for the file A.B on the currently logged disk.
- STAT DSK:** Show the statistical information for the currently logged disk.
- STAT *.COM \$R/O** Set all files on the currently logged disk which have a *type* COM (CP/M program files) to read only.

STAT NEW.DTA \$R/W

Set the file NEW.DTA to read/write.

5.5.15 SUBMIT

Format: **SUBMIT [disk-id:]filename [parameters]**

where:

disk-id is an optional disk identifier.

filename is the name of the file containing the CP/M commands. This file must be named *filename*.SUB.

parameters are optional parameters passed to the SUBMIT commands.

Description:

You use a **SUBMIT** command to send a group of commands to CP/M for execution. SUBMIT makes your Commodore 64 operate in *batch* mode where, with a single command, you can execute any number of programs or utilities.

The file containing the commands must have a type SUB. This file can contain any CP/M commands. CP/M creates a file called \$\$\$.SUB as a temporary work file when you execute a SUBMIT command.

NOTE: All commands in a SUBMIT file must be in upper case.

For example, you could have these commands in file DISK DTA.SUB:

```
DIR  
STAT *.*  
ERA *.BAK  
STAT DSK:
```

To execute all four of these CP/M commands, you simply enter:

```
SUBMIT DISKDTA <CR>
```

Remember, CP/M then executes the commands in the file *in the order in which the commands appear in the file*. SUBMIT processing only executes commands. It does not pass any information to the programs it executes. If you want to pass data to the programs, use the XSUB command.

You can *chain* from one .SUB file to another. Whenever a SUB file finds another SUBMIT command, the first file is stored and the second file becomes active. When the second file's commands are finished, the first .SUB file becomes active at the command following the SUBMIT command. For example, you could have these two files:

File A.SUB contains:

STAT DSK:

SUBMIT B

STAT DSK:

File B.SUB contains:

ERA *.BAK

DIR

When you enter the command:

SUBMIT A

the following commands are executed:

STAT DSK:

ERA *.BAK

DIR

STAT DSK:

You can also pass parameters to the .SUB file. The parameters are sequentially numbered in the file and have the form:

\$n

where:

n starts at 1 and is incremented by 1.

The parameters can be any information required by the commands in your .SUB file. They can be filenames, disk id's, file types, or anything that you need. SUBMIT does a straight substitution of the parameter values for the parameter indicators (\$*n*) in the .SUB file before passing the commands to CP/M. The first parameter goes to all occurrences of \$1; the second to \$2, etc.

Suppose you want to check the status of your disk and then edit a file. You could have a file called DSKEDIT.SUB that contains this information:

```
STA $1:DSK:  
ED $2.$3  
STAT $1:$2.$3
```

Then, to check the status of Disk A and edit the file MY.DTA, you would use this submit command:

```
SUBMIT DSKEDIT A MY DTA
```

SUBMIT processing replaces the parameter indicators with the values in your SUBMIT command and the data in file. When passed to CP/M for processing, DSKEDIT.SUB looks like this:

```
STAT A:DSK:  
ED MY.DTA  
STAT A:MY.DTA
```

When you are using SUBMIT parameters, you can enter these special characters through the parameter string:

- To enter a \$ as data, you must enter two consecutive \$\$. This is transferred to the command line as a \$. Thus, to enter the value "\$XY" as a parameter, you must use \$\$XY.
- To enter a control character, use the up-arrow symbol (^) followed by the control character. To enter **CTRL** X, you would enter the character string ^X.

You can have a SUBMIT command as the *last* command in a .SUB file. This lets you *chain* from one .SUB command file to another.

Examples:

SUBMIT STARTUP This executes the CP/M commands in the file called STARTUP.SUB.

SUBMIT NEW A B This executes the CP/M commands in the file called NEW.SUB. The value "A" is passed to any \$1 indicators in the file. The value "B" is passed to any \$2 indicators.

5.5.16 SYSGEN

Format: **SYSGEN** [[*disk-id*:]*filename.type*]

where:

disk-id is an optional disk identifier.

filename.type is the name of the file that will contain the new copy of the system.

Description:

You use a **SYSGEN** command to create a new copy of your CP/M operating system. The CP/M system is stored on special tracks called the *system tracks* (tracks 0 and 1). These tracks never appear in the file directory listing and you cannot read or write to these tracks as part of processing any normal program.

You need the system tracks on any disk from which you may do a warm or cold start. It's a good idea to have a copy of the system on most disks that contain programs. Whenever you enter a **CTRL-C (^C)**, CP/M reloads part of its system tracks (the BDOS and CCP) in a *warm start*.

You use the **SYSGEN** command to copy these tracks from one disk to another or to create a new copy of the system after you have used a **MOVCPM** command.

You use a **SYSGEN** command in one of these three ways:

1. To copy your CP/M system from one disk to another. You do not make any changes to the system; you simply copy it.
2. You use MOVCPM to create a different sized version of CP/M and you use SYSGEN to copy it to a disk.
3. You use DDT to make special changes to your copy of CP/M and you use SYSGEN to write the system to a disk.

SYSGEN does not destroy any information currently on the user area of a disk. SYSGEN simply writes a new copy of the CP/M system on the disk.

If you specify a *disk-id* parameter, SYSGEN does not ask for the source drive but uses the value you selected for *disk-id*.

If you want to create a new copy of CP/M after using MOVCPM to create a new version, you follow this procedure. The text that you enter is shown in boldface. The messages from CP/M are shown in italics.

SYSGEN <CR>

COMMODORE 64 SYSGEN VERSION 2.0

SOURCE DRIVE NAME

(OR RETURN TO SKIP) <CR>

DESTINATION DRIVE NAME

(OR RETURN TO SKIP) B<CR>

DESTINATION ON B, THEN TYPE RETURN <CR>

FUNCTION COMPLETE

To copy a version of CP/M from one disk to another, follow the above procedure but supply the appropriate answers for the source and destination drives.

NOTE: If you SYSGEN onto your current system disk a version of CP/M that is a different size from the one you're running, you CANNOT warm start the system. The location of operating system components will not match and the CP/M will crash.

Example:

To copy the system tracks from your current disk to another disk, enter:

SYSGEN <CR>

and answer the questions that CP/M asks.

5.5.17 TYPE

Format: **TYPE [disk-id:]filename.type**

where:

disk-id is an optional disk identifier.

filename.type is the name of the file to be listed on your screen.

Description:

You use a **TYPE** command to list an ASCII format file on your screen. If you don't specify a *disk-id* value, CP/M uses the currently logged disk. You must specify a valid CP/M filename. **TYPE** does *not* accept the wildcard (*) notation.

You can use a **CTRL -P (^P)** before you enter your **TYPE** command and the listing will appear on your screen and on your printer. All commands and data continue to appear on both the screen and the printer until you enter another **^P**.

You can stop the **TYPE** listing by pressing any key. You can *temporarily stop* the listing by pressing a **CTRL -s (^S)**; you restart the listing by pressing any key.

Remember that **TYPE** displays the contents of the specified file, assuming that the file contains ASCII characters. If you **TYPE** a program file (.COM), you will see garbage on your screen. Be sure that you are listing a text file when you use **TYPE**.

Examples:

TYPE A:BILLS.LST List the contents of the file on disk A called **BILLS.LST**.

TYPE X List the contents of the file called X
on the currently logged disk.

5.5.18 USER

Format: **USER [user-num]**

where:

user-num is a decimal integer between 0 and 15.

Description:

You use a **USER** command to display and change the current user number. CP/M assumes a default user number of zero (0).

Once you change the user number, you can access only those files associated with the new user number. You can always enter a user number 0 to return to the default setup.

To *display* the current user number enter:

USER <CR>

To *change* the current user number to 5 enter:

USER 5

You should not change the user number unless you want to protect certain files from use by those who do not know the associated user number. In a single-user CP/M system, it's generally unnecessary to change the user number.

Examples:

USER 2 Change the user number to 2.

USER Display the current user number.

5.5.19 XSUB

Format: **XSUB**

Description:

You use an **XSUB** command when you want to enter more than commands in a .SUB file. **XSUB** is a subset of **SUBMIT** processing and **CANNOT** be entered as a response to the CP/M prompt. **XSUB** may appear *only* in a **SUBMIT (.SUB)** file. Read the description of the **SUBMIT** command for full details on how .SUB files are processed.

XSUB must be the *first* command in your .SUB file. You can enter parameters on an **XSUB** command in the same way as for a **SUBMIT** command.

XSUB allows you to enter data that would normally be entered through the keyboard for some programs. If you are using a program that accepts buffered console input (uses BDOS function 10), then the program will accept the answers from the **XSUB** file instead of waiting for you to enter data from the keyboard. Not all programs do this, but all the CP/M utilities and commands do accept data in this manner.

Example:

You want to submit a file that will run DDT and load the file you specify. Your file called DDTRUN.SUB contains:

```
XSUB
DDT
I$1.$2
R
```

You can submit this file and specify that the file WORDPROC.DTA be read into memory through DDT by entering:

```
SUBMIT DDTRUN WORDPROC DTA
```

This SUBMIT command accepts the DDT commands to read the file WORDPROC.DTA into memory by processing the information after the XSUB command.

CHAPTER 6

CP/M ON THE COMMODORE 64

- The Structure of CP/M
- The BOOT Programs
- The BIOS Programs
- CP/M Disk Organization
- The CP/M BDOS
- Calling a Z80 Program from the 6510
- Calling a 6510 Program from the Z80
- Program Execution under CP/M
- Z80 Schematic
- Commodore 64 Schematic

In this chapter, you will find technical information about implementing CP/M on your Commodore 64. You will need this information only if you intend to make changes or additions to CP/M as supplied with your Commodore 64 and its Z80 cartridge.

CP/M was one of the first microcomputer operating systems designed to run on machines of more than one manufacturer. It is written in Intel 8080 Assembler language. The Z80 add-on processor on your Commodore 64 executes a superset of the 8080 machine language. Any program written for the 8080 processor will run on the Z80, but the reverse may not be true.

When CP/M is running on your Commodore 64, *the 6510 main processor and the Z80 add-on processor* are alternately active. The two processors trade control of the computer according to what operations are required. Because device drivers already reside in your Commodore 64 operating system, all input and output is performed by the 6510. The Z80 runs only the CP/M operating system, its utilities, and applications.

In addition to the standard functions required by the CP/M operating system, you can access your own *special purpose routines* running in 6510 native mode. This is useful, for example, if you want to attach an instrument to the optional IEEE interface cartridge on your Commodore 64. You could then easily code a driver for the instrument and gain access to it through a well defined, and protected, interface.

6.1 THE STRUCTURE OF CP/M

The principal component of CP/M is the **Basic Disk Operating System (BDOS)**. All requests for operating system services — disk input/output, printer output, screen output — are carried out through a set of standard calls to the BDOS.

NOTE: It is possible to call entry points in the CP/M BIOS directly. This technique is NOT recommended unless you are very sure of what you are doing. **WARNING.** Direct BIOS calls may be incompatible with future CP/M releases.

A second major component of CP/M is the **Console Command Processor (CCP)**. The CCP analyzes and interprets the commands that you enter from the keyboard, initiating whatever action you request. Of the resident CP/M system, the CCP occupies the lowest memory areas (see Figure 6.3).

Transient programs (those not a permanent part of the BDOS) are loaded into the **Transient Program Area (TPA)** and may, if they need the space, overlay the CCP when executing.

If a program executing in the TPA does overlay the CCP, the CCP must be reloaded when the transient program terminates. You will see this CCP reload operation (a "warm boot") as a line of asterisks appearing on your screen after a program has finished.

The final major component of CP/M is the **Basic Input/Output System (BIOS)**. This has nothing to do with the BASIC language. The BIOS is the component of CP/M that allows CP/M to be run on a variety of machines. The BIOS forms a bridge between the BDOS and the individual characteristics of the machine that it runs on. Each machine has a specially tailored BIOS that supports the hardware and peripherals attached to it.

The CP/M BIOS is much like the CBM Kernal in your Commodore 64. Like the Kernal, the BIOS contains a set of standard routines that give you access to hardware functions.

Your Commodore 64 has a unique BIOS that provides easy access to the standard Commodore 64 peripherals, either serial or IEEE.

6.1.1 How CP/M Works on Your Commodore 64

Four specially tailored assembly language programs and the CP/M operating system are required to run CP/M on your Commodore 64. Two of the assembly language programs run under the 6510 microprocessor and two under the Z80 microprocessor:

- 6510 CP/M BOOT program (BOOT65)
- Z80 CP/M BOOT program (BOOT80)

- 6510 BIOS (BIOS65)
- Z80 BIOS (BIOS80)

The BOOT programs "bootstrap" CP/M. That is, they load it into memory, initialize some areas, and begin its execution. Once the BOOT programs have completed their tasks, they are no longer needed and the memory they occupied is used for other purposes.

CP/M comes from Digital Research as a core operating system. It needs an add-on software component called a **BIOS** (**B**asic **I**nput/**O**utput **S**ystem). The BIOS contains a set of entry points that perform specific "primitive" tasks for CP/M, such as:

- Set the track number for the next read or write operation.
- Write a character to the printer.
- Read a character from the keyboard.

CP/M is not concerned with how these tasks are performed. All this work is taken care of in the custom BIOS written specifically to support a certain hardware environment. It is this BIOS that allows CP/M to run many different machines equipped with many different peripherals.

On your Commodore 64, the CP/M BIOS is in two parts. One part runs under the Z80 add-on processor (BIOS80) and the other under the 6510 Commodore 64 main processor (BIOS65). This arrangement allows the 6510 to serve as an *input/output processor* for the Z80, handling all disk, printer, keyboard, and screen input or output.

The 6510 part of the BIOS initiates execution of CP/M under the Z80 processor by transferring control to the Z80 BOOT program, which loads CP/M and BIOS80. Whenever a processor is switched on, it resumes execution at the instruction immediately following the instruction that switched it off. This means that when the Z80 returns control to the 6510, execution will resume within BIOS65.

When a CP/M program, running on the Z80, requests an *input/output* operation, the Z80 BIOS places a *function code and any required parameter values* at predetermined locations in memory. Remember, memory is shared between the two processors, which makes it very easy for them to pass data back and forth.

Once these parameter values are in place, BIOS80 switches the Z80 out and the 6510 in. The 6510 resumes execution in the 6510 portion of the BIOS. BIOS65 examines the function code passed to it by BIOS80 and initiates the indicated action.

Once the 6510 has completed the action, BIOS65 places return values and/or flag values into predetermined locations and switches control back to the Z80 processor.

Under the Z80 processor, execution resumes where it left off in BIOS80. BIOS80 examines the shared memory areas to determine the success or failure of the requested function and carries out any other action necessary to complete the function.

6.1.2 6510 Memory Use

Figure 6.1 shows the memory allocation as seen from the 6510 running in native mode. Figure 6.2 shows details on the BIOS65 memory area.

6510 CP/M Memory Map

6510 ADDRESS

\$FFFF

\$F000

6510 KERNAL ROM

\$E000

6510 I/O SYSTEM

\$D000

48K RAM AVAILABLE FOR Z80
RUNNING CP/M

\$1000

BIOS65 AND SHARED DATA AREAS

\$0800

0400 TO 07FF SCREEN RAM
0000 TO 03FF ZERO PAGE AND 6510 STACK

\$0000

The addresses shown are for the 6510 microprocessor. For Z80 addresses, subtract \$1000 hexadecimal from the addresses shown (see Section 6.1.3 for an explanation of Z80/6510 address conversion).

NOTE: If you add the IEEE interface cartridge to your Commodore 64 system, you can run only a 44K version of CP/M. The top 4K (\$C000—\$D000) of the CP/M 48K area is used to handle the IEEE interface cartridge.

BIOS65 Memory Map

6510 ADDRESS

\$1000

\$0F00

\$0E00

\$0D00

BIOS65

\$0C00

\$0B00

\$0A00

SHARED DATA

\$0900

DISK I/O BUFFER

\$0800

The addresses shown are for the 6510 microprocessor. For Z80 addresses, add \$F000 hexadecimal to the addresses shown (see Section 6.1.3 for an explanation of Z80/6510 address conversion).

6.1.3 Addresses under CP/M

You can see from the memory map in Figure 6.3 that the Z80 processor uses the memory between \$1000 and \$BFFF—a 48K byte area. CP/M, however, makes use of fixed areas in the zero page (\$0000-\$0100) of memory. This area is also required by the Commodore 64 operating system.

To avoid a conflict in the use of the zero page and to provide space for BIOS65, all Z80 addresses have \$1000 added to them. Thus, the Z80 address \$0000 becomes actual address \$1000. Table 6.1 shows the mapping between Z80 addresses and actual memory addresses.

NOTE: If you are using the optional IEEE interface cartridge, you have only 44K bytes available for CP/M. The IEEE bus access routines require an additional 4K at the high end of the CP/M memory (\$B000—\$BFFF).

Table 6.1 Z80 to 6510 Actual Address Mapping

Z80 ADDRESS	ACTUAL (6510) ADDRESS
0000->0FFF	1000->1FFF
1000->1FFF	2000->2FFF
2000->2FFF	3000->3FFF
3000->3FFF	4000->4FFF
4000->4FFF	5000->5FFF
5000->5FFF	6000->6FFF
6000->6FFF	7000->7FFF
7000->7FFF	8000->8FFF
8000->8FFF	9000->9FFF
9000->9FFF	A000->AFFF
A000->AFFF	B000->BFFF
B000->BFFF	C000->CFFF
C000->CFFF	D000->DFFF
D000->DFFF	E000->EFFF
E000->EFFF	F000->FFFF
F000->FFFF	0000->0FFF

NOTE: Notice that to access the 6510 low addresses, you reference the Z80 high addresses.

6.1.4 Z80 Memory Use

The amount of memory available to CP/M on your Commodore 64 depends on your hardware configuration. If you are using the standard *Commodore 64 serial disk drives and printer*, CP/M can occupy a maximum of 48K bytes. If you have acquired the *IEEE interface cartridge*, CP/M can occupy a maximum of 44K bytes. The IEEE interface cartridge consumes 4K at the high end of the CP/M address space (see Figure 6.1).

You can, of course, generate a CP/M system that is smaller than the maximum available space. You can do that if you need space for a routine that must run in Commodore 64 native mode (under the 6510 processor). You can, for example, generate a 40K CP/M version and have 8K (or 4K if you have the IEEE cartridge) available for your Commodore 64 native mode routine. Figure 6.3 shows a diagram of the Z80 address space.

Z80 Memory Map

ADDRESS

44K 48K

\$AFFF	\$BFFF	BIOS80
\$AA00	\$BB00	BDOS
\$9C06	\$AC06	CCP
\$9400	\$A400	TPA (44K—33,792 bytes) (48K—37,888 bytes)
\$0100	\$0100	ZERO PAGE
\$0000	\$0000	

Many microcomputer operating systems use the zero page of memory (addresses between \$0000 and \$0100) to hold important values. Both CP/M and your Commodore 64

operating system do this. Table 6.4 shows the contents of the CP/M Zero Page.

Table 6.2 CP/M Zero Page

ADDRESS	CONTENT
\$0000 – \$0003	Contains a jump instruction to the warm start entry point in the BIOS.
\$0004	Contains the current default disk drive number (0=A and 1=B) in the low order 4 bits and the I/O byte in the high order 4 bits.
\$0005 – \$0007	Contains a jump instruction to the BDOS main entry point. The value stored in locations \$0006 – \$0007 is the lowest address <i>required</i> by CP/M. You also use this jump instruction (or the address) when you make direct BDOS calls.
\$0038 – \$003A	This is Restart Location 7 and is used by DDT for programmed breakpoints (an RST 7 instruction causes a call to this location).
\$005C – \$006C	This is the first default file control block for use by transient programs.
\$006C – \$007C	This is the second default file control block for use by transient programs.

Table 6.2 (Continued)

ADDRESS	CONTENT
\$007D – \$007F	This location contains the random record position for random file access via the first default file control block.
\$0080 – \$00FF	<p>This is the default 128-byte disk input/output buffer.</p> <p>This area also receives the command line that you enter when your program is loaded by the CCP.</p>
<p>NOTE: The areas of the zero page not shown in this table are reserved for future use. You should not use any of these areas in programs you write unless you are sure of their use</p>	

6.2 THE BOOT PROGRAMS

The BOOT programs—BOOT65 and BOOT80—are used to load CP/M from disk. Once they have completed this task, the memory they occupy is used for other purposes.

The **BOOT65** program is in the file called "CP/M" that you LOAD and RUN to start execution of the CP/M operating system on your Commodore 64. You can find a listing of this program in Appendix E. The actual assembly language program source is available on one of your CP/M system diskettes.

You LOAD and RUN **BOOT65** as you would any BASIC program on your Commodore 64. If you LIST it, you will see that it contains a single BASIC statement:

10 SYS (2036)

This statement transfers control to the actual **BOOT65** code located at decimal address 2036.

The program then reads in the **BIOS65** and **BOOT80** pro-

grams and places them at the correct locations in memory. Finally, BOOT65 transfers control to the startup code in BIOS65.

The **BOOT80** program is a Z80 assembly language program that is the first program to execute when the Z80 processor is switched on. You can find a listing of this program in Appendix E. The actual assembly language program source is available on one of your CP/M system diskettes.

BOOT80 is loaded by the BOOT65 program at the Z80 reset address \$0000 (6510 address \$1000). When the Z80 is first turned on, it always begins execution at address \$0000.

BOOT80 loads:

- Z80 BIOS (BIOS80)
- CP/M CCP (CP/M Command Processor)
- CP/M BDOS (Basic Disk Operating System)

When these programs are loaded, BOOT80 transfers control to the cold start entry point in BIOS80, thus beginning actual CP/M operating system execution.

6.3 THE BIOS PROGRAMS

The BIOS (Basic Input/Output System) is the specially tailored link between the CP/M operating system and the individual peripherals—printer, disk drives, screen—attached to your Commodore 64.

Each computer that runs CP/M has its own unique BIOS. On your Commodore 64 the BIOS is in two parts:

- BIOS65 executes under the 6510 main processor.
- BIOS80 executes under the Z80 add-on processor.

These two portions of the BIOS operate together to make your Commodore 64 peripherals available to CP/M.

Why are there two programs for the BIOS? Your Commodore 64 already has code in place to handle its peripherals. Thus more memory is made available for CP/M and your CP/M-based applications by simply providing a link to that existing code, rather than trying to re-implement the peripheral-handling code on the Z80.

In operation, BIOS80 is called from CP/M with a request

for an input/output operation. BIOS80 places required parameter values and a function flag in certain memory locations, then switches control from the Z80 back to the 6510 Commodore 64 main processor.

The 6510 resumes execution where it left off in BIOS65. BIOS65 examines the function code stored in memory to find out what it should do, carries out the task (usually an input/output request), places the result in a predetermined memory location, and switches the Z80 back on.

The Z80 resumes execution where it left off in BIOS80. BIOS80 retrieves the results passed to it from BIOS65 and returns the proper information to CP/M.

BIOS80 is called from the CP/M BDOS to perform the following functions:

- cold start boot
- warm start boot
- console (keyboard) status check
- get keyboard character (console input)
- write character to screen (console output)
- print a character (lister output)
- move disk head to the home position
- select disk
- set track to read/write
- set sector to read/write
- read disk sector
- write disk sector
- check printer status (lister status)
- sector translation

The *punch* and *reader* functions of the BIOS are meaningless on your Commodore 64. These are null routines in BIOS80.

Some of the functions listed above simply cause values to be placed in predefined memory locations. Others result in a transfer to the 6510 portion of the BIOS where the actual work is performed.

Before BIOS80 switches control back to the 6510, it places a *function code* at location \$F900 (\$0900 relative to the 6510). This code, which currently ranges from 0 to 9 and 255, tells BIOS65 what action is required. These function codes and their meanings are shown in Table 6.3.

Table 6.3 BIOS80/BIOS65 Function Codes

NUMBER	FUNCTION
0	Read the specified sector
1	Write the specified sector
2	Get a character from the keyboard
3	Write a character to the screen
4	Check the printer status
5	Write a character to the printer
6	Disk format command
7	Jump to 6510 address \$0E00
8	Jump to 6510 address \$0F00
9	Jump indirect via a 6510 address stored at \$F906
10->254	Reserved for future use
255	Execute a cold start reset on your Commodore 64

Table 6.4 BIOS80/BIOS65 Communication Addresses

ADDRESS	CONTENT
Z80 6510	
\$F900 \$0900	Command register: contains one of the function codes as shown in Table 6.2.
\$F901 \$0901	Data register: used to pass data and error indicators between the two BIOS.
\$F902 \$0902	Sector register: contains the current sector number for disk read and write requests.
\$F903 \$0903	Track register: contains the current track number for disk read and write requests.
\$F904 \$0904	Drive register: contains the disk drive number for disk read and write requests.
\$F905 \$0905	Keyboard register: contains the last character read from the keyboard.

BIOS65 and BIOS80 communicate with each other through a series of contiguous memory locations as shown in Table 6.4.

6.4 CP/M DISK ORGANIZATION

Your Commodore 64 CP/M BIOS programs provide a completely compatible interface between your disks and the CP/M BDOS. All disk-related functions expected by the CP/M BDOS are available through your BIOS programs.

The organization of a CP/M disk is different from the organization of a standard Commodore 64 disk. The CP/M disk has somewhat less capacity than a Commodore 64 format disk.

A Commodore 64 CP/M disk is formatted as 35 tracks containing 17 256-byte sectors (0–16) where track 1 is the outermost track and track 35 is the innermost track. A Commodore 64 CP/M disk can hold a maximum of 136,000 characters of **user data**.

Notice that the full disk capacity (152,320 characters) is not available for user data storage.

Table 6.5 shows the allocation of tracks on your Commodore 64 CP/M format disk.

Table 6.5 CP/M Disk Track/Sector Allocations

TRACK	SECTOR	CONTENT
1	0	BOOT65 (Commodore 64 file "CPM")
1	1 – >4	BIOS65
1	5	BOOT80
1	6 – >13	CP/M CCP (Command Processor)
1&	14 – >16	CP/M BDOS
2	0 – >10	
2	11 – >16	BIOS80
3	0 – >7	CP/M Disk Directory
3	8 – >16	CP/M Disk Space
4 – >17	0 – >16	CP/M Disk Space
18	0 – >16	Commodore 64 Directory
19 – 35	0 – >16	CP/M Disk Space

NOTE: The Commodore 64 Directory written on track 18 allows you to start CP/M from Commodore 64 running in native mode. This directory shows that only a single file—CPM—exists on the disk. The standard Commodore 64 Block Availability Map (BAM) indicates that the disk is completely full.

6.5 THE CP/M BDOS

The CP/M Basic Disk Operating System (BDOS) provides a standard interface between CP/M application programs and the hardware on which they run. All input/output and operating system service requests are routed through the BDOS. Because of this, you don't have to write device-specific code into your application program for every system that it might run on. The device-specific code for a particular system is written only once—in the CP/M BIOS.

The standard BDOS interface means that software can be written and run on *any system able to support CP/M*, as long as the software developer stays within the BDOS standard.

The 39 BDOS functions (numbered 0–37 and 40 decimal) perform tasks valuable in almost any application. For example, they

- Read a character from the keyboard.
- Write a character to the keyboard.
- Open a disk file.
- Print a string.
- Write to the printer.
- Delete a file.
- Create a file.

For a list of the BDOS functions, see Table 6.6.

You *call the BDOS* from Z80 Assembler or other languages through the *BDOS jump vector* at **Z80 address \$0005**. This jump vector contains a single jump instruction:

JMP BDOS-ADDRESS

The **bdos-address** varies with the size of the CP/M system you have generated. The JMP instruction itself is placed at location \$0005 when CP/M is loaded.

To use the BDOS functions, you code:

CALL 5

When the BDOS has completed the function, it returns control to the statement following the CALL statement.

NOTE: Bytes 6 and 7 of the BDOS jump vector contain the lowest address required by CP/M (stored as low byte/high byte). This means that your application program can use memory up to, but not including, this address.

BDOS functions are numbered. Some require that you pass to them the parameter values or the address of a parameter in certain registers. Some return an indicator or error code in a register.

When calling a BDOS function, you always **load the BDOS function code in register C**. If the function requires that you *pass it parameters*, you place:

- Single-byte parameters in register E.
- Double-byte parameters in register pair DE.

If the function *returns a value* to you, you find:

- Single-byte returns in register A.
- Double-byte returns in register pair HL.

NOTE: The BDOS does NOT preserve values stored in the Z80 registers. If you want to protect values stored in registers, you should push them onto the stack before you call the BDOS. You can then pop them off the stack on return from the BDOS call.

6.5.1 Sample BDOS Function Call

As an example of a BDOS function call, we will use Function 1, the Console (keyboard) Input function. Function 1 returns in register A the last character entered from the keyboard. To use Function 1, you can write code like the following:

```
MVI C,1      ;LOAD FUNCTION 1 INTO REGISTER C
;     CALL 0005H   ;CALL THE BDOS JUMP VECTOR
; WHEN THE BDOS HAS A CHARACTER, IT RETURNS HERE
; REGISTER A CONTAINS THE INPUT CHARACTER
;

STA KEYCHAR  ;STORE REGISTER A IN KEYCHAR
               VARIABLE
```

Table 6.6 BDOS Functions

FUNCTION (Register C)	DESCRIPTION
0 SYSTEM RESET	<p>INPUT: NONE RETURN: NONE</p> <p>Returns control to the CCP and resets CP/M as though you rebooted.</p>
1 CONSOLE INPUT	<p>INPUT: NONE RETURN: A ← character input</p> <p>Reads a character from the keyboard. Examines the character to see if it is a CP/M control character.</p>

Table 6.6 (Continued)

FUNCTION (Register C)	DESCRIPTION
--	--------------------

2 CONSOLE OUTPUT

INPUT: E ← character to display
RETURN: NONE

Writes a character to the screen.

3 READER INPUT

INPUT: NONE
RETURN: A ← character read

This function is not supported on your Commodore 64.

4 PUNCH OUTPUT

INPUT: E ← character to punch
RETURN: NONE

This function is not supported on your Commodore 64.

5 LIST OUTPUT

INPUT: E ← character to print
RETURN: NONE

Writes a character to your printer.

Table 6.6 (Continued)

FUNCTION (Register C)	DESCRIPTION
6 DIRECT CONSOLE I/O	<p>INPUT: E \leftarrow character to display (output) E \leftarrow OFFH (input)</p> <p>RETURN: A \leftarrow character (input) A \leftarrow status (output)</p> <p>Performs raw console input (read from keyboard) and output (write to screen). Characters are transferred through the BDOS without being examined or changed.</p>
7 GET I/O BYTE	<p>INPUT: NONE</p> <p>RETURN: A \leftarrow I/O byte</p> <p>The I/O byte function is not supported on your Commodore 64.</p>
8 SET I/O BYTE	<p>INPUT: E \leftarrow new I/O byte</p> <p>RETURN: NONE</p> <p>The I/O byte function is not supported on your Commodore 64.</p>
9 PRINT STRING	<p>INPUT: DE \leftarrow string address</p> <p>RETURN: NONE</p> <p>Writes the character string to the screen. The string must terminate with a "\$".</p>

Table 6.6 (Continued)

FUNCTION (Register C)	DESCRIPTION
--------------------------	-------------

10 READ CONSOLE BUFFER

INPUT: DE \leftarrow buffer address
RETURN: characters in buffer

Reads from the keyboard until a carriage return or CTL-M is entered or until the keyboard buffer overflows.

11 GET CONSOLE STATUS

INPUT: NONE
RETURN: A \leftarrow console status

Checks the keyboard status. A contains OFFH if a character is ready; 00H if not.

12 RETURN VERSION NUMBER

INPUT: NONE
RETURN: HL \leftarrow version number

Returns the CP/M version number.

13 RESET DISK SYSTEM

INPUT: NONE
RETURN: NONE

Resets the entire disk system to its initial state.

Table 6.6 (Continued)

FUNCTION (Register C)	DESCRIPTION
14 SELECT DISK	<p>INPUT: E ← disk number to select RETURN: NONE</p> <p>Selects a disk (A=0 and B=1).</p>
15 OPEN FILE	<p>INPUT: DE ← address of FCB RETURN: A ← directory code</p> <p>Opens a disk file for processing. Returns a 255 in A if the file could not be found.</p>
16 CLOSE FILE	<p>INPUT: DE ← address of FCB RETURN: A ← directory code</p> <p>Closes a disk file. Returns a 255 in A if the file could not be found.</p>
17 SEARCH FOR FIRST	<p>INPUT: DE ← address of FCB RETURN: A ← directory code</p> <p>Searches for the first file matching the name given in the FCB. Returns a 255 in A if no match was found.</p>

Table 6.6 (Continued)

FUNCTION (Register C)	DESCRIPTION
18 SEARCH FOR NEXT	<p>INPUT: NONE RETURN: A ← directory code</p> <p>Similar to Function 17, but begins search where 17 left off. Also returns a 255 in A if no match was found.</p>
19 DELETE FILE	<p>INPUT: DE ← address of FCB RETURN: A ← directory code</p> <p>Deletes a disk file. Returns a 255 in A if the file could not be found.</p>
20 READ SEQUENTIAL	<p>INPUT: DE ← address of FCB RETURN: A ← directory code</p> <p>Reads the next 128-byte record into the memory pointed to by the current DMA address. Returns a 00H in A if the read succeeded; non-zero if end-of-file was encountered.</p>
21 WRITE SEQUENTIAL	<p>INPUT: DE ← address of FCB RETURN: A ← directory code</p>

Table 6.6 (Continued)

FUNCTION (Register C)	DESCRIPTION
	Writes the 128-byte record pointed to by the current DMA address. Returns a 00H in A if the write succeeded; a non-zero for a full disk.

22 MAKE FILE

INPUT: DE ← address of FCB
RETURN: A ← directory code

Creates the disk file named in the FCB. Returns a 255 in A if the create failed.

23 RENAME FILE

INPUT: DE ← address of FCB
RETURN: A ← directory code

Renames a disk file. The name of the file is in the first 16 bytes of the FCB, the new name is in the next 16 bytes. Returns a 255 in A if the rename fails.

24 RETURN LOGIN VECTOR

INPUT: NONE
RETURN: HL ← login vector

Returns the disk login vector. The least significant bit of L represents Disk A and the next Drive B. When set to 1, the drive is on-line.

Table 6.6 (Continued)

FUNCTION (Register C)	DESCRIPTION
25 RETURN CURRENT DISK	<p>INPUT: NONE RETURN: A ← current disk number</p> <p>Returns the number of the currently logged disk (0=A and 1=B).</p>
26 SET DMA ADDRESS	<p>INPUT: DE ← DMA address RETURN: NONE</p> <p>Sets the address of the 128-byte disk sector buffer.</p>
27 GET ADDR (ALLOC)	<p>INPUT: NONE RETURN: HL ← ALLOC address</p> <p>Returns the address of the allocation vector of the current disk.</p>
28 WRITE PROTECT DISK	<p>INPUT: NONE RETURN: NONE</p> <p>Protects the current disk from being written to.</p>

Table 6.6 (Continued)

FUNCTION (Register C)	DESCRIPTION
29 GET READ ONLY VECTOR	<p>INPUT: NONE RETURN: HL \leftarrow read only vector</p> <p>Returns a vector indicating which drives are temporarily write-protected. The least significant bit of L represents Disk A and the next Drive B. When set to 1, the drive is write-protected.</p>
30 SET FILE ATTRIBUTES	<p>INPUT: DE \leftarrow address of FCB RETURN: A \leftarrow directory code</p> <p>Sets read only and system file attributes.</p>
31 GET ADDR (DISK PARMS)	<p>INPUT: NONE RETURN: HL \leftarrow address of DPB</p> <p>Returns the address of the Disk Parameter Block.</p>
32 SET/GET USER CODE	<p>INPUT: E \leftarrow user code (SET) E \leftarrow OFFH (GET) RETURN: A \leftarrow user code (GET)</p>

Table 6.6 (Continued)

FUNCTION (Register C)	DESCRIPTION
--------------------------	-------------

Returns or sets the current user code (user number).

33 READ RANDOM

INPUT: DE ← address of FCB
RETURN: A ← return code

Performs a random record read on a disk file. Return codes are:

- 01 reading unwritten data
- 03 cannot close current extent
- 04 seek to unwritten extent
- 06 seek past end of disk

34 WRITE RANDOM

INPUT: DE ← address of FCB
RETURN: A ← return code

Performs a random record write to a disk file. Return codes are:

- 01 reading unwritten data
- 03 cannot close current extent
- 04 seek to unwritten extent
- 05 out of directory space
- 06 seek past end of disk

Table 6.6 (Continued)

FUNCTION (Register C)	DESCRIPTION
35 COMPUTE FILE SIZE	<p>INPUT: DE ← address of FCB RETURN: file size</p> <p>Returns the size of the file, in records, to the random record field of the FCB.</p>
36 SET RANDOM RECORD	<p>INPUT: DE ← address of FCB RETURN: NONE</p> <p>Sets the random record number of a record that was read sequentially. The random record number is placed into the random record field of the FCB.</p>
37 RESET DRIVE	<p>INPUT: DE ← drive vector RETURN: NONE</p> <p>Resets the disk drives indicated in the drive vector. The least significant bit of L represents Disk A and the next Drive B. When set to 1, the drive is reset.</p>
38 NOT USED	
39 NOT USED	

Table 6.6 (Continued)

FUNCTION (Register C)	DESCRIPTION
40 WRITE RANDOM WITH ZERO FILL	
INPUT: DE ← address of FCB RETURN: A ← return code	Identical to WRITE RANDOM (Function 34), except that new blocks are zero-filled before data is moved into them.

6.6 CALLING A Z80 PROGRAM FROM THE 6510

You sometimes may want to call a Z80 routine from your Commodore 64 while it is running in native mode. You may, for example, want to take advantage of the Z80 register structure or its extended instruction set, which make some routines easier to write or more efficient to execute.

When you first switch on your Z80 processor, it will always begin execution at its reset address:

6510 ADDRESS \$1000—Z80 ADDRESS \$0000

To call a Z80 routine from the 6510, you must either:

- Load the routine at 6510 address \$1000.
- Place a Z80 jump instruction at 6510 address \$1001 that transfers control to the actual code location.

In BOTH cases, 6510 address \$1000 (Z80 \$0000) must contain a **NOP instruction (\$00)**. This is a requirement of the processor switching hardware. Of course, if you place a jump instruction at 6510 address \$1001, you must load the actual Z80 routine elsewhere in memory.

On subsequent calls to the Z80, routine execution will resume at the instruction following the *last instruction executed before the Z80 switched itself off*. It does NOT resume execution at the reset address.

6.6.1 Some Examples

Suppose you load some Z80 code at 6510 address \$1000. You can transfer control to that code by switching on the Z80 processor:

```
LDA    #0      ;LOAD ZERO INTO A
STA    $DE00   ;STORE ZERO IN THE MODE SWITCH
            LOCATION
NOP    ;REQUIRED BY THE SWITCH
            HARDWARE
```

The first time this code is executed, the Z80 will start executing instructions at \$0000 (6510 address \$1000); that address must contain a NOP instruction. Subsequent executions of the code (without turning off your Commodore 64) will cause the Z80 to resume execution where it left off when it switched the 6510 back on.

Assume now that you have loaded your Z80 code at 6510 address \$B000. This corresponds to a Z80 address of \$A000. You can get to this routine by using code similar to the following:

```
LDA    #$00   ;OPCODE FOR A NOP INSTRUCTION
STA    $1000  ;MEET THE SWITCHING
            REQUIREMENT
LDA    #$C3   ;Z80 JUMP INSTRUCTION OPCODE
STA    $1001  ;FIRST BYTE OF JUMP INSTRUCTION
LDA    #$00   ;LOW BYTE OF Z80 JUMP ADDRESS
STA    $1002  ;NEXT BYTE OF JUMP INSTRUCTION
LDA    #$A0   ;HIGH BYTE OF Z80 ADDRESS
STA    $1003  ;LAST BYTE OF JUMP INSTRUCTION
LDA    #0     ;LOAD ZERO INTO A
STA    $DE00  ;STORE ZERO IN THE MODE
            SWITCH LOCATION
NOP    ;REQUIRED BY THE SWITCH
            HARDWARE
```

Subsequent executions of this code (without turning off your Commodore 64) will cause the Z80 to resume execution where it left off when it switched the 6510 back on. You could thus use address \$1000 for other purposes after calling the Z80 routine the first time.

You can return from your Z80 routine by using the code below:

```
MVI A,1      ;LOAD ONE INTO A
STA OCE00H ;STORE ONE IN MODE SWITCH
              LOCATION
              ;TO TURN ON THE 6510
NOP          ;REQUIRED BY THE HARDWARE
              AFTER A MODESW
;
;THE NEXT TIME IT IS SWITCHED ON, THE Z80 RESUMES
EXECUTION HERE
;
```

NOTE: You **MUST** follow the mode switching store instruction with a NOP instruction.

6.7 CALLING A 6510 PROGRAM FROM THE Z80

There may be times when you want the 6510, running in Commodore 64 native mode, to perform some special tasks for you.

For example, suppose you add the IEEE expansion cartridge to your Commodore 64 in order to attach an IEEE standard instrument. Instruments require special control commands that can be issued only by the 6510 main processor.

The 6510 portion of the BIOS (BIOS65) includes a facility for calling your own code. This facility is implemented through the BIOS function codes 7, 8, and 9.

- BIOS function code 7 instructs BIOS65 to transfer control to:

6510 ADDRESS \$0E00—Z80 ADDRESS \$FE00

- BIOS function code 8 instructs BIOS65 to transfer control to:

6510 ADDRESS \$0F00—Z80 ADDRESS \$FF00

- BIOS function code 9 instructs BIOS65 to transfer control indirectly to the instruction whose address is stored at:

6510 ADDRESS \$0907—Z80 ADDRESS \$F907

The code that you load at these locations MUST end with a 6510 RTS instruction. This instruction returns control to BIOS65, which can then switch the Z80 processor back on.

As you see, function codes 7 and 8 always transfer control to the same location. If you use both functions 7 and 8, your programs cannot be larger than \$100 bytes (256 decimal). If you use only function code 7, you can expand your program into the function code 8 space. This gives you a maximum program size of \$200 bytes (512 decimal).

If you need more space than you can get under function codes 7 and 8, you can use function code 9. When you pass function code 9 to BIOS65, it transfers control to the address stored at 6510 location \$0F07. This address can be anywhere in the 6510 address space.

NOTE: When you use BIOS function 9, the indirect address you store at Z80 address \$FF07 (6510 address \$0F07) MUST be a 6510 base address.

6.7.1 Switching on the 6510

If you are going to use a 6510 routine, you have to know how to switch on the 6510 processor. The two processors

cannot operate at the same time. When you switch one of them on, the other is automatically switched off.

Processor switching is controlled by storing a *mode switch* value in:

6510 ADDRESS \$DE00—Z80 ADDRESS \$CE00

The *mode switch* values are:

- 0 → activates the Z80 processor
- 1 → activates the 6510 processor

Suppose you load some 6510 code at 6510 address \$0E00 that you wish to execute from a Z80 program. You can do that using code like the following:

```
MVI A,7      ;LOAD THE FUNCTION CODE INTO A
STA 0F900H   ;STORE THE FUNCTION CODE IN
              COMMAND REGISTER
;
;
;          PREPARE ANY OTHER PARAMETERS
; REQUIRED
; BY THE CODE YOU HAVE
; PLACED AT 6510 ADDRESS $0E00—Z80
; ADDRESS $FE00
;
MVI A,1      ;LOAD ONE INTO A
STA 0CE00H   ;STORE ONE IN MODE SWITCH
              LOCATION
              ;TO TURN ON THE 6510
NOP         ;REQUIRED BY THE HARDWARE
              AFTER A MODESW
;
;
;          AFTER COMPLETION OF THE 6510
ROUTINE, Z80 RESUMES
EXECUTION HERE
;
```

From the example above, you can see that it's easy to call a 6510 routine from the Z80. The 6510 routine that you write does not have to switch control back to the Z80. The BIOS65 program takes care of the return to the Z80.

NOTE: You MUST follow the mode-switching store instruction with a NOP instruction.

You must, of course, load your 6510 routine into the correct memory location before you transfer control to it. If you use BIOS function 9, you must also load the 6510 address of the code to be executed in indirect address location \$F907 (Z80).

6.8 PROGRAM EXECUTION UNDER CP/M

Programs destined to execute under CP/M must be stored in a disk file and have a file name extension of .COM (see Chapter 5 for an explanation of CP/M file-naming conventions and details on executing programs). User programs running under CP/M are loaded into the Transient Program Area (TPA) for execution.

You execute a program under CP/M simply by entering its name (without the extension). The general form is:

[DISKID:]PROGRAM-FILENAME

where *diskid* is an optional disk identifier (A or B) and *program-filename* is the name of the file that contains your program. The program file MUST have the extension .COM.

Suppose, for example, that you have a program stored in a file named STARTREK.COM. To execute that program, you respond to the CP/M prompt (usually A>) with:

STARTREK

CP/M will then load the file STARTREK.COM into the TPA (Transient Program Area) and transfer control to it (at location \$100). When STARTREK completes its execution, it returns to CP/M via a Z80 RET instruction or via a jump to location \$0000. The return via a jump to location \$0000 causes a warm start reboot of CP/M.

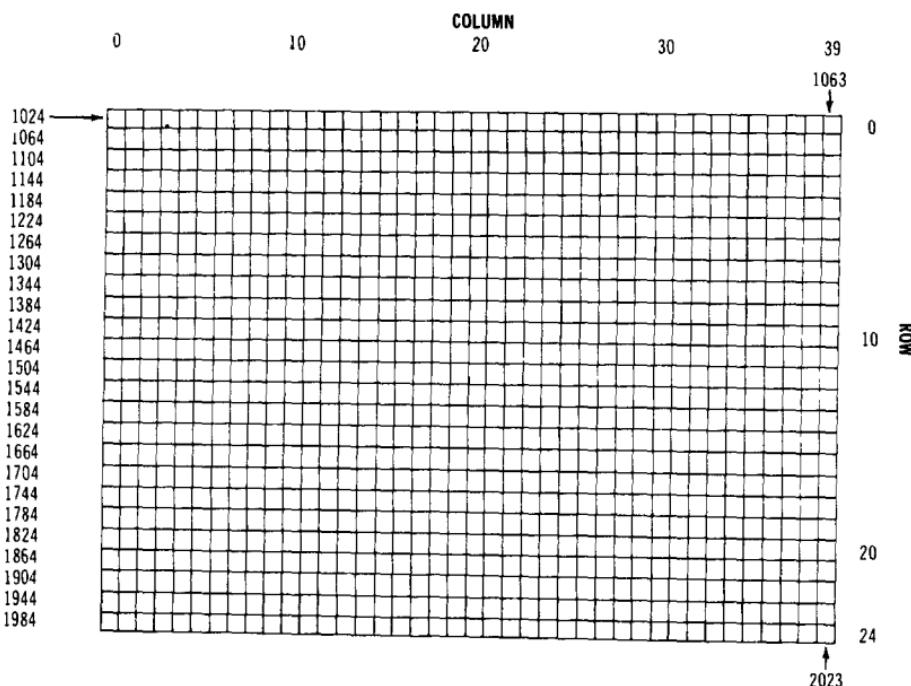
APPENDICES

APPENDIX A

COMMODORE 64 MEMORY MAP

The following charts list which memory locations control placing characters on the screen, and the locations used to change individual character colors, as well as showing character color codes.

SCREEN MEMORY MAP

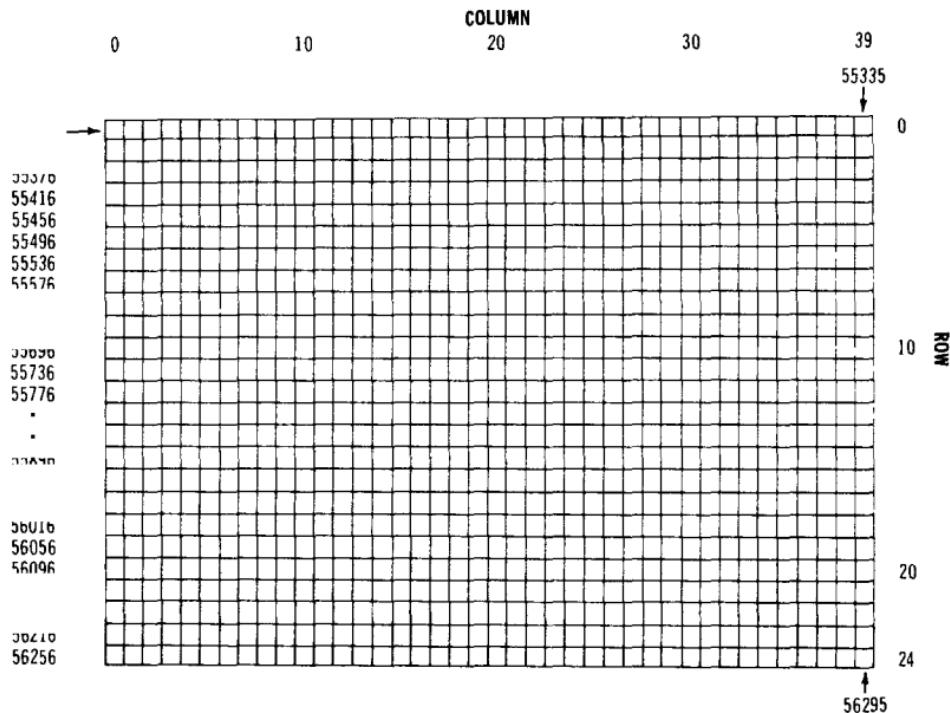


The actual values to POKE into a color memory location to change a character's color are:

Ø	BLACK	8	ORANGE
1	WHITE	9	BROWN
2	RED	1Ø	Light RED
3	CYAN	11	GRAY 1
4	PURPLE	12	GRAY 2
5	GREEN	13	Light GREEN
6	BLUE	14	Light BLUE
7	YELLOW	15	GRAY 3

For example, to change the color of a character located at the upper left-hand corner of the screen to red, type: POKE 55296,2.

COLOR MEMORY MAP



APPENDIX B

BIBLIOGRAPHY

This bibliography lists a variety of currently available CP/M and Z80 books. Look at several books covering the topics that interest you before you make your selection.

Each author covers the topics from a different viewpoint. Find the book that you feel most comfortable with. Some people prefer a more technical discussion and should select a book with in-depth technical detail. Others like a less technical approach and should seek a book that is easy to understand.

You also can subscribe to a new magazine devoted exclusively to CP/M:

**The User's Guide to CP/M Systems and Software
Box 3050
Stanford, CA 94305**

You may be interested in joining the CP/M User's Group, which provides software written by members for their CP/M systems. Software is often available for only a copying charge. You can contact the CP/M User's Group through:

**CP/M User's Group
c/o Lifeboat Associates
1651 Third Avenue
New York, NY 10028**

B.1 CP/M Books

This list gives some of the most recent CP/M books in alphabetical order by title. It is by no means a list of all the CP/M books available today. The prices shown are subject to change.

CP/M Handbook With MP/M by Rodnay Zaks, SYBEX, paper, \$14.95

This is a reference guide to CP/M, written in a readable style for beginners.

CP/M Primer by Stephen Murtha, Howard W. Sams, paper, \$14.95

This book helps both the first-time microcomputer user and the experienced user who is just beginning to use CP/M.

CP/M Word Processing by Chris DeVoney, Que Corporation, paper, \$16.50

This book covers the use of word processing packages developed to run under the CP/M operating system. It contains detailed evaluations of 17 popular CP/M word processing packages and tells how to decide which word processor best meets your needs.

How to Get Started with CP/M by Carl Townsend, Dilithium Press, paper, \$13.95

This book describes the CP/M operating system in an easy, comfortable style. It eases the reader into understanding the details of this widely used microcomputer operating system.

Osborne CP/M User Guide by Thom Hogan, Osborne, paper, \$12.99

One of the most complete and up-to-date CP/M books available. This book contains easy-to-understand descriptions of the CP/M operating system and commands. It also contains detailed technical information for more experienced users.

Using CP/M by Judi Fernandez and Ruth Ashley, John Wiley, paper, \$12.95

This is a complete, detailed introduction to the use of CP/M, written in an easy-to-understand style.

Vanloves CP/M Software Directory edited by Rolland Love and Gerald Van Diver, Vital Information, paper, \$24.95.

This up-to-date computer resource for CP/M describes peripherals, software, and accessories for CP/M systems. It includes a bibliography and lists of user groups, magazines, supplies, and computer accessories.

B.2 Z80 Books

8080/Z80 Assembly Language by Alan Miller, John Wiley, paper, \$10.95

A step-by-step guide to programming the 8080 and Z80 microprocessors. This book helps intermediate and advanced programmers to get even more out of their 8080/Z80.

Programming the Z80 by Rodnay Zaks, SYBEX, paper, \$15.95

This book covers the Z80 from basic concepts through advanced programming techniques. Exercises are offered to measure reader comprehension along the way. The book's topics range from hardware organizations to data structures.

Z80 and 8080 Assembly Language Programming by Kathe Spracklen, Hayden Book Co., paper, \$9.70

This book covers programming techniques and gives complete instruction sets for the 8080 and Z80 microprocessors. Each chapter includes exercises and answers to help readers learn to use the Z80 and 8080 more efficiently.

Z80 Microcomputer Design Projects by William Barden, Howard W. Sams, paper, \$13.95

This book gives a solid, in-depth look at the popular Z80 microprocessor. It provides a complete look at the internal architecture of the Z80.

Z80 Microcomputer Handbook by William Barden, Howard W. Sams, paper, \$11.95

This book is designed to teach you about the Z80. There is extensive coverage of Z80 machine language and the Z80 assembler language.

Z80 Microcomputer Programming and Interfacing, Books 1 and 2 by Elizabeth Nichols, Howard W. Sams, paper, Book 1—\$12.95, Book 2—\$12.95, Book 1 & 2—\$24.95

Book 1 introduces computers to readers who have no background in computer science. Book 2 assumes a familiarity with Book 1 and continues an in-depth discussion of the design and use of the popular Z80 microprocessor. Both volumes are written in a self-teaching format with exercises and answers.

Z80 User's Manual by Joseph Carr, Prentice-Hall, paper, \$15.95

An all-in-one guide to the Z80. This book is useful for both beginning and advanced Z80 users. It includes in-depth technical details for the Z80.

APPENDIX C

CP/M COMMAND LIST

This appendix is a simple listing of CP/M commands. For details on these commands, see Chapter 5.

Load and execute a program:

[disk-id:]filename <CR>

Change the currently logged disk:

disk-id:

Assemble a Z80 assembler program:

ASM filename[.parms]

ASM error codes are given in Table 5.4.

Run the CP/M debugger:

DDT [[disk-id:]filename[.type]]

DDT commands are given in Table 5.5.

Get a directory listing:

DIR [disk-id:]filename.type]

Dump a file in ASCII and hexadecimal format:

DUMP [disk-id:]filename.type

Edit a file:

ED [*disk-id:filename[.type]*] [[*disk-id2:filename2[.type2]*]]

ED control characters are given in Table 5.8.
ED commands are given in Table 5.9.

Erase a file:

ERA [*disk-id:filename.type*]

Create an executable module from ASM output:

LOAD [*disk-id:filename*]

Copy a new version of CP/M:

MOVCP [{ * | *size* }] [*]

Copy a file or disk:

PIP *destination=source[command-parameters]*

Table 5.10 gives PIP logical devices.

Table 5.11 gives special PIP devices.

Table 5.12 gives PIP command parameters.

Rename a file:

REN [*disk-id: new-file = old-file*]

Save *page-num* 256-byte pages of memory beginning at the start of the TPA (100 hexadecimal):

SAVE *page-num [disk-id:filename[. type]]*

Get disk and I/O device status information:

STAT command

Table 5.13 shows STAT command options.

Table 5.14 shows STAT command attributes.

Submit a file for batch execution:

SUBMIT [*disk-id:*]*filename [parameters]*

Generate a new CP/M system:

SYSGEN [[*disk-id:*]*filename.type*]

Print a file to the screen:

TYPE [*disk-id:*]*filename.type*

Change the user number:

USER [*user-num*]

Include keyboard data in your SUBMIT file:

XSUB

ASCII, CHR\$, AND HEXADECIMAL CHARACTER CODES

When running in *native mode* your Commodore 64 uses two sets of character codes:

- CHR\$ Codes (see Appendix F of your Commodore 64 User's Guide).
- Screen Display Codes (see Appendix E of your Commodore 64 User's Guide).

CP/M employs another character code set called the **ASCII Character Codes** (shown in Table D.1 below).

NOTE: The CTRL-Shifted column of Table D.1 shows the values generated when you hold the **CTRL** key down and press the character key.

When you use the CONFIG utility to alter character code values, you must supply the ASCII *hexadecimal* value of the new character. Therefore, the character code values shown in Table D.1 are expressed in hexadecimal.

If you're not sure what a hexadecimal value is, don't worry. Look up the character in Table D.1 and use the value shown (including the letters).

Table D.1 ASCII Character Codes (Hexadecimal Values)

CHARACTER	HEX VALUE	CTRL SHIFTED
RUN/STOP	03	03
INS/DEL	08	18
RETURN	0D	0D
CLR/HOME	1B	7F
LEFT/RIGHT	1C/1D	1D
UP/DOWN	1E/1F	1F
SPACE	20	20

Table D.1 (Continued)

CHARACTER	HEX VALUE	CTRL SHIFTED
!	21	21
"	22	22
#	23	23
*	24	24
%	25	25
&	26	26
,	27	27
(28	28
)	29	29
*	2A	2A
+	2B	2B
,	2C	7B
	2D	2D
.	2E	7D
/	2F	5C
0	30	00
1	31	31
2	32	32
3	33	33
4	34	34
5	35	35
6	36	36
7	37	37
8	38	7B
9	39	7D
:	3A	7B
;	3B	7D
aa	40	60
a	41	01
b	42	02
c	43	03
d	44	04
e	45	05
f	46	06
g	47	07
h	48	08
i	49	09
j	4A	0A

Table D.1 (Continued)

CHARACTER	HEX VALUE	CTRL SHIFTED
k	4B	0B
l	4C	0C
m	4D	0D
n	4E	0E
o	4F	0F
p	50	10
q	51	11
r	52	12
s	53	13
t	54	14
u	55	15
v	56	16
w	57	17
x	58	18
y	59	19
z	5A	1A
£	5C	7C
.	5E	7E
←	5F	5F
A	61	01
B	62	02
C	63	03
D	64	04
E	65	05
F	66	06
G	67	07
H	68	08
I	69	09
J	6A	0A
K	6B	0B
L	6C	0C
M	6D	0D
N	6E	0E
O	6F	0F
P	70	10
Q	71	11
R	72	12
S	73	13

Table D.1 (Continued)

CHARACTER	HEX VALUE	CTRL SHIFTED
T	74	14
U	75	15
V	76	16
W	77	17
X	78	18
Y	79	19
Z	7A	1A
F1	80	81
F2	81	81
F3	82	83
F4	83	83
F5	84	85
F8	85	85
F7	86	87
F8	87	87

APPENDIX E

BIOS AND BOOT LISTINGS

This appendix gives the source listings for the BIOS and BOOT programs on the 6510 and the Z80.

Xerox to Commodore 64 Receive Utility

COPYRIGHT © 1982
COMMODORE INTERNATIONAL

0100 =	TPA	EQU	100H	;START ADDRESS OF PROGRAM
005C =	FCB	EQU	005CH	;FILE CONTROL BLOCK
0080 =	DMADDR	EQU	0080H	;DMA ADDRESS
000D =	CR	EQU	0DH	;CARRIAGE RETURN
0006 =	ACK	EQU	06H	
0015 =	NAK	EQU	15H	
0000 =	BOOT	EQU	0000H	
0005 =	BDOS	EQU	0005H	
0E00 =	SIO	EQU	0E00H	
FF00 =	MEM	EQU	OFF00H	;BUFFER MEMORY
0300 =	PGM65	EQU	0300H	
0080 =	SIZE65	EQU	128	
	:			
	:			SYNTAX FOR COMMAND IS
	:			
	:			RECEIVE FILENAME.EXT
	:			
0100	ORG	TPA		
	:			
0100 31D802		LXI	SP,STACK	;SET UP LOCAL STACK
	:			
	:			CHECK FOR VALID FILENAME
	:			
0103 113B02		LXI	D,NONAME	;NONAME MESSAGE
0106 3A5D00		LDA	FCB + 1	

0109 FE20	CPI	"		
010B CAE201	JZ	DONE	;IF SPACE, NO NAME GIVEN	
;				
010E 115802	LXI	D,BADNAME	;CHECK FOR AMBIGUOUS NAME	
0111 215C00	LXI	H,FCB		
0114 3E3F	MVI	A,'?'		
0116 0610	MVI	B,16	;COUNTER	
;				
0118 BE	QLOOP:	CMP	M	;IS IT '?'
0119 CAE201		JZ	DONE	;IF SO, BAD NAME
,				
011C 23	INX	H		
011D 05	DCR	B		
011E C21801	JNZ	QLOOP	;DO 16 TIMES	
,				
0121 118000	LXI	D,DMADDR		
0124 CD1702	CALL	SETDMA		
;				
;			TRANSFER 6510 CODE TO \$E00 (OFE00H)	
;				
;				
0127 0680	MVI	B,SIZE65		
0129 210003	LXI	H,PGMA65		
012C 1100FE	LXI	D,OFE00H		
,				
012F 78	MOV	A,B		
0130 A7	ANA	A		
0131 CA3C01	JZ	SKIP		
0134 7E	LOADLP	MOV	A,M	
0135 12	STAX	D		
0136 23	INX	H		
0137 13	INX	D		
0138 05	DCR	B		
0139 C23401	;	JNZ	LOADLP	
;			GET READY BY OPENING FILES	
;				
013C 115C00	SKIP:	LXI	D,FCB	
013F CD1D02	CALL	DELETE		
0142 115C00	LXI	D,FCB		
0145 CD2302	CALL	MAKE		
;				

0148	117602	LXI	D,NODIR	
014B	3C	INR	A	;WAS 255 IF NO FILE SPACE
014C	CAE201	JZ	DONE	
;				
014F	118000	LXI	D,DMADDR	
0152	CD1702	CALL	SETDMA	
;				
0155	AF	READS:	XRA	A
0156	32B702		STA	POINT
;				
;				
0159	3E06	GNEXT:	MVI	A,ACK
015B	32FFE	GBLK.	STA	0FEFFH ;SEND INITIAL ACK
;				
015E	3E07	MVI	-	A,7
0160	3200F9	STA		0F900H
0163	3E01	MVI		A,1
0165	3200CE	STA		0CE00H
0168	00	NOP		
;				
; NEED TEST FOR ERROR				
;				
0169	3AFFFE	LDA	0FEFFH	
016C	A7	ANA	A	
016D	C2C401	JNZ	AGAIN	
;				
;				
0170	118000	LXI	D,DMADDR	
0173	3AB702	LDA	POINT	
0176	B3	ORA	E	
0177	5F	MOV	E,A	
0178	2100FF	LXI	H,MEM	
017B	7E	MOV	A,M	
017C	FE3A	CPI	'.'	
017E	C2C401	JNZ	AGAIN	
;				
0181	AF	XRA	A	
0182	32B602	STA	BADDAT	
0185	CDE801	CALL	GYBTE	
0188	A7	ANA	A	
0189	CAD901	JZ	FINISH	

018C FE20	CPI	32	
018E C2C401	JNZ	AGAIN	
;			
;			
0191 0E00	GETQ:	MVI	C,0 ;CHECKSUM
0193 47		MOV	B,Z ;COUNTER
;			
0194 C5	GQLP:	PUSH	B
0195 CDE801		CALL	GBYTE
;			
0198 12		STAX	D
0199 1C		INR	E
019A C1		POP	B
019B 81		ADD	C
019C 4F		MOV	C,A
019D 05		DCR	B
019E C29401		JNZ	GQLP
;			
01A1 C5		PUSH	B
01A2 CDE01		CALL	CBYTE
01A5 C1		POP	B
01A6 81		ADD	C
01A7 C2C401		JNZ	AGAIN
;			
01AA 3AB602		LDA	BADDAT
01AD B7		ORA	A
01AE C2C401		JNZ	AGAIN
;			
;			
01B1 3AB702		LDA	POINT
01B4 C620		ADI	32
01B6 32B702		STA	POINT
01B9 FE80		CPI	128
01BB C25901		JNZ	GNEXT
;			
01BE CDC901		CALL	SWRITE
01C1 C35501		JMP	READS
;			
01C4 3E15	AGAIN:	MVI	A,NAK
01C6 C35801		JMP	GBLK
;			

01C9 115C00	SWRITE:	LXI	D,FCB
01CC CD2902		CALL	WRITE
01CF 119502		LXI	D,DFULL
01D2 B7		ORA	A
01D3 C2E201		JNZ	DONE
;			
01D6 C9		RET	
01D7 00		NOP	
01D8 00		NOP	
;			
01D9 115C00	FINISH:	LXI	D,FCB
01DC CD2F02		CALL	CLOSE
01DF 11A102		LXI	D,EOTRAN
;			
01E2 CD3502	DONE.	CALL	PRINT
01E5 C30000		JMP	BOOT
;			
;			
;			
01E8 CDF501	GBYTE:	CALL	GNIB
01EB 87		ADD	A
01EC 87		ADD	A
01ED 87		ADD	A
01EE 87		ADD	A
01EF 47		MOV	B,A
01F0 CDF501		CALL	GNIB
01F3 80		ADD	B
01F4 C9		RET	
;			
01F5 23	GNIB:	INX	H
01F6 7E		MOV	A,M
01F7 FE30		CPI	'0'
01F9 DA1102		JC	NOTHEX
01FC FE3A		CPI	'9' + 1
01FE DA0E02		JC	NUMBER
0201 FE41		CPI	'A'
0203 DA1102		JC	NOTHEX
0206 FE47		CPI	'F' + 1
0208 D21102		JNC	NOTHEX
;			
020B D637	ALPHA:	SUI	'A'-10

020D C9		RET	
	,		
020E D630	NUMBER:	SUI	0'
0210 C9		RET	
	,		
0211 3EFF	NOTHEX:	MVI	A,OFFH
0213 32B602		STA	BADDAT
0216 C9		RET	
	:		
	:		
	:		
0217 0E1A	SETDMA:	MVI	C,26
0219 CD0500		CALL	BDOS
021C C9		RET	
	,		
021D 0E13	DELETE:	MVI	C,19
021F CD0500		CALL	BDOS
0222 C9		RET	
	,		
0223 0E16	MAKE.	MVI	C,22
0225 CD0500		CALL	BDOS
0228 C9		RET	
	,		
0229 0E15	WRITE:	MVI	C,21
022B CD0500		CALL	BDOS
022E C9		RET	
	,		
022F 0E10	CLOSE:	MVI	C,16
0231 CD0500		CALL	BDOS
0234 C9		RET	
	,		
	,		
0235 0E09	PRINT:	MVI	C,9
0237 CD0500		CALL	BDOS
023A C9		RET	
	,		
023B 46494C454E	NONAME: DB		'FILENAME MUST BE SPECIFIED',ODH,ODH,'\$'
	,		
0258 414D424947	BADNAM: DB		'AMBIGUOUS FILES NOT ALLOWED',ODH,ODH,'\$'

0276	4E4F204449	NODIR:	DB	'NO DIRECTORY SPACE AVAILABLE'
0292	0D0D24		DB	ODH,ODH,'\$'
		;		
0295	4449534B20	DFULL:	DB	'DISK FULL'
029E	0D0D24		DB	ODH,ODH,'\$'
		;		
		;		
02A1	5452414E53	EOTRAN:	DB	'TRANSFER COMPLETE.',ODH,ODH,'\$'
		;		
02B6		BADDAT:	DS	1
02B7		POINT:	DS	1
		;		
02B8			DS	32
02DB =		STACK	EQU	\$

Commodore 64 Copy Utility 1.0

COPYRIGHT © 1982
COMMODORE INTERNATIONAL

0100		ORG	100H	
		;		
		;		EQUATES
		;		
F800 =	BUFFER	EQU	0F800H	
F900 =	CMD	EQU	0F900H	
F901 =	DATA	EQU	0F901H	
F902 =	SECTOR	EQU	0F902H	
F903 =	TRACK	EQU	0F903H	
F904 =	DISKNO	EQU	0F904H	
0001 =	OFF	EQU	1	
CE00 =	MODESW	EQU	0CE00H	
0000 =	VICRD	EQU	0	
0001 =	VICWR	EQU	1	
0006 =	VICFMT	EQU	6	
0005 =	BDOS	EQU	0005H	
0000 =	BOOT	EQU	0000H	
000D =	CR	EQU	0DH	;CARRIAGE RETURN
000A =	LF	EQU	0AH	;LINE FEED

000C =	CLS	EQU	0CH	;CLEAR SCREEN
	;			
0100 316B06	START:	LXI	SP,STACK	
0103 111403		LXI	D,COPMSG	
0106 CD0503	;	CALL	PRINT	;PROGRAM NAME, ETC.
0109 CD0003	IN1TO4:	CALL	CONIN	
	;			
010C FE31		CPI	'1'	
010E CA2301		JZ	FORMAT	
	;			
0111 FE32		CPI	'2'	
0113 CAD701		JZ	BACKUP	
	;			
0116 FE33		CPI	'3'	
0118 CA7B01		JZ	SYSTEM	
	;			
011B FE34		CPI	'4'	
011D CA0000		JZ	BOOT	
	;			
0120 C30901		JMP	IN1TO4	
	;			
0123 11A603	FORMAT	LXI	D,FMTMSG	;FORMAT A DISK
0126 CD0503		CALL	PRINT	
	;			
0129 CDDB02		CALL	CRORRS	;GET KEYBOARD INPUT
012C CA0001		JZ	START	;IF RUN/STOP, GO TO MENU
	;			
012F 116104		LXI	D,FMTING	;FORMATTING MESSAGE
0132 CD0503		CALL	PRINT	
	;			
0135 3E06		MVI	A,VICFMT	
0137 CD0A03		CALL	IO6510	;SEND FORMAT COMMAND TO 6510
	;			
013A 3A01F9		LDA	DATA	;CHECK FOR ERROR
013D A7		ANA	A	
013E C27501		JNZ	FMTERR	
	;			
0141 2100F8		LXI	H,BUFFER	;FILL DISK BUFFER WITH E5's
0144 3EE		MVI	A,0E5H	;FOR DIRECTORY SECTORS
0146 77	FMT0:	MOV	M,A	

0147 2C		INR	L	
0148 C24601		JNZ	FMTO	;DO THIS 256 TIMES
;				
014B 3E03		MVI	A,3	
014D 3203F9		STA	TRACK	;DIRECTORY TRACK
;				
0150 3E00		MVI	A,0	
0152 3204F9		STA	DISKNO	;FORCE DRIVE 0
;				
0155 3E00		MVI	A,0	;INITIAL SECTOR
;				
0157 3202F9	FMT1:	STA	SECTOR	;SET SECTOR
015A 3E01		MVI	A,VICWR	;GET READY FOR WRITE
015C CD0A03		CALL	IO6510	;GO DO IT
015F 3A01F9		LDA	DATA	;A=0 IF OK
0162 A7		ANA	A	
0163 C27501		JNZ	FMTERR	
;				
0166 3A02F9		LDA	SECTOR	
0169 3C		INR	A	
016A FE08		CPI	8	;DO ONLY SECTORS 0-7
016C C25701		JNZ	FMT1	;LOOP UNTIL DONE
;				
016F 118704		LXI	D,FMTDON	
0172 C37502		JMP	DONE	
;				
0175 119A04	FMTERR:	LXI	D,FMTERM	
0178 C37502		JMP	DONE	
;				
017B 11D304	SYSTEM:	LXI	D,SYSMSG	;SYSTEM TRACKS ONLY
017E CD0503		CALL	PRINT	
;				
0181 112905		LXI	D,SRCMSG	
0184 CD0503		CALL	PRINT	
;				
0187 116905		LXI	D,PRSMMSG	
018A CD0503		CALL	PRINT	
018D CDDB02		CALL	CRORRS	
\$190 CA0001		JZ	START	;IF SPACEBAR, GO TO MENU
;				
0193 CDEA02	;	CALL	CRLF	

0196 216B06		LXI	H, MEM	;BEGINNING OF MEMORY SPACE ***
;				
0199 3E01		MVI	A, 1	
0198 CD8402		CALL	RDTRK	;READ TRACK 1
;				
019E 3E02		MVI	A, 2	
01A0 CD8402		CALL	RDTRK	;READ TRACK 2
;				
01A3 3E12		MVI	A, 18	
01A5 CD8402		CALL	RDTRK	;READ TRACK 18
;				
01A8 114905		LXI	D,DSTMSG	;PRINT DESTINATION MESSAGE
01AB CD0503		CALL	PRINT	
;				
01AE 110F06		LXI	D,RTNMSG	
01B1 CD0503		CALL	PRINT	
;				
01B4 CD0003	SYS1.	CALL	CONIN	
01B7 FE0D		CPI	CR	,WAIT FOR CARRIAGE RETURN
01B9 C2B401		JNZ	SYS1	
;				
01BC CDEA02		CALL	CRLF	
;				
01BF 216B06		LXI	H, MEM	;SETUP FOR WRITE ***
;				
01C2 3E01		MVI	A, 1	
01C4 CDAE02		CALL	WRTRK	
;				
01C7 3E02		MVI	A, 2	
01C9 CDAE02		CALL	WRTRK	
;				
01CC 3E12		MVI	A, 18	
01CE CDAE02		CALL	WRTRK	
;				
01D1 118E05		LXI	D,SYSDON	
01D4 C37502		JMP	DONE	
;				
01D7 11AC05	BACKUP:	LXI	D,BAKMSG	;BACKUP DISK
01DA CD0503		CALL	PRINT	
;				

01DD 116905	LXI	D,PRSMMSG	
01EO CD0503	CALL	PRINT	
01E3 CDD802	CALL	CRORRS	
01E6 CA0001	JZ	START	
01E9 CDEA02	CALL	CRLF	
	:		
01EC 3E01	MVI	A,1	;START WITH TRACK 1
01EE 3203F9	STA	TRACK	
	:		
01F1 3E05	MVI	A,5	;DO OUTER LOOP 5 TIMES
01F3 324A06	STA	OUTER	
	:		
01F6 3A03F9	BKLP:	LDA	TRACK
01F9 324806		STA	WTRACK ;SAVE FOR WRITE TRACK
	:		
01FC 3E07	MVI	A,7	
01FE 324906	STA	INNER	;INNER LOOP COUNTER
	:		
0201 112905	LXI	D,SRCMSG	
0204 CD0503	CALL	PRINT	
	:		
0207 110F06	LXI	D,RTNMSG	
020A CD0503	CALL	PRINT	
	:		
020D CD0003	BKRD1.	CALL	CONIN
0210 FE0D		CPI	CR
0212 C20D02		JNZ	BKRD1
	:		
0215 216B06	LXI	H,MEM	;START OF AVAILABLE MEMORY
	,		
0218 3A03F9	BKRD:	LDA	TRACK
021B CD8402		CALL	RDTRK
021E 3A03F9		LDA	TRACK
0221 3C		INR	A
0222 3203F9		STA	TRACK
0225 3A4906		LDA	INNER
0228 3D		DCR	A
0229 324906		STA	INNER
022C C21802		JNZ	BKRD
	:		
022F 3A4806		LDA	WTRACK

0232 3203F9		STA	TRACK	;RESTORE TRACK POINTER
0235 3E07		MVI	A,7	
0237 324906		STA	INNER	;INNER COUNTER
;				
023A 114905		LXI	D,DSTMSG	
023D CD0503		CALL	PRINT	
0240 110F06		LXI	D,RTNMSG	
0243 CD0503		CALL	PRINT	
;				
0246 CD0003	BKWR1:	CALL	CONIN	
0249 FE0D		CPI	0DH	
024B C24602		JNZ	BKWR1	
;				
024E 216B06		LXI	H,MEM	;START OF MEMORY AGAIN
;				
0251 3A03F9	BKWR:	LDA	TRACK	
0254 CDAE02		CALL	WRTRK	
0257 3A03F9		LDA	TRACK	
025A 3C		INR	A	
025B 3203F9		STA	TRACK	
025E 3A4906		LDA	INNER	
0261 3D		DCR	A	
0262 324906		STA	INNER	
0265 C25102		JNZ	BKWR	
;				
0268 214A06		LXI	H,OUTER	
026B 35		DCR	M	
026C C2F601		JNZ	BKLP	
;				
;				
026F 11FC05		LXI	D,BAKDON	
0272 C37502		JMP	DONE	
;				
0275 CD0503	DONE.	CALL	PRINT	;PRINT DONE MESSAGE
;				
0278 11B804		LXI	D,ANYKEY	
027B CD0503		CALL	PRINT	
027E CD0003		CALL	CONIN	,WAIT FOR ANY KEY
0281 C30001		JMP	START	
;				
0284 3203F9	RDTRK:	STA	TACK	,A=TRACK ON ENTRY

0287 3E00		MVI	A,0	;START WITH SECTOR 0
	;			
0289 3202F9	RD1:	STA	SECTOR	
028C 3E00		MVI	A,VICRD	;READ SECTOR COMMAND
028E CD0A03		CALL	IO6510	;GO DO IT
0291 3A01F9		LDA	DATA	
0294 A7		ANA	A	
0295 C2FA02		JNZ	RDERR	,READ ERROR IF <>0
	;			
0298 1100F8		LXI	D,BUFFER	
029B 1A	RD2:	LDAX	D	;GET CHARACTER FROM BUFFER
029C 77		MOV	M,A	; AND PUT IN MEMORY
029D 13		INX	D	
029E 23		INX	H	;BUMP POINTERS
029F 7B		MOV	A,E	;DONE 256 YET?
02A0 A7		ANA	A	
02A1 C29B02		JNZ	RD2	;JUMP IF NO
	;			
02A4 3A02F9		LDA	- SECTOR	
02A7 3C		INR	A	
02A8 FE11		CPI	17	,17 = LAST SECTOR + 1
02AA C28902		JNZ	RD1	
	;			
02AD C9		RET		
	;			
02AE 3203F9	WRTRK:	STA	TRACK	;A = TRACK ON ENTRY
02B1 3E00		MVI	A,0	
	;			
02B3 3202F9	WR1:	STA	SECTOR	
02B6 1100F8		LXI	D,BUFFER	
02B9 7E	WR2:	MOV	A,M	
02BA 12		STAX	D	;PUT CHAR IN BUFFER
02BB 23		INX	H	
02BC 13		INX	D	;INCREMENT POINTERS
02BD 7B		MOV	A,E	;DONE 256 YET?
02BE A7		ANA	A	
02BF C2B902		JNZ	WR2	;JUMP IF NO
	;			
02C2 3E01		MVI	A,VICWR	;SECTOR WRITE COMMAND
02C4 CD0A03		CALL	IO6510	;GO DO IT
	;			

02C7 3A01F9	LDA	DATA		
02CA A7	ANA	A		
02CB C2F402	JNZ	WRERR	;JUMP IF WRITE ERROR	
02CE 3A02F9	LDA	SECTOR		
02D1 3C	INR	A		
02D2 FE11	CPI	17	;17=LAST SECTOR+1	
02D4 C2B302	JNZ	WR1	;KEEP READING	
 ;				
02D7 C9	RET			
 ;				
02D8 FE20	CR1.	CPI	20H	;SPACEBAR?
02DA C8		RZ		
 ;				
02DB CD0003	CRORRS-	CALL	CONIN	
02DE FE0D		CPI	CR	;CARRIAGE RETURN
02E0 C2DB02		JNZ	CR1	
 ;				
02E3 A7	ANA	A	;KILL ZERO FLAG	
02E4 C9	RET			
 ;				
02E5 0E02	CONOUT:	MVI	C,2	
02E7 C30500		JMP	BDOS	
 ;				
02EA 1E0D	CRLF:	MVI	E.CR	
02EC CDE502		CALL	CONOUT	
02EF 1EOA		MVI	E,LF	
02F1 C3E502		JMP	CONOUT	
 ;				
02F4 111D06	WRERR:	LXI	D,WRMSG	
02F7 C37502		JMP	DONE	
 ;				
02FA 113306	RDERR:	LXI	D,RDMSG	
02FD C37502		JMP	DONE	
 ;				
0300 0E01	CONIN:	MVI	C,1	
0302 C30500		JMP	BDOS	
 ;				
0305 0E09	PRINT:	MVI	C,9	
0307 C30500		JMP	BDOS	
 ;				
030A 3200F9	IO6510:	STA	CMD	,PUT A IN 6510 COMMAND REGISTER

030D 3E01	MVI	A,OFF
030F 3200CE	STA	MODESW ,TURN OFF Z80
0312 00	NOP	
0313 C9	RET	
;		
;		
; TEXT AND MESSAGES:		
;		
0314 0C0A434F4D COPMSG-	DB	CLS,LF,'COMMODORE 04 UTILITY 1 0'
0333 0D0A0A	DB	CR,LF,LF
0336 2020312E20	DB	'1. FORMAT DISK',CR,LF
0349 2020322E20	DB	'2. BACKUP DISK',CR,LF
035C 2020332E20	DB	'3. COPY SYSTEM TRACKS ONLY',CR,LF
037B 2020342E20	DB	'4. EXIT',CR,LF,LF
0388 504C454153	DB	'PLEASE CHOOSE FUNCTION (1-4) \$'
;		
03A6 0C0A464F52 FMTMSG:	DB	CLS,LF,'FORMAT DISK UTILITY',CR,LF,LF
03BE 494E495449	DB	'INITIALIZES DISK FOR CP/M',CR,LF
03D9 0A43415554	DB	LF,'CAUTION! FORMAT ERASES ALL DATA',CR,LF,LF
03FD 504C414345	DB	'PLACE DISK TO BE FORMATTED IN',CR,LF
041C 4452495645	DB	'DRIVE 0 AND PRESS ENTER',CR,LF,LF
0436 202020204F	DB	' OR',CR,LF,LF
043F 5052455353	DB	'PRESS SPACEBAR TO RETURN TO MENU \$'
;		
0461 0D0A0A464F FMTING:	DB	CR,LF,LF,'FORMATTING DISK, PLEASE WAIT...'
0483 0D0A0A24	DB	CR,LF,LF,'\$'
;		
0487 464F524D41 FMTDON:	DB	'FORMAT COMPLETE',CR,LF,LF,'\$'
;		
049A 492043414E FMTERM:	DB	'I CANNOT FORMAT THIS DISK!',CR,LF,LF,'\$'
;		
04B8 5052455353 ANYKEY:	DB	'PRESS ANY KEY TO CONTINUE \$'
;		
04D3 0C0A535953 SYSMSG-	DB	CLS,LF,'SYSTEM TRACK COPY UTILITY',CR,LF,LF
04F1 434F504945	DB	'COPIES SYSTEM TRACKS FROM MASTER DISK',CR,LF
0518 544F20534C	DB	'TO SLAVE DISK',CR,LF,LF,'\$'
;		
0529 494E534552 SRCMSG:	DB	'INSERT MASTER DISK IN DRIVE 0',CR,LF,'\$'
0549 494E534552 DSTMSG:	DB	'INSERT SLAVE DISK IN DRIVE 0',CR,LF,'\$'

0569	5052455353	PRMSG-	DB	'PRESS RETURN (OR SPACEBAR FOR MENU) \$'
		,		
058E	5359535445	SYSDON:	DB	'SYSTEM TRACK COPY COMPLETE',CR,LF,LF,'\$'
		,		
05AC	0C0A444953	BAKMSG:	DB	CLS,LF,'DISK BACKUP UTILITY',CR,LF,LF
05C4	5448452045		DB	'THE ENTIRE MASTER DISK IS ',CR,LF
05E0	434F504945		DB	'COPIED TO THE SLAVE DISK',CR,LF,LF
05FB	24		DB	'\$'
		,		
05FC	4241434B55	BAKDON:	DB	'BACKUP COMPLETE',CR,LF,LF,'\$'
		,		
060F	5052455353	RTNMSG:	DB	'PRESS RETURN \$'
		,		
061D	0D0A0A4449	WRMSG:	DB	CR,LF,LF,'DISK WRITE ERROR',CR,LF,'\$'
		,		
0633	0D0A0A4449	RDMSG:	DB	CR,LF,LF,'DISK READ ERROR',CR,LF,'\$'
		,		
0648		WTRACK	DS	1
0649		INNER	DS	1
064A		OUTER	DS	1
064B			DS	32
066B =		STACK	QU	\$
066B =		MEM	EQU	\$
				;***

Z80 Bootstrap Routine for the Commodore 64

COPYRIGHT © 1982
COMMODORE INTERNATIONAL

This routine is loaded from Track 1, Sector 5 of the Commodore 64 CP/M disk by a routine in BIOS65.

The load address is 0000H (with respect to the Z80 CPU). When the Z80 is enabled this program loads the Z80 BIOS and CCP and BDOS into RAM and jumps to it.

3400 =	CCP	EQU	3400H	
	,CCP	EQU	0000H	,FOR MAKING BOOT0.HEX
	,CCP	EQU	0100H	,FOR MAKING BOOT1.HEX
001C =	NSECTS	EQU	1CH	

F903 =	TRACK	EQU	0F903H
F902 =	SECTOR	EQU	0F902H
F904 =	DISKNO	EQU	0F904H
FCFF =	IOTYPE	EQU	0FCFFH ;IO SETUP BYTE IN BIOS65
4A33 =	KYBDMD	EQU	CCP + 1633H ;CAPS LOCK FLAG
0000 =	VICRD	EQU	0
F900 =	CMD	EQU	0F900H
0001 =	OFF	EQU	01H
CE00 =	MODESW	EQU	0CE00H
F901 =	DATA	EQU	0F901H
F800 =	BUFFER	EQU	0FB00H
4A00 =	BOOT	EQU	CCP + 1600H
	;		
0000		ORG	0000H ;Z80 RESET LOCATION
	;		
0000 00		NOP	;NOP REQUIRED FOR HARDWARE
0001 110034		LXI	D,CCP ;START OF LOAD ADDRESS
0004 3E00		MVI	A,0
0006 3204F9		STA	DISKNO ;LOAD IN FROM DRIVE A
0009 2601		MVI	H,1 ;READ BEGINNING TRK 1, SEC 6
000B 2E06		MVI	L,6
000D 7C	LOAD1	MOV	A,H
000E 3203F9		STA	TRACK
0011 7D		MOV	A,L
0012 3202F9		STA	SECTOR
0015 3E00		MVI	A,VICRD ;SECTOR READ COMMAND
0017 3200F9		STA	CMD
001A 3E01		MVI	A,OFF
001C 3200CE		STA	MODESW ;TURN OFF SELF
001F 00		NOP	
0020 3A01F9		LDA	DATA ;WAS TRANSFER OK?
0023 B7		ORA	A
0024 C20D00		JNZ	LOAD1 ;JUMP IF NO
	;		
	;		OUTPUT '*' TO SHOW LOADING
	;		
0027 3E2A		MVI	A,'*' ;PRINT '*'
0029 3201F9		STA	DATA
002C 3E03		MVI	A,3
002E 3200F9		STA	CMD
0031 3E01		MVI	A,OFF

```
0033 3200CE      STA      MODESW
0036 00          NOP
;
;
;      MOVE SECTOR TO MEMORY
;
0037 0100F8      LXI      B,BUFFER
003A 0A          LOAD2: LDAX    B
003B 12          STAX    D
003C 0C          INR     C
003D 1C          INR     E
003E C23A00      JNZ     LOAD2
;
;
;      UPDATE POINTERS
;
;
```

CP/M Version 2.2 System Relocator — 2/80

**CP/M Relocator Program, Included with the Module To
Perform the Move from 900H to the Destination
Address**

**COPYRIGHT © 1980
DIGITAL RESEARCH**

Modified for Use on the Commodore 64

**MODIFICATIONS COPYRIGHT © 1982
COMMODORE INTERNATIONAL**

```
0041                  INR     D
0042 2C                  INR     L
0043 7D                  MOV     A,L
;
;
;      CHECK FOR END OF TRACK
;
0044 FE11                  CPI     17
0046 DA4C00                JC     LOAD3
0049 24                  INR     H
004A 2E00                  MVI     L,0
```

011E C21801	JNZ	QLOOP	;DO 16 TIMES	
;				
0121 118000	LXI	D,DMAADDR		
0124 CD0D02	CALL	SETDMA		
;				
0127 3E07	MVI	A,07H	;1200 BAUD DATA	
0129 D300	OUT	0		
;				
012B 3E18	MVI	A,18H		
012D D306	OUT	6		
012F 210001	LXI	H,0100H		
0132 CD0602	CALL	SETUP		
0135 21C103	LXI	H,03CLH		
0138 CD0602	CALL	SETUP		
013B 214404	LXI	H,0444H		
013E CD0602	CALL	SETUP		
0141 216805	LXI	H,0568H		
0144 CD0602	CALL	SETUP		
;				
0147 115C00	LXI	D,FCB		
014A CD1302	CALL	OPEN		
014D 116002	LXI	D,NOFILE		
0150 3C	INR	A	;WAS 255 IF NO FILE	
0151 CAA201	JZ	DONE		
;				
0154 CDFC01	WTACK:	CALL	SIN	;WAIT FOR INITIAL ACK
0157 FE06	CPI	ACK		
0159 C25401	JNZ	WTACK		
;				
015C 3E00	RDNEXT:	MVI	A,0	
015E 328F02	STA	POINT	;QUARTER SECTOR POINTER	
;				
0161 115C00	LXI	D,FCB		
0164 CD1902	CALL	READ		
0167 B7	ORA	A		
0168 C28B01	JNZ	EOF		
;				
0168 CDA801	AGAIN:	CALL	SEND	;SEND 32 BYTES
;				
016E CDFC01	WTANS:	CALL	SIN	
0171 FE15	CPI	NAK		

0173 CA6801	JZ	AGAIN	,BAD CHECKSUM, SEND AGAIN	
	;			
0176 FE06	CPI	ACK		
0178 C26E01	JNZ	WTANS	,IF NOT ACK, KEEP WAITING	
	;			
0178 3A8F02	LDA	POINT	,POINT TO QUARTER	
017E C620	ADI	32		
0180 328F02	STA	POINT		
0183 FE80	CPI	128		
0185 CA5C01	JZ	RDNEXT	,IF 0, READ ANOTHER SECTOR	
	;			
0188 C36B01	JMP	AGAIN	,SEND NEXT QUARTER	
	;			
0188 3E3A	EOF:	MVI	A,'.'	,OUTPUT START OF STRING
018D CDF001		CALL	SOUT	
	;			
0190 3E30	MVI	A,'0'		
0192 CDF001	CALL	SOUT		
	;			
0195 3E30	MVI	A,'0'		
0197 CDF001	CALL	SOUT		
	;			
019A 3E0D	MVI	A.CR		
019C CDF001	CALL	SOUT		
	;			
019F 117A02	LXI	D,EOTRAN		
	;			
01A2 CD1F02	DONE:	CALL	PRINT	
01A5 C30000		JMP	BOOT	
	;			
01A8 3E3A	SEND:	MVI	A,'.'	
01AA CDF001		CALL	SOUT	
	;			
01AD 3E20	MVI	A,32		
01AF CDD901	CALL	SHOUT	,NUMBER OF DATA BYTES	
	;			
01B2 0E00	MVI	C,0	,CLEAR CHECKSUM	
01B4 218000	LXI	H,DMADDR		
01B7 3A8F02	LDA	POINT	,POINT TO SECTOR QUARTER	
01BA B5	ORA	L		
01BB 6F	MOV	L,A	,OR DATA INTO LSB	
	;			

01BC 79	SEND1:	MOV	A,C	;FORM CHECKSUM
01BD 86		ADD	M	
01BE 4F		MOV	C,A	
01BF 7E		MOV	A,M	;GET CHARACTER
	;			
01C0 E5		PUSH	H	;SAVE ADDRESS
01C1 CDD901		CALL	SHOUT	;OUTPUT HEX DIGITS
01C1 E1		POP	H	
	;			
01C5 2C		INR	L	;NEXT BYTE
01C6 7D		MOV	A,L	
01C7 E61F		ANI	1FH	;CHECK FOR MOD 32
01C9 C2BC01		JNZ	SEND1	;DO 32 TIMES
	;			
01CC 79		MOV	A,C	;FIX CHECKSUM
01CD EEFF		XRI	OFFH	
01CF 3C		INR	A	
01D0 CDD901		CALL	SHOUT	
	;			
01D3 3E0D		MVI	A,0DH	
01D5 CDF001		CALL	SOUT	
01D8 C9		RET		
	;			
01D9 F5	SHOUT:	PUSH	PSW	
01DA 0F		RRC		
01DB 0F		RRC		
01DC 0F		RRC		
01DD 0F		RRC		
01DE CDE201		CALL	SNOUT	;OUTPUT HIGH Nibble
	;			
01E1 F1		POP	PSW	
01E2 E60F	SNOUT:	ANI	0FH	;MASK OFF BITS
01E4 FEOA		CPI	10	
01E6 DAEE01		JC	SNUM	
01E9 C637		ADI	'A'-10	
01EB C3F001		JMP	SOUT	
	;			
01EE C630	SNUM:	ADI	'0'	
	;			
01F0 F5	SOUT:	PUSH	PSW	
01F1 DB06	SOUT:IN		06H	,XEROX CHANNEL A CONTROL

01F3 E604	ANI	04H	
01F5 CAF101	JZ	SOUT1	
;			
01F8 F1	POP	PSW	
01F9 D304	OUT	04H	;XEROX CHANNEL A DATA
01FB C9	RET		
;			
01FC DB06	SIN:	IN	6
01FE E601	ANI	01H	
0200 CAFC01	JZ	SIN	
0203 DB04	IN	4	
0205 C9	RET		
;			
0206 7C	SETUP:	MOV	A,H
0207 D306	OUT	6	
0209 7D	MOV	A,1	
020A D306	OUT	6	
020C C9	RET		
;			
020D 0E1A	SETDMA:	MVI	C,26
020F CD0500	CALL	BDOS	
0212 C9	RET		
;			
0213 0EOF	OPEN:	MVI	C,15
0215 CD0500	CALL	BDOS	
0218 C9	RET		
;			
0219 0E14	READ:	MVI	C,20
0218 CD0500	CALL	BDOS	
021E C9	RET		
;			
021F 0E09	PRINT:	MVI	C,9
0221 CD0500	CALL	BDOS	
0224 C9	RET		
;			
0225 46494C454E	NONAME: DB	'FILENAME MUST BE SPECIFIED',0DH,0DH,'\$'	
;			
0242 414D424947	BADNAM: D8	'AMBIGUOUS FILES NOT ALLOWED',0DH,0DH,'\$'	
;			
0260 492043414E	NOFILE: DB	'I CANNOT FIND THAT FILE',0DH,0DH,'\$'	
;			

027A	5452414E53	EOTRAN:	DB	'TRANSFER COMPLETE.',0DH,0DH,'\$'
			;	
028F		POINT:	DS	1
			;	
0290			DS	32
02B0	=	STACK	EQU	\$

I/O Configuration Utility for Commodore 64

**COPYRIGHT © 1982
COMMODORE INTERNATIONAL**

FC00	=	IOMEM	EQU	0FC00H
F800	=	BUFFER	EQU	0F800H
FCFF	=	IOTYPE	EQU	0FCFFH
FC10	=	FNBASE	EQU	0FC10H
FD00	=	KYBASE	EQU	0FD00H
0001	=	VICWR	EQU	1
F900	=	CMD	EQU	0F900H
F901	=	DATA	EQU	0F901H
F902	=	SECTOR	EQU	F902H
F903	=	TRACK	EQU	0F903H
F904	=	DISKNO	EQU	0F904H
F905	=	KYCHAR	EQU	0F905H
0033	=	KYBDMD	EQU	33H
0001	=	CRPOS	EQU	1
F28D	=	SHFTST	EQU	0F28DH
0063	=	LASTKY	EQU	63H
0066	=	MSGPTR	EQU	66H
0009	=	CONINV	EQU	09H
0001	=	OFF	EQU	01H
CE00	=	MODESW	EQU	0CE00H
			;	
0000	=	BOOT	EQU	0000H
0005	=	BDOS	EQU	0005H
000C	=	CLS	EQU	0CH
000D	=	CR	EQU	0DH
000A	=	LF	EQU	0AH
0100			ORG	100H
			;	

0100 318308	START:	LXI	SP,STACK	;INITIALIZE STACK PTR
0103 115E04		LXI	D,IOMSG	
0106 CD7101		CALL	PRINT	
	;			
0109 3AFFFC		LDA	IOTYPE	
010C E601		ANI	01H	;# OF DISKS
010E C631		ADI	'1'	,FORM ASCII
0110 5F		MOV	E,A	
0111 CD7601		CALL	CONOUT	
	;			
0114 11C204		LXI	D,PRTMSG	
0117 CD7101		CALL	PRINT	
	;			
011A 11D604		LXI	D,P1515	
011D 3AFFFC		LDA	IOTYPE	
0120 E602		ANI	02H	;CHECK PRINTER TYPE
	;			
0122 CA2801		JZ	ST1	;1515 IF=0
	;			
0125 11DD04		LXI	D,P4022	;4022 IF=1
	;			
0128 CD7101	ST1:	CALL	PRINT	
	;			
0128 11E404		LXI	D,CAPMSG	
012E CD7101		CALL	PRINT	
	;			
0131 11FB04		LXI	D,ONMSG	;ASSUME ON
0134 3AFFFC		LDA	IOTYPE	
0137 E620		ANI	20H	;BIT 5
	;			
0139 CA3F01		JZ	ST2	
013C 110005		LXI	D,OFFMSG	
	;			
013F CD7101	ST2:	CALL	PRINT	
	;			
0142 110605		LXI	D,MENU	
0145 CD7101		CALL	PRINT	
	;			
0148 CD7B01	ST3:	CALL	KEYIN	
0148 FE31		CPI	'1'	
014D CA9201		JZ	CHGDRV	
	;			

0150 FE32	CPI	'2'	
0152 CA9D01	JZ	CHRPT	
	;		
0155 FE33	CPI	'3'	
0157 CAB601	JZ	CHGCAP	
	;		
015A FE34	CPI	'4'	
015C CAC001	JZ	CHGFNC	
	,		
015F FE35	CPI	'5'	
0161 CACD02	JZ	CHGKEY	
	;		
0164 FE36	CPI	'6'	
0166 CA1A04	JZ	SAVDSK	
	,		
0169 FE37	CPI	'7'	
016B CA0000	JZ	BOOT	
	;		
016E C34801	JMP	ST3	;NOT A VALID RESPONSE
	;		
0171 0E09	PRINT:	MVI	C,9
0173 C30500	JMP	BDOS	
	;		
0176 0E02	CONOUT:	MVI	C,2
0178 C30500	JMP	BDOS	
	;		
017B 1EFF	KEYIN:	MVI	E,OFFH
017D 0E06		MVI	C,6
017F C30500		JMP	BDOS
	;		
0182 2A0100	CONIN:	LHLD	BOOT+1
0185 2E09		MVI	L,CONINV
0187 E9		PCHL	
	;		
0188 3200F9	IO6510:	STA	CMD
01BB 3E01		MVI	A,OFF
018D 3200CE		STA	MODESW
0190 00		NOP	
0191 C9		RET	
	,		
0192 3AFFFC	CHGDRV:	LDA	IOTYPE

0195 EE01	XRI	01H		
0197 32FFFC	STA	IOTYPE		
019A C30001	JMP	START		
;				
019D 21FFFC	CHGPRT:	LXI	H,IOTYPE	
01A0 7E		MOV	A,M	
01A1 E602		ANI	02H	
01A3 CAAD01		JZ	CHGP1	
;				
01A6 7E		MOV	A,M	;GET IOTYPE
01A7 E6F1		ANI	0F1H	;CLEAR BITS FOR 1515 PRINTER
01A9 77		MOV	M,A	
01AA C30001		JMP	START	
;				
01AD 7E	CHGP1:	MOV	A,M	;GET IOTYPE
01AE E6FB		ANI	0FBH	;CLEAR BIT 2
01B0 F60A		ORI	0AH	;SET BITS FOR 4022 PRINTER
01B2 77		MOV	M,A	
01B3 C30001		JMP	START	
;				
01B6 21FFFC	CHGCAP:	LXI	H,IOTYPE	
01B9 7E		MOV	A,M	
01BA EE20		XRI	20H	;INVERT BIT
01BC 77		MOV	M,A	
01BD C30001		JMP	START	
;				
01C0 11707	CHGFNC:	LXI	D,FNKMSG	
01C3 CD7101		CALL	PRINT	
;				
01C6 3E00		MVI	A,0	
01C8 325F08		STA	KYMODE	
01CB 11A007	FNNEXT:	LXI	D,FM1	
01CE CD7101		CALL	PRINT	
01D1 3A5F08		LDA	KYMODE	
01D4 C631		ADI	'1'	
01D6 5F		MOV	E,A	
01D7 CD7601		CALL	CONOUT	
01DA 11A407		LXI	D,FM2	
01DD CD7101		CALL	PRINT	
;				
01E0 CDA802		CALL	CALCAD	
;				

01E3 7E	FN2	MOV	A,M
01E4 23		INX	H
01E5 FE20		CPI	20H
01E7 DAF301		JC	CONTRL
;			
01EA 5F		MOV	E,A
01EB E5		PUSH	H
01EC CD7601		CALL	CONOUT
01EF E1		POP	H
01FO C3E301		JMP	FN2
;			
01F3 F5	CONTRL.	PUSH	PSW
01F4 1E22		MVI	E,'''
01F6 CD7601		CALL	CONOUT
01F9 F1		POP	PSW
01FA FE00		CPI	0
01FC CA0502		JZ	CRLF
;			
01FF 11A907		LXI	D,CRM
0202 CD7101		CALL	PRINT
0205 11AE07	CRLF:	LXI	CD,CRLFM
0208 CD7101		CALL	PRINT
;			
020B 215F08		LXI	H,KYMODE
020E 34		INR	M
020F 7E		MOV	A,M
0210 FE08		CPI	8
0212 C2CB01		JNZ	FNNEXT
;			
0215 11B107		LXI	D,FNINST
0218 CD7101		CALL	PRINT
;			
021B CD7B01	ASKAGN.	CALL	KEYIN
021E D631		SUI	'1'
0220 DA1B02		JC	ASKAGN
;			
0223 FE08		CPI	8
0225 CA0001		JZ	START
0228 D21B02		JNC	ASKAGN
;			
022B 325F08		STA	KYMODE
;			

022E 111C08	LXI	D,FM3	
0231 CD7101	CALL	PRINT	
;			
0234 11A007	LXI	D,FM1	
0237 CD7101	CALL	PRINT	
;			
023A 3A5F08	LDA	KYMODE	;GET CURRENT FN #
023D C631	ADI	'1'	;FORM ASCII
023F 5F	MOV	E,A	
0240 CD7601	CALL	CONOUT	
0243 11A407	LXI	D,FM2	
0246 CD7101	CALL	PRINT	
0249 CDA802	CALL	CALCAD	
024C 225D08	SHLD	KYADDR	
;			
024F 3E00	MVI	A,0	
0251 326208	STA	NUMCHR	
,			
0254 CD7B01	INLOOP:	CALL	KEYIN
0257 FE0D		CPI	0DH
0259 CA8502		JZ	ITSCR
;			
025C FE08		CPI	08H
025E CAB902		JZ	ITS8S
;			
0261 FE1A		CPI	1AH
0263 CA9102		JZ	ITSCZ
;			
0266 FE20		CPI	20H
0268 DA5402		JC	INLOOP
;			
026B FE00		CPI	80H
026D D25402		JNC	INLOOP
;			
0270 47	MOV	B,A	,SAVE CHAR
0271 3A6208	LDA	NUMCHR	
0274 FEOF	CPI	15	;IF ALREADY 15 CHAR,
0276 D25402	JNC	INLOOP	; NO ROOM FOR 00H
;			
0279 C5	PUSH	B	
027A 58	MOV	E,B	

027B CD7601		CALL	CONOUT	
027E C1		POP	B	
;				
027F CD9902		CALL	OUTPUT	
0282 C35402		JMP	INLOOP	,GO FOR MORE
;				
0285 47	ITSCR:	MOV	B,A	;SAVE CHAR
0286 3A6208		LDA	NUMCHR	
0289 FEOF		CPI	15	;NO ROOM IF 15 CHAR
028B D25402		JNC	INLOOP	
;				
028E CD9902		CALL	OUTPUT	
;				
0291 0600	ITSCZ:	MVI	B,0	
0293 CD9902		CALL	OUTPUT	
0296 C3C001		JMP	CHGFNC	
,				
0299 2A5D08	OUTPUT.	LHLD	KYADDR	
029C 3A6208		LDA	NUMCHR	
029F 3C		INR	A	
02A0 326208		STA	NUMCHR	
02A3 3D		DCR	A	
02A4 85		ADD	L	;ADD IN OFFSET
02A5 6F		MOV	L,A	
02A6 70		MOV	M,B	
02A7 C9		RET		
;				
02A8 2110FC	CALCAD:	LXI	H,FNBASE	
02AB 1600		MVI	D,0	
02AD 3A5F08		LDA	KYMODE	
02B0 17		RAL		
02B1 17		RAL		
02B2 17		RAL		
02B3 17		RAL		
02B4 E6F0		ANI	0FOH	
02B6 5F		MOV	E,A	
02B7 19		DAD	D	
02B8 C9		RET		
;				
02B9 3A6208	ITSBS:	LDA	NUMCHR	
02BC FE00		CPI	0	

02BE CA5402	JZ	INLOOP	;IF 0 JUST GO TO LOOP
;			
02C1 3D	DCR	A	
02C2 326208	STA	NUMCHR	
02C5 326208	STA	NUMCHR	
02C5 1E08	MVI	E,08H	,BACKSPACE
02C7 CD7601	CALL	CONOUT	
02CA C35402	JMP	INLOOP	
;			
;			
02CD 114306	CHGKEY-	LXI	D,KYINST
02D0 CD7101		CALL	PRINT
;			
02D3 112F07	CK0.	LXI	D,PRMSG
02D6 CD7101		CALL	PRINT
;			
02D9 CD8201		CALL	CONIN
02DC 2A0100		LHLD	BOOT + 1
02DF 2E33		MVI	L,KYBDMD ,UNSHIFT = 0, CAPS = 1
02E1 46		MOV	B,M
02E2 3A8DF2		LDA	SHFTST ,GET MODIFIER STATUS
02E5 E601		ANI	01H ;IS SHIFT KEY DOWN?
02E7 CAEC02		JZ	CK1 ;JUMP IF NO
;			
02EA 0602		MVI	B,2 ;SHIFT = 2
02EC 3A8DF2	CK1	LDA	SHFTST
02EF E604		ANI	04H ;IS THE CONTROL KEY DOWN?
02F1 CAF602		JZ	CK2 ;JUMP IF NO
;			
02F4 0603		MVI	B,3 ;CONTROL = 3
02F6 2A0100	CK2	LHLD	BOOT + 1
02F9 2E63		MVI	L,LASTKY
02FB 7E		MOV	A,M
02FC 326008		STA	KYCHK ,SAVE FOR EXIT TEST
02FF 87		ADD	A ;*2
0300 B7		ADD	A ;*4
0301 80		ADD	B ;ADD IN OFFSET
0302 2100FD		LXI	H,KY8ASE
0305 85		ADD	L
0306 6F		MOV	L,A ;HL NOW HAS ADDRESS OF KEY
;			

0307 225D08	SHLD	KYADDR	;ADDRESS OF KEY
030A 78	MOV	A,B	,8 IS THE MODE
030B 325F08	STA	KYMODE	
;			
030E 2A0100	LHLD	BOOT + 1	
0311 2E66	MVI	L,MSGPTR	
0313 3600	MVI	M,0	
0315 23	INX	H	
0316 3600	MVI	M,0	,DISABLE MESSAGE MODE IF ANY
;			
0318 113C07	LXI	D,ISMSG	
0318 CD7101	CALL	PRINT	
;			
031E 2A5D08	LHLD	KYADDR	
0321 7E	MOV	A,M	;GET KEY CODE
0322 CD6A03	CALL	PHEX	, AND PRINT IN HEX
;			
0325 114107	LXI	D,INMSG	
0328 CD7101	CALL	PRINT	
;			
032B 3A5F08	LDA	KYMODE	
032E 115E07	LXI	D,UNSH	;UNSHIFT MODE IF 0
0331 FE00	CPI	0	
0333 CA4903	JZ	PMODE	
;			
0336 114607	LXI	D,CAPS	
0339 FE01	CPI	1	
033B CA4903	JZ	PMODE	;CAPS MODE IF 1
;			
033E 114E07	LXI	D,SHIFT	
0341 FE02	CPI	2	
0343 CA4903	JZ	PMODE	;SHIFT MODE IF 2
;			
0346 115607	LXI	D,CONT	;MUST BE CONTROL MODE
;			
0349 CD7101	PMODE:	CALL	PRINT
;			
034C 116607	LXI	D,MODE	
034F CD7101	CALL	PRINT	
;			
0352 CD8603	CALL	GHEX	
;			

0355 C26303	JNZ	ASGKEY		
	;			
0358 3A6008	LDA	KYCHK	,NO CHARACTERS, 2 CR'S?	
035B FE01	CPI	CRPOS	,IS IT CR KEY POSITION?	
035D CA0001	JZ	START	;RESTART IF 2 CR'S	
	;			
0360 C3D302	JMP	CK0	;NEXT KEY	
0363 2A5D08	ASGKEY.	LHLD KYADDR		
0366 77	MOV	M,A	;PUT NEW CHARACTER IN MEMORY	
0367 C3D302	JMP	CK0		
	;			
036A F5	PHEX:	PUSH PSW	;SAVE CHARACTER	
036B 0F		RRC		
036C 0F		RRC		
036D 0F		RRC		
036E 0F		RRC		
036F CD7303	CALL	HEX	;PRINT TOP NIBBLE	
	;			
0372 F1	POP	PSW	;PRINT LOWER NIBBLE	
	;			
0373 E60F	HEX:	ANI 0FH	;4 BITS	
0375 FE0A	CPI	10	;LETTER OR NUMBER?	
0377 DA8003	JC	NUMBER		
	;			
037A C637	ADI	'A'-10	;MAKE HEX LETTER	
037C FF	MOV	E,A		
037D C37601	JMP	CONOUT		
	;			
0380 C630	NUMBER.	ADI	'0'	;MAKE ASCII NUMBER
0382 5F		MOV	E,A	
0383 C37601		JMP	CONOUT	
	;			
0386 3E00	GHEX:	MVI A,0		
0388 326208		STA NUMCHR		
	;			
038B CD8201	GH0:	CALL CONIN		
038E FE0D		CPI 0DH		
0390 C2A503		JNZ GH1		
	;			
0393 3A6208		LDA NUMCHR		

0396 FE00	CPI	0	
0398 C8	RZ		
;			
0399 FE02	CPI	2	
039B C28B03	JNZ	GH0	
;			
039E 3EFF	MVI	A,0FFH	
03A0 A7	ANA	A	
03A1 3A6108	LDA	HEXIN	
03A4 C9	RET		
;			
03A5 FE08	GH1:	CPI	08H
03A7 C2CA03	JNZ	GH4	,JUMP NOT BACKSPACE
;			
03AA 3A6208	LDA	NUMCHR	
03AD FE00	CPI	0	
03AF CA8B03	JZ	GH0	
;			
03B2 3D	DCR	A	
03B3 326208	STA	NUMCHR	
03B6 3A6108	LDA	HEXIN	
03B9 0F	RRC		
03BA 0F	RRC		
03BB 0F	RRC		
03BC 0F	RRC		
03BD E60F	ANI	0FH	
03BF 326108	STA	HEXIN	
03C2 1E08	MVI	E 08H	
03C4 CD7601	CALL	CONOUT	
03C7 C38B03	JMP	GH0	
;			
03CA 47	GH4:	MOV	B,A
03CB 3A6208	LDA	NUMCHR	
03CE FE02	CPI	2	
03D0 CA8B03	JZ	GH0	
;			
03D3 78	MOV	A,B	
03D4 FE30	CPI	'0'	
03D6 DA8B03	JC	GH0	
03D9 FE3A	CPI	'9' + 1	
03DB DAFF03	JC	GOTNUM	
;			

03DE FE41	CPI	'A'	
03E0 DA8803	JC	GH0	
03E3 FE47	CPI	'F' + 1	
03E5 DAF203	JC	GOTLET	
03E8 FE61	CPI	'A'	
03EA DA8803	JC	GH0	
03ED FE67	CPI	'F' + 1	
03EF D28803	JNC	GH0	
;			
03F2 F5	GOTLET	PUSH	PSW
03F3 5F		MOV	E,A
03F4 CD7601		CALL	CONOUT
03F7 F1		POP	PSW
03F8 E60F		ANI	OFH
03FA C609		ADI	9
03FC C30504		JMP	MAKNUM
03FF F5	GOTNUM.	PUSH	PSW
0400 5F		MOV	E,A
0401 CD7601		CALL	CONOUT
0404 F1		POP	PSW
;			
0405 E60F	MAKNUM:	ANI	OFH
0407 47		MOV	B,A
0408 3A6108		LDA	HEXIN
0408 87		ADD	A
040C 87		ADD	A
040D 87		ADD	A
040E 87		ADD	A
040F 80		ADD	B
0410 326108		STA	HEXIN
;			
0413 216208	LXI	H,NUMCHR	
0416 34	INR	M	
0417 C38803	JMP	GH0	
;			
;			

041A 2100FC	SAVDSK	LXI	H,IOMEM
041D 3E03		MVI	A,3
041F 3202F9		STA	SECTOR
0422 1100F8	SAV2:	LXI	D,BUFFER
	;		
0425 7E	SAV1:	MOV	A,M
0426 12		STAX	D
0427 23		INX	H
0428 13		INX	D
0429 7D		MOV	A,L
042A A7		ANA	A
042B C22504		JNZ	SAV1 ;256 TIMES
	;		
042E 3E00		MVI	A,0
0430 3204F9		STA	DISKNO
	;		
0433 3C		INR	A
0434 3203F9		STA	TRACK
	;		
0437 3E01		MVI	A,VICWR
0439 CD8801		CALL	IO6510
043C 3A01F9		LDA	DATA
043F A7		ANA	A
0440 C25204		JNZ	WRERR
	;		
0443 3A02F9		LDA	SECTOR
0446 3C		INR	A
0447 3202F9		STA	SECTOR
044A FE05		CPI	5
044C C22204		JNZ	SAV2 ;WRITE SECTORS 3 AND 4
	;		
044F C30001		JMP	START
	,		
0452 111306	WRERR:	LXI	D,WERMSG
0455 CD7101		CALL	PRINT
0458 CD8201		CALL	CONIN
045B C30001		JMP	START
	;		
	,		
	;	MESSAGES	
	,		

045E	0C0A434F4D	IOMSG:	DB	CLS,LF,'COMMODORE 64 I/O CONFIGURATION UTILITY' CR,LF,LF
0489	5448452043		DB	'THE CURRENT I/O ASSIGNMENTS ARE:',CR,LF,LF
04AC	20204E554D		DB	' NUMBER OF DRIVES. \$'
04C2	0D0A	PRTMSG:	DB	CR,LF
04C4	2020505249		DB	' PRINTER TYPE: \$'
		:		
04D6	313531350D	P1515:	DB	'1515',CR,LF,'\$'
04DD	343032320D	P4022	DB	'4022',CR,LF,'\$'
		:		
04E4	2020494E49	CAPMSG:	DB	' INITIAL CAPS MODE. \$'
		:		
04FB	4F4E0D0A24	ONMSG	DB	'ON',CR,LF,'\$'
0500	4F46460D0A	OFFMSG:	DB	'OFF',CR,LF,'\$'
		,		
0506	0A0A	MENU.	DB	LF,LF
0508	444F20594F		DB	'DO YOU WISH TO',CR,LF,LF
051A	2020312E20		DB	' 1. CHANGE NUMBER OF DISK DRIVES',CR,LF
053E	2020322E20		DB	' 2. CHANGE PRINTER TYPE',CR,LF
0559	2020332E20		DB	' 3. CHANGE INITIAL CAPS MODE',CR,LF
0579	2020342E20		DB	' 4. CHANGE FUNCTION KEY ASSIGNMENTS',CR,LF
05A0	2020352E20		DB	' 5. CHANGE KEY CODES',CR,LF
05BB	2020362E20		DB	' 6 SAVE CURRENT I/O SETUP ON DISK',CR,LF
05DE	2020372E20		DB	' 7. RETURN TO CP/M',CR,LF,LF
05F5	504C454153		DB	'PLEASE ENTER SELECTION (1-7) \$'
		:		
0613	0D0A0A4449	WERMSG:	DB	CR,LF,LF,'DISK WRITE ERROR',CR,LF
0628	5052455353		DB	'PRESS ANY KEY TO CONTINUE \$'
0643	0C0A	KYINST:	DB	CLS,LF
0645	5052455353		DB	'PRESS KEY TO EXAMINE KEY CODE',CR,LF,LF
0665	544F204348		DB	'TO CHANGE KEY CODE, ENTER DATA IN',CR,LF
06B8	2020204845		DB	' HEXADECIMAL AFTER "CHANGE TO" ',CR,LF,LF
06AB	544F204558		DB	'TO EXIT KEY CODE MODE. TYPE "RETURN" ',CR,LF
06D1	2020205457		DB	' TWICE AFTER "PRESS KEY" ',CR,LF,LF
06EE	544F204B45		DB	'TO KEEP CURRENT KEY CODE, TYPE',CR,LF

070E	2020202252	DB	' "RETURN" AFTER "CHANGE TO" ',CR,LF,LF
072E	24	DB	'\$'
072F	0D0A505245	PRSMMSG:	DB CR,LF,'PRESS KEY \$'
		;	
073C	0D49532024	ISMSG:	DB CR,'IS \$'
		;	
0741	20494E2024	INMSG:	DB ' IN \$'
0746	4341505320	CAPS	DB 'CAPS \$'
074E	534849465	SHIFT:	DB 'SHIFT \$'
0756	434F4E5452	CONT.	DB 'CONTROLS\$'
075E	554E534849	UNSH:	DB 'UNSHIFT\$'
0766	204D4F4445	MODE.	DB ' MODE — CHANGE TO \$'
		;	
0779	0C0A544845	FNKMSG:	DB CLS,LF,'THE FUNCTION KEY ASSIGNMENTS ARE ',CR,LF,LF
079F	24	DB	'\$'
07A0	20204624	FM1	DB ' F\$'
		;	
07A4	3A20202224	FM2	DB ': "\$'
		;	
07A9	3C43523E24	CRM	DB '<CR>\$'
07AE	0D0A24	CRLFM	DB CR,LF,'\$'
		;	
07B1	0A454E5445	FNINST	DB LF,'ENTER FUNCTION KEY NUMBER (1-8) ',CR,LF
07D3	2020544F20	DB	'TO CHANGE PRESET VALUES.',CR,LF,LF
07F0	454E544552	DB	'ENTER 9 TO LEAVE FUNCTION',CR,LF
080B	20204B4559	DB	' KEY UTILITY. \$'
		;	
081C	0D0A0A5459	FM3	DB CR,LF,LF,'TYPE IN TEXT. USING "RETURN" ',CR,LF
083D	20204F5220	DB	' OR "CTRL-Z" AS TERMINATOR.',CR,LF,LF,'\$'
		;	
085D	KYADDR	DS	2 ;KEYBOARD LOOKUP ADDRESS
0B5F	KYMODE	DS	1 ;KEYBOARD MODE
0860	KYCHK	DS	1
0861	HEXIN	DS	1
0862	NUMCHR	DS	1
0863		DS	32
0883	=	STACK	EQU \$

SYSGEN – System Generation Program 8/79

System Generation Program, Version for MDS

COPYRIGHT © DIGITAL RESEARCH
1976, 1977, 1978, 1979

MODIFICATIONS COPYRIGHT © 1982
COMMODORE INTERNATIONAL

Modified for use on Commodore 64. The system sectors run linearly from Track 1 Sector to Track 2 Sector 16.

0022 =	NSECTS	EQU	34	,NO. OF SECTORS PER TRACK
0002 =	NTRKS	EQU	2	;LAST OS TRACK + 1
0003 =	NDISK5	EQU	3	;NUMBER OF DISK DRIVES
0080 =	SECSIZ	EQU	128	,SIZE OF EACH SECTOR
0007 =	LOG2SEC	EQU	7	,LOG 2 SECSIZ
0001 =	SKEW	EQU	1	,SECTOR SKEW FACTOR
	,			
005C =	FCB	EQU	005CH	,DEFAULT FCB LOCATION
007C =	FCBCR	EQU	FCB + 32	,CURRENT RECORD LOCATION
0100 =	TPA	EQU	0100H	,TRANSIENT PROGRAM AREA
0900 =	LOADP	EQU	900H	,LOAD POINT FOR SYSTEM DURING LOAD/STORE
0005 =	BDOS	EQU	5H	,DOS ENTRY POINT
0000 =	BOOT	EQU	0	;JMP TO 'BOOT' TO REBOOT SYSTEM
0001 =	CONI	EQU	1	,CONSOLE INPUT FUNCTION
0002 =	CONO	EQU	2	,CONSOLE OUTPUT FUNCTION
000E =	SELF	EQU	14	;SELECT DISK
000F =	OPENF	EQU	15	,DISK OPEN FUNCTION
0014 =	DREADF	EQU	20	,DISK READ FUNCTION
	,			
000A =	MAXTRY	EQU	10	,MAXIMUM NUMBER OF RETRIES ON EACH READ/WRITE
000D =	CR	EQU	0DH	,CARRIAGE RETURN
000A =	LF	EQU	0AH	,LINE FEED
0010 =	STACKSIZE	EQU	16	,SIZE OF LOCAL STACK
	,			
0001 =	WBOOT	EQU	1	

; ,ADDRESS OF WARM BOOT
 ; (OTHER PATCH ENTRY
 ; POINTS ARE COMPUTED RELATIVE
 TO WBOOT)

0018 =	SELDSK	EQU	24	,WBOOT + 24 FOR DISK SELECT
001B =	SETTRK	EQU	27	,WBOOT + 27 FOR SET TRACK FUNCTION
001E =	SETSEC	EQU	,,130	,WBOOT + 30 FOR SET SECTOR FUNCTION
0021 =	SETDMA	EQU	33	,WBOOT + 33 FOR SET DMA ADDRESS
0024 =	READF	EQU	36	,WBOOT + 36 FOR READ FUNCTION
0027 =	WRITF	EQU	39	,WBOOT + 39 FOR WRITE FUNCTION

;
 0100 ORG TPA ;TRANSIENT PROGRAM AREA
 0100 C32302 JMP START
 0103 434F505952 DB 'COPYRIGHT @ 1978, DIGITAL RESEARCH '

,
 0128 02 OST DB NTRKS ,OPERATING SYSTEM TRACKS
 0129 22 SPT: DB NSECTS ,SECTORS PER TRACK (CAN BE
PATCHED)

;
GETCHAR:
 ; READ CONSOLE CHARACTER TO REGISTER A
 012A 0E01CD0500 MVI C,CONIT ' CALL BDOS'
 ; CONVERT TO UPPER CASE BEFORE RETURN
 012F FE61D8 CPI 'A' OR 20H ! RC ,RETURN IF BELOW LOWER CASE A
 0132 FE78 CPI ('Z' OR 20H) + 1
 0134 D0 RNC ,RETURN IF ABOVE LOWER CASE Z
 0135 E65FC9 ANI 5FH! RET

;
PUTCHAR.
 ; WRITE CHARACTER FROM A TO CONSOLE
 013B 5F0E02CD05 MOV E,A! MVI C,CONO! CALL BDOS! RET

;
CRLF. ,SEND CARRIAGE RETURN, LINE FEED

013F 3E0D	MVI	A,CR
0141 CD3801	CALL	PUTCHAR
0144 3E0A	MVI	A,LF

0146 CD3801 CALL PUTCHAR
0149 C9 RET
;
CRMSG: ;PRINT MESSAGE ADDRESSED BY H,L TIL ZERO
;WITH LEADING CRLF
014A E5CD3F01E1 PUSH H! CALL CRLF! POP H
;DROP THRU TO OUTMSG0
OUTMSG:
014F 7EB7C8 MOV A,M! ORA A! RZ
;MESSAGE NOT YET COMPLETED
0152 E5CD3801E1 PUSH H! CALL PUTCHAR! POP H! INX H
015B C34F01 JMP OUTMSG
;
SEL:
;SELECT DISK GIVEN BY REGISTER A
015B 4F2A010011 MOV C,A! LHLD WBOOT! LXI D,SELDISK! DAD D! PCHL
;
TRK: ;SET UP TRACK
0164 2A0100 LHLD WBOOT ;ADDRESS OF BOOT ENTRY
0167 111B00 LXI D,SETTRK ;OFFSET FOR SETTRK ENTRY
016A 19 DAD D
016B E9 PCHL ;GONE TO SETTRK
;
SEC: ;SET UP SECTOR NUMBER
016C 2A0100 LHLD WBOOT
016F 111E00 LXI D,SETSEC
0172 19 DAD D
0173 E9 PCHL
;
DMA: ;SET DMA ADDRESS TO VALUE OF B,C
0174 2A0100 LHLD WBOOT
0177 112100 LXI D,SETDMA
017A 19 DAD D
017B E9 PCHL
;
READ: ;PERFORM READ OPERATION
017C 2A0100 LHLD WBOOT
017F 112400 LXI D,READF
0182 19 DAD D
0183 E9 PCHL
;
WRITE: ;PERFORM WRITE OPERATION

0184 2A0100	LHLD	WBOOT
0187 112700	LXI	D,WRITF
018A 19	DAD	D
018B 0E00	MVI	C,0 ,SET UP NORMAL SECTOR WRITE
018D E9	PCHL	
	;	
	DREAD:	:DISK READ FUNCTION
018E 0E14	MVI	C,DREADF
0190 C30500	JMP	BDOS
	;	
	OPEN:	,FILE OPEN FUNCTION
0193 0E0FC30500	MVI C,OPENF ! JMP BDOS	
	;	
	GETPUT	
	,	GET OR PUT CP/M (RW=0 FOR READ, 1 FOR WRITE)
	:	DISK IS ALREADY SELECTED
	,	
0198 21B008	LXI	H,LOADP-80H ,SET UP INITIAL DMADDR
019B 225204	SHLD	
	,	
	:	CLEAR TRACK TO 00
019E 3E00	MVI	A,0 ;START WITH TRACK 0 + 1
01A0 324F04	STA	TRACK
01A3 4F	MOV	C,A
01A4 CD6401	CALL	TRK ,TRACK NUMBER TO BIOS
01A7 3E09	MVI	A,9 .SECTOR 10 (-1)
01A9 325004	STA	SECTOR
01AC C3C301	JMP	RWSEC
	;	
	RWTRK:	,READ OR WRITE NEXT TRACK
01AF 214F04	LXI	H,TRACK
01B2 34	INR	M ,TRACK = TRACK + 1
01B3 3A2801	LDA	OST ,NUMBER OF OPERATING SYSTEM
		TRACKS
01B6 BE	CMP	M ;= TRACK NUMBER ?
01B7 CA2202	JZ	ENDRW ;END OF READ OR WRITE
	,	
		OTHERWISE NOTDONE, GO TO NEXT TRACK
01BA 4E	MOV	C,M ,TRACK NUMBER
01BB CD6401	CALL	TRK ,TO SET TRACK
01BE 3EFF	MVI	A,0FFH ,COUNTS 0, 1, . . . 33

01C0 325004	STA	SECTOR	,SECTOR INCREMENTED BEFORE READ OR WRITE
	RWSEC:	;READ OR WRITE SECTOR	
01C3 3A2901	LDA	SPT	;SECTORS PER TRACK
01C6 215004	LXI	H,SECTOR	
01C9 34	INR	M	;TO NEXT SECTOR
01CA BE	CMP	M	;A=34 AND M=012 . 33 (USUALLY)
01CB CAAF01	JZ	RWTRK	;
01CE 2A5204	LHLD	DMADDR	;SET UP DMA FOR NEXT ADDR
01D1 118000	LXI	D,80H	,SECTOR SIZE
01D4 19	DAD	D	,DMADDR=DMADDR + 80H
01D5 225204	SHLD	DMADDR	
	;		
	;	READ OR WRITE SECTOR TO OR FROM CURRENT DMA ADDR	
01D8 215004	LXI	H,SECTOR	
01DB 4E	MOV	C,M	;VALUE TO C READY FOR SELECT
01DC CD6C01	CALL	SEC	,SET UP SECTOR NUMBER
01DF 2A5204	LHLD	DMADDR	:BASE DMA ADDRESS FOR THIS TRACK
01E2 44	MOV	B,H	
01E3 4D	MOV	C,L	;TO BC FOR SEC CALL
01E4 CD7401	CALL	DMA	,DMA ADDRESS SET FROM B,C DMA ADDRESS SET, CLEAR RETRY COUNT
01E7 AF	XRA	A	
01EB 325404	STA	RETRY	;SET TO ZERO RETRIES
	;		
	TRYSEC:	;TRY TO READ OR WRITE CURRENT SECTOR	
01EB 3A5404	LDA	RETRY	
01EE FEOA	CPI	MAXTRY	;TOO MANY RETRIES?
01F0 DA0702	JC	TRYOK	
	;		
	;	PAST MAXTRIES, MESSAGE AND IGNORE	
01F3 21C303	LXI	H ERRMSG	
01F6 CD4F01	CALL	OUTMSG	
01F9 CD2A01	CALL	GETCHAR	
01FC FE0D	CPI	CR	
01FE C20E03	JNZ	REBOOT	
	;		

, TYPED A CR, OK TO IGNORE
 0201 CD3F01 CALL CRLF
 0204 C3C301 JMP RWSEC
 ;
 TRYOK:
 ; OK TO TRY READ OR WRITE
 0207 3C INR A
 0208 325404 STA RETRY ,REDAY = RETRY + 1
 020B 3A5104 LDA RW ;READ OR WRITE?
 020E B7 ORA A
 020F CA1802 JZ TRYREAD
 ;
 ; MUST BE WRITE
 0212 CD8401 CALL WRITE
 0215 C31B02 JMP CHKRW ;CHECK FOR ERROR RETURNS
 TRYREAD:
 0218 CD7C01 CALL READ
 CHKRW:
 021B B7 ORA A
 021C CAC301 JZ RWSEC ;ZERO FLAG IF R/W OK
 ;
 ; ERROR, RETRY OPERATION
 021F C3EB01 JMP TRYSEC
 ;
 ;
 ENDRW. ;END OF READ OR WRITE, RETURN TO CALLER
 0222 C9 RET
 ;
 ;
 START.
 ;
 0223 317504 LXI SP,STACK ;SET LOCAL STACK POINTER
 0226 212003 LXI H,SIGNON
 0229 CD4F01 CALL OUTMSG
 ;
 ; CHECK FOR DEFAULT FILE LOAD INSTEAD OF GET
 ;
 022C 3A5D00 LDA FCB + 1 ;BLANK IF NO FILE
 022F FE20 CPI ''
 0231 CA8102 JZ GETSYS ;SKIP TO GET SYSTEM MESSAGE
 IF BLANK

0234 115C00	LXI	D,FCB	;TRY TO OPEN IT
0237 CD9301	CALL	OPEN	;
023A 3C	INR	A	,255 BECOMES 00
023B C24702	JNZ	RDOK	;OK TO READ IF NOT 255
	;	FILE NOT PRESENT, ERROR AND REBOOT	
	;		
023E 212004	LXI	H,NOFILE	
0241 CD4A01	CALL	CRMSG	
0244 C30E03	JMP	REBOOT	
	;		
	;	FILE PRESENT	
	;	READ TO LOAD POINT	
	;		
	RDOK:		
0247 AF	XRA	A	
0248 327C00	STA	FCBCR	,CURRENT RECORD = 0
	;		
	;	PRE-READ AREA FROM TPA TO LOADP	
	;		
024B 0E10	MVI	C,(LOADP-TPA)/SECSIZ	
	;	PRE-READ FILE	
	PRERD		
024D C5	PUSH	B	,SAVE COUNT
024E 115C00	LXI	D,FCB	;INPUT FILE CONTROL COUNT
0251 CD8E01	CALL	DREAD	;ASSUME SET TO DEFAULT BUFFER
0254 C1	POP	B	;RESTORE COUNT
0255 B7	ORA	A	
0256 C27B02	JNZ	BADRD	,CANNOT ENCOUNTER END-OF FILE
0259 0D	DCR	C	;COUNT DOWN
025A C24D02	JNZ	PRERD	;FOR ANOTHER SECTOR
	;		
	;	SECTORS SKIPPED AT BEGINNING OF FILE	
	;		
025D 210009	LXI	H,LOADP	
	RDINP:		
0260 E5	PUSH	H	
0261 44	MOV	B,H	
0262 4D	MOV	C,L	;READY FOR DMA
0263 CD7401	CALL	DMA	;DMA ADDRESS SET

0266 115C00	LXI	D,FCB	;READY FOR READ
0269 CD8E01	CALL	DREAD	;
026C E1	POP	H	;RECALL DMA ADDRESS
026D B7	ORA	A	;00 IF READ OK
026E C2C702	JNZ	PUTSYS	,ASSUME EOF IF NOT.
	;	MORE TO READ, CONTINUE	
0271 118000	LXI	D,SECSIZ	
0274 19	DAD	D	;HL IS NEW LOAD ADDRESS
0275 C36002	JMP	RDINP	
	;		
	BADRD:	,EOF ENCOUNTERED IN INPUT FILE	
0278 213704	LXI	H,BADFILE	
027B CD4A01	CALL	CRMSG	
027E C30E03	JMP	REBOOT	
	;		
	;		
	GETSYS:		
0281 212F03	LXI	H,ASKGET	;GET SYSTEM?
0284 CD4A01	CALL	CRMSG	
0287 CD2A01	CALL	GETCHAR	
028A FE0D	CPI	CR	
028C CAC702	JZ	PUTSYS	;SKIP IF CR ONLY
	;		
028F D641	SUI	'A'	;NORMALIZE DRIVE NUMBER
0291 FE03	CPI	NDISK5	;VALID DRIVE?
0293 DA9C02	JC	GETC	;SKIP TO GETC IF SO
	;		
	;	INVALID DRIVE NUMBER	
0296 CD1903	CALL	BADDISK	
0299 C38102	JMP	GETSYS	;TO TRY AGAIN
	;		
	GETC		
	;	SELECT DISK GIVEN BY REGISTER A	
029C C641	ADI	'A'	
029E 325F03	STA	GDISK	;TO SET MESSAGE
02A1 D641	SUI	'A'	
02A3 CD5B01	CALL	SEL	;TO SELECT THE DRIVE
	;	GETSYS, SET RW TO READ AND GET THE SYSTEM	
02A6 CD3F01	CALL	CRLF	
02A9 215503	LXI	H,GETMSG	
02AC CD4F01	CALL	OUTMSG	

02AF CD2A01	CALL	GETCHAR
02B2 FE0D	CPI	CR
02B4 C20E03	JNZ	REBOOT
02B7 CD3F01	CALL	CRLF
;		
02BA AF	XRA	A
02BB 325104	STA	RW
02BE CD9801	CALL	GETPUT
02C1 21EA03	LXI	H,DONE
02C4 CD4F01	CALL	OUTMSG
;		
; PUT SYSTEM		
PUTSYS:		
02C7 217303	LXI	H,ASKPUT
02CA CD4A01	CALL	CRMSG
02CD CD2A01	CALL	GETCHAR
02D0 FE0D	CPI	CR
02D2 CA0E03	JZ	REBOOT
02D5 D641	SUI	'A'
02D7 FE03	CPI	NDISKS
02D9 DAE202	JC	PUTC
;		
; INVALID DRIVE NAME		
02DC CD1903	CALL	BADDISK
02DF C3C702	JMP	PUTSYS ,TO TRY AGAIN
;		
PUTC.		
; SET DISK FROM REGISTER C		
02E2 C641	ADI	'A'
02E4 32AF03	STA	PDISK ,MESSAGE SET
02E7 D641	SUI	'A'
02E9 CD5B01	CALL	SEL ,SELECT DEST DRIVE
; PUT SYSTEM, SET RW TO WRITE		
02EC 21A003	LXI	H,PUTMSG
02EF CD40A01	CALL	CRMSG
02F2 CD2A01	CALL	GETCHAR
02F5 FE0D	CPI	CR
02F7 C20E03	JNZ	REBOOT
02FA CD3F01	CALL	CRLF
;		
02FD 215104	LXI	H,RW

0300 3601	MVI	M,1	
0302 CD9B01	CALL	GETPUT	;TO PUT SYSTEM BACK ON DISKETTE
0305 21EA03	LXI	H,DONE	
0308 CD4F01	CALL	OUTMSG	
030B C3C702	JMP	PUTSYS	;FOR ANOTHER PUT OPERATION
;			
REBOOT:			
030E 3E00	MVI	A,0	
0310 CD5B01	CALL	SEL	
0313 CD3F01	CALL	CRLF	
0316 C30000	JMP	BOOT	
;			
BADDISK:			
;BAD DISK NAME			
0319 21FC03	LXI	H,QDISK	
031C CD4A01	CALL	CRMMSG	
031F C9		RET	
;			
;			
;			
;			
DATA AREAS			
;			
MESSAGES			
0320 5359534745	SIGNON-	DB	'SYSGEN VER'
032B 322E30		DB	VERS/0+'0','.',VERS MOD 10+'0'
032E 00		DB	0
032F 534F555243	ASKGET	DB	'SOURCE DRIVE NAME'
0340 0D284F5220		DB	0DH,'(OR RETURN TO SKIP)',0
0355 534F555243	GETMSG-	DB	'SOURCE ON '
035F	GDISK:	DS	1 ,FILLED IN AT GET FUNCTION
0360 2C20544845		DB	', THEN TYPE RETURN',0
0373 4445535449	ASKPUT	DB	'DESTINATION DRIVE NAME'
0389 0D284F5220		DB	0DH,'(OR RETURN TO REBOOT)',0
03A0 4445535449	PUTMSG.	DB	'DESTINATION ON '
03AF	PDISK:	DS	1 ,FILLED IN AT PUT FUNCTION
03B0 2C20544845		DB	', THEN TYPE RETURN',0
03C3 5045524D41	ERRMSG:	DB	'PERMANENT ERROR, TYPE RETURN TO IGNORE',0
03EA 46554E4354	DONE:	DB	'FUNCTION COMPLETE',0
03FC 494E56414C	QDISK:	DB	'INVALID DRIVE NAME (USE A, B, OR C)',0
0420 4E4F20534F	NOFILE	DB	'NO SOURCE FILE ON DISK',0
;			
BADFILE:			

0437	534F555243	DB	'SOURCE FILE INCOMPLETE',0	
		;		
		;	VARIABLES	
044E	SDISK-	DS	1	;SELECTED DISK FOR CURRENT OPERATION
044F	TRACK:	DS	1	;CURRENT TRACK
0450	SECTOR:	DS	1	;CURRENT SECTOR
0451	RW:	DS	1	;READ IF 0, WRITE IF 1
0452	DMADDR-	DS	2	;CURRENT DMA ADDRESS
0454	RETRY:	DS	1	;NUMBER OF TRIES ON THIS SECTOR
0455		DS	STACKSIZE*2	
		STACK:		
0475			END	

Custom BIOS for CP/M 2.2 On Commodore 64

COPYRIGHT © 1982
COMMODORE INTERNATIONAL

This version has the following attributes:

1. Memory map set up for 52K RAM system with I/O and drivers by BOOT65
2. Disk tables and vectors included for 2 drives
3. The Intel I/O byte is not implemented
4. Punch and reader are null routines
5. Keyboard and message tables are part of BIOS65
6. A 20K to 48K byte CP/M environment can be supported on the Commodore 64 (44K with IEEE)
7. Virtual Drive B is supported for 1540
8. Drive B is not virtual on IEEE disk

0000 =	BASE	EQU	0000H	;BEGINNING OF ADDRESSABLE RAM
		;		
002C =	MSIZE	EQU	44	;CP/M VERSION MEMORY SIZE IN KILOBYTES
		;		
	,			"BIAS" IS ADDRESS OFFSET FROM 3400H FOR MEMORY SYSTEMS

, THAN 20K (REFERRED TO AS "B" THROUGHOUT THE TEXT)

6000 = BIAS EQU (MSIZE-20) *1024

, NOTE: TO CREATE MOVCMP, THE FOLLOWING CCP EQUATES ARE USED.

;

;CCP EQU 0000H ;FOR BIOS0.HEX
;CCP EQU 0100H ;FOR BIOS1.HEX

9400 = CCP EQU 3400H + BIAS ;BASE OF CCP
9C06 = BDOS EQU CCP + 806H BASE OF BDOS
AA00 = BIOS EQU CCP + 1600H BASE OF BIOS
0004 = CDISK EQU BASE + 0004H CURRENT DISK NUMBER 0=A,
....., 15=P

0003 = IOBYTE EQU BASE + 0003H INTEL I/O BYTE
0000 = TRANS EQU 0000H ;0 IMPLIES NO TRANSLATION
0005 = ENTRY EQU 0005H ;BDOS ENTRY VECTOR

;

;

, Z80 INSTRUCTIONS

0018 = JR EQU 18H
0038 = JRC EQU 38H
0030 = JRNC EQU 30H
0028 = JRZ EQU 28H
0020 = JRNZ EQU 20H

;

;

, THE FOLLOWING EQUATES DEFINE THE COMMON
MEMORY FOR PASSING DATA TO AND FROM THE 6510
I/O ROUTINES

;

F800 = HSTBUF EQU 0F800H ;256 BYTE DISK BUFFER
F900 = CMD EQU 0F900H ;COMMAND REGISTER
F901 = DATA EQU 0F901H ;DATA REGISTER
F902 = SECTOR EQU 0F902H ;SECTOR REGISTER
F903 = TRACK EQU 0F903H ;TRACK REGISTER
F904 = DISKNO EQU 0F904H ;DRIVE NUMBER REGISTER
F905 = KYCHAR EQU 0F905H ;KEYBOARD CHARACTER
REGISTER

FCFF =	IOTYPE	EQU	0FCFFH	,IO CONFIGURATION BYTE
	;			THE Z80 SHUTS ITSELF OFF BY WRITING "OFF" TO THE
	,			LOCATION "MODESW"
0001 =	OFF	EQU	1	
CE00 =	MODESW	EQU	0CE00H	
	;			THE FOLLOWING ARE THE COMMANDS TO THE 6510 I/O
	,			ROUTINES
	;			
0000 =	VICRD	EQU	0	;READ SPECIFIED SECTOR
0001 =	VICWR	EQU	1	;WRITE SPECIFIED SECTOR
0002 =	VICIN	EQU	2	;DO A KEYBOARD SCAN
0003 =	VICOUT	EQU	3	,OUTPUT DATA TO SCREEG
0004 =	VICPST	EQU	4	,GET PRINTER STATUS
0005 =	VICPRT	EQU	5	;SEND CHARACTER TO PRINTER
0006 =	VICFMT	EQU	6	,FORMAT DISK COMMAND
0007 =	AUX1	EQU	7	,JUMP TO \$0E00 IN 6510 SPACE
0008 =	AUX2	EQU	8	,JUMP TO \$0F00 IN 6510 SPACE
0009 =	INDIR	EQU	9	;JUMP INDIRECT VIA OF906
	;			
	;			
AA00		ORG	BIOS	,ORIGIN OF THIS PROGRAM
0016 =	NSECTS	EQU	(\$-CCP)/256	;WARM START SECTOR COUNT
	;			JUMP VECTOR FOR INDIVIDUAL SUBROUTINES
AA00 C36CAA		JMP	BOOT	,COLD START
AA03 C31DAB	WBOOTE:	JMP	WBOOT	,WARM START
AA06 C39AAB		JMP	CONST	;CONSOLE STATUS
AA09 C3FEAB		JMP	CONIN	,CONSOLE CHARACTER IN
AA0C C376AC		JMP	CONOUT	,CONSOLE CHARACTER OUT
AA0F C3B1AC		JMP	LIST	;LIST CHARACTER OUT
AA12 C3FAAC		JMP	PUNCH	;PUNCH CHARACTER OUT
AA15 C3FDAC		JMP	READER	;READER CHARACTER OUT
AA18 C302AD		JMP	HOME	;MOVE HEAD TO HOME POSITION
AA1B C30CAD		JMP	SELDSK	;SELECT DISK
AA1E C320AD		JMP	SETTRK	,SET TRACK NUMBER
AA21 C326AD		JMP	SETSEC	,SET SECTOR NUMBER
AA24 C32BAD		JMP	SETDMA	,SET DMA ADDRESS
AA27 C334AD		JMP	READ	;READ RISK

AA2A C347AD	JMP	WRITE	;WRITE DISK
AA2D C3D1AC	JMP	LISTST	,RETURN LIST STATUS
AA30 C331AD	JMP	SECTRAN	;SECTOR TRANSLATE
	;		
AA33 00	KYBDMD	DB	00H ;CAPS LOCK FLAG
	;		
	;		FIXED DATA TABLES FOR TWO DRIVES
	;		DISK PARAMETER HEADER FOR DISK 00
AA34 00000000	DPBASE	DW	TRANS,0000H
AA38 00000000		DW	0000H,0000H
AA3C F0AE54AA		DW	DIRBF,DPBLK
AA40 AEAFF0AF		DW	CHK00,ALL00
	;		DISK PARAMETER HEADER FOR DISK 01
AA44 00000000		DW	TRANS,0000H
AA48 00000000		DW	0000H,0000H
AA4C F0AE54AA		DW	DIRBF,DPBLK
AA50 BEAF8FAF		DW	CHK01,ALL01
	;		
	;		
AA54 2200	DPBLK		;DISK PARAMETER BLOCK, COMMON TO ALL DISKS
AA56 03		DW	34 .SECTORS PER TRACK
AA57 07		DB	3 ;BLOCK SHIFT FACTOR
AA58 00		DB	7 ;BLOCK MASK
AA59 8700		DW	0 ;NULL MASK
AA5B 3F00		DW	135 ;DISK SIZE-1
AA5D C0		DB	63 ;DIRECTORY MAX
AA5E 00		DB	192 ;ALLOC 0
AA5F 1000		DW	0 ;ALLOC 1
AA61 0200		DW	16 ;CHECK SIZE
	;		
	;		END OF FIXED TABLES
	;		
	;		MEMORY INITIALIZED WHEN BIOS READ IN AT BOOT
	;		TIME
	;		
AA63 40	LASTKY:	DB	40H ;VECTOR OF LAST KEY PRESSED
AA64 00	TOGGLE	DB	00H ;CAPS LOCK HOUSEKEEPING
AA65 00	CSTAT:	DB	00H ;CHARACTER AVAILABLE FLAG
AA66 0000	MSGPTR:	DW	0000H ;MESSAGE POINTER
AA68 00FD	TBLPTR.	DW	0FD00H ;KEYBOARD CODE TABLE

AA6A 00FC	MSGTBL:	DW	0FC00H	;MESSAGE VECTOR TABLE
	;			
	;			MISC. CONSOLE EQUATES
	;			
F2BD =	SHFTST	EQU	0F28DH	;CONTROL,COMMODORE,SHIFT KEYS
F0CC =	FLASH	EQU	0FOCCH	,CURSOR FLASH ENABLE
F0CF =	CURSOR	EQU	0FOCFH	;CURSOR CHARACTER
	;			
	;			INDIVIDUAL SUBROUTINES TO PERFORM EACH FUNCTION
	;			
	BOOT:			
AA6C 3E20	;	MVI	A,20H	;ASCII SPACE
AA6E 32CFF0		STA	CURSOR	,SET UP CURSOR
AA71 AF		XRA	A	;ZERO IN THE ACCUM
AA72 320300		STA	Iobyte	;CLEAR THE IOBYTE
AA75 320400		STA	CDISK	;SELECT DISK ZERO
AA78 32EFAE		STA	CURDSK	,CLEAR VIRTUAL DISK POINTER
AA7B 32E1AE		STA	HSTACT	;HOST BUFFER INACTIVE
AA7E 32E3AE		STA	UNACNT	;CLEAR UNALLOC COUNT
AA81 3EC3		MVI	A,0C3H	,C3 IS JUMP OPCODE
AA83 320000		STA	0+BASE	. FOR JUMP TO WBOOT
AA86 2103AA		LXI	H,WBOOTE	;WBOOT ENTRY POINT
AA89 220100		SHLD	1+BASE	;SET ADDRESS FIELD
	;			
AA8C 320500		STA	5+BASE	,JUMP TO BDOS OPCODE
AABF 21069C		LXI	H,BDOS	,BDOS ENTRY POINT
AA92 220600		SHLD	6+BASE	;SET ADDRESS FIELD
	,			
AA95 018000		LXI	B,80H+BASE	,DEFAULT DMA ADDRESS
AA98 CD2BAD		CALL	SETDMA	
	;			
AA9B 11A6AA		LXI	D,SIGNON	;DE POINTS TO SIGNON MSG
AA9E 0E09		MVI	C,9	,PRINT STRING FUNCTION
AAA0 CD0500		CALL	ENTRY	;GO TO BDOS
AAA3 C3B9AB		JMP	GOCPM1	;GET READY FOR CCP
	;			
AAA6 0C0A	SIGNON:	DB	0CH,0AH	;CLEAR SCREEN
AAA8 2020202043		DB	' COMMODORE 64 20K CP/M VERS 2.2'	
AACC 0D0A0A		DB	0DH,0AH,0AH	
AACF 2020436F70		DB	' COPYRIGHT @ 1979, DIGITAL RESEARCH',0DH,0AH	

AAF7 20202020	DB	' COPYRIGHT @ 1982, COMMODORE',0DH,0AH	
AB1B 0A24	DB	0AH,'\$'	,END OF STRING MARKER
;			
;			
WBOOT:			
AB1D 318000	LXI	SP,80H + BASE ;USE SPACE BELOW BUFFER FOR STACK	
AB20 0E00	MVI	C,0	;SELECT DISK 0
AB22 CD0CAD	CALL	SELDSK	
AB25 AF	XRA	A	;FORCE DRIVE A
AB26 3204F9	STA	DISKNO	;ABSOLUTELY, POSITIVELY
AB29 CD79AE	CALL	CHGDSK	,IF NOT ALREADY SELECTED
AB2C CD02AD	CALL	HOME	;GO TO TRACK 00
AB2F 3E0D	MVI	A,0DH	;CARRIAGE RETURN
AB31 CDAAAC	CALL	COUT5	;OUTPUT IT
;			
AB34 110094	LXI	D,CCP	;START OF LOAD
AB37 0616	MVI	B,NSECTS	
AB39 2601	MVI	H,1	,TRACK NUMBER
AB3B 2E06	MVI	L,6	;SECTOR NUMBER
AB3D 7C	LOAD1:	MOV	A,H
AB3E 3203F9	STA	TRACK	
AB41 7D	MOV	A,L	
AB42 3202F9	STA	SECTOR	
AB45 3E00	MVI	A,VICRD	,DISK READ COMMAND
AB47 CD90AB	CALL	IO6510	
;			
AB4A 3A01F9	LDA	DATA	
AB4D B7	ORA	A	
AB4E 20ED	J1:	DB	JRNZ, (LOAD1-J1-2) AND OFFH
AB50 E5	PUSH	H	
AB51 C5	PUSH	B	
AB52 010001	LXI	B,256	
AB55 2100F8	LXI	H,HSTBUF	,DISK BUFFER
AB58 ED	DB	0EDH	;LDIR INSTRUCTION
AB59 B0	DB	0B0H	
AB5A 0E2A	MVI	C,'*' ;SHOW IT'S LOADING	
AB5C CD76AC	CALL	CONOUT	
AB5F C1	POP	B	
AB60 E1	POP	H	
AB61 05	DCR	B	;DECREMENT SECTOR COUNT

AB62 280B	J2	DB	JRZ,GOCPM-J2-2
AB64 2C		INR	L ;NEXT SECTOR
AB65 7D		MOV	A,L
AB66 FE11		CPI	17
AB68 38D3	J3:	DB	JRC, (LOAD1-J3-2) AND OFFH
AB6A 24		INR	H
AB6B 2E00		MVI	L,0
AB6D 18CE	J4:	DB	JR, (LOAD1-J4-2) AND OFFH
	;		END OF LOAD OPERATION, SET PARAMETERS AND GO TO CP/M
GOCPM:			
AB6F 3EC3		MVI	A,0C3H ;C3 IS A JMP INSTRUCTION
AB71 320000		STA	0+BASE ;FOR JMP TO WBOOT
AB74 2103AA		LXI	H,WBOOTE ;WBOOT ENTRY POINT
AB77 220100		SHLD	1+BASE ;SET ADDRESS FIELD FOR JMP AT 0
	;		
AB7A 320500		STA	5+BASE ;FOR JMP TO BDOS
AB7D 21069C		LXI	H,BDOS ;BDOS ENTRY POINT
AB80 220600		SHLD	6+BASE ;ADDRESS FIELD OF JUMP AT 5 TO BDOS
	;		
AB83 018000		LXI	B,80H+BASE ;DEFAULT DMA ADDRESS IS 80H
AB86 CD2BAD		CALL	SETDMA
	;		
	;		
AB89 3A0400	GOCPM1:	LDA	CDISK ;GET CURRENT DISK NUMBER
AB8C 4F		MOV	C,A ;SEND TO THE CCP
AB8D C30094		JMP	CCP ;GO TO CP/M FOR FURTHER PROCESSING
	;		
	;		
	,		MAIN ROUTINE TO TRANSFER EXECUTION TO 6510
	,		
AB90 3200F9	IO6510:	STA	CMD ;PUT A IN 6510 COMMAND REGISTER
AB93 3E01		MVI	A,OFF
AB95 3200CE		STA	MODESW ;TURN OFF Z80
AB98 00		NOP	;
AB99 C9		RET	REQUIRED BY HARDWARE
	;		

```

        ; CONST :CONSOLE STATUS, RETURN OFFH IF CHARACTER READY,
        ;          00H IF NOT
ABA9A 2A66AA      LHLD   MSGPTR  ,MESSAGE MODE?
ABA9D 7C           MOV     A,H
ABA9E B5           ORA     L
ABA9F 3EFF         MVI     A,OFFH  ,DATA READY FLAG
ABA1  C0           RNZ
                    ;RETURN IF MSGPTR<>0

        ;
ABA2 3A65AA      LDA     CSTAT   ,ALREADY A CHAR?
ABA5  A7           ANA     A
ABA6  C0           RNZ
                    ,YES IF NOT 0

ABA7  3E02         MVI     A,VICIN ,CHECK KEYBOARD COMMAND
ABA9  CD90AB      CALL    IO6510

        ;
ABAC 3A8DF2      LDA     SHFTST ,GET STATUS OF CONTROL KEYS
ABAFA E602         ANI     02H    ,CHECK FOR COMMODORE KEY
ABB1  2810         J5.    DB      JRZ, CONST0-J5-2 ,JUMPIF NOT PRESSED

        ;
ABB3  3A64AA      LDA     TOGGLE  ,IS THIS AN UPSTROKE?
ABB6  A7           ANA     A
ABB7  200A         J6.    DB      JRNZ,CONST0-J6-2 ,NO WAITING TO
                           RELEASE

ABB9  3A33AA      LDA     KYBDMD ,GET CAPS MODE FLAG
ABBCE EE01         XRI     01H    ,TOGGLE MODE BIT
ABBE  3233AA      STA     KYBDMD
ABC1  3E01         MVI     A.1
ABC3  3264AA      CONST0: STA     TOGGLE

        ;
ABC6  3A05F9      LDA     KYCHAR ,GET SCANNED DATA
ABC9  FE3A         CPI     3AH    ,BAD CONTROL DATA
ABCB  280A         J7:    DB      JRZ,CONST1-J7-2

        ;
ABCD  FE3D         CPI     3DH    ,BAD CONTROL DATA
ABCF  2806         J8.    DB      JRZ,CONST1-J8-2

        ;
ABD1  2163AA      LXI     H,LASTKY ,COMPARE WITH PREVIOUS
ABD4  BE           CMP     M       ; SCAN DATA
ABD5  2005         J9:    DB      JRNZ,CONST2-J9-2 ,IF DIFFERENT, NEW KEY

```

ABD7 AF	CONST1:	XRA	A	;DATA NOT READY FLAG
ABD8 3265AA		STA	CSTAT	;SAVE FOR LATER
ABDB C9		RET		
	;			
ABDC F5	CONST2:	PUSH	PSW	
ABDD 01F401		LXI	B,500	
ABE0 0B	CONST3:	DCX	B	;DELAY FOR KEYBOUNCE
ABE1 79		MOV	A,C	
ABE2 B0		ORA	B	
ABE3 20FB	J10:	DB	JRNZ,(CONST3-J10-2) AND OFFH	
	;			
ABE5 3E02		MVI	A,VICIN	;GET CHARACTER AGAIN
ABE7 CD90AB		CALL	IO6510	
	;			
ABEA F1		POP	PSW	
ABEB 2105F9		LXI	H,KYCHAR	
ABEE BE		CMP	M	
ABEF 20E6	J11:	DB	JRNZ,(CONST1-J11-2) AND OFFH	;IF<>0, BOUNCING
	;			
ABF1 3263AA		STA	LASTKY	;UPDATE LAST KEY
ABF4 FE40		CPI	40H	;IF 40H, NO KEY PRESSED
ABF6 28DF	J12:	DB	IRZ,CONST1-J12-2) AND OFFH	
	;			
ABF8 3EFF		MVI	A,OFFH	;DATA READY FLAG
ABFA 3265AA		STA	CSTAT	;SAVE FOR LATER
ABFD C9		RET		
	;			
	CONIN:	,CONSOLE CHARACTER INTO REGISTER A		
ABFE 3E00		MVI	A,0	,TURN ON CURSOR
AC00 32CCFO		STA	FLASH	
	;			
AC03 2A66AA		LHLD	MSGPTR	;ARE WE IN MESSAGE MODE?
AC06 7C		MOV	A,H	
AC07 B5		ORA	L	
AC08 2044	J13:	DB	JRNZ,CONIN5-J13-2	
	;			
	;			
AC0A CD9AAB	CONIN1.	CALL	CONST	;CHECK CONSOLE STATUS
AC0D B7		ORA	A	
AC0E 28FA	J14.	DB	JRZ,(CONIN1-J14-2) AND OFFH	;UNTIL NEW

CHAR

AC10 AF		XRA	A	
AC11 3265AA		STA	CSTAT	,CLEAR CSTAT
AC14 3A33AA	CONIN2	LDA	KYBDMD	;UNSHIFT = 0, CAPS = 1
AC17 47		MOV	B,A	
AC18 3A8DF2		LDA	SHFTST	;GET MODIFIER STATUS
AC1B E601		ANI	01H	;IS A SHIFT KEY DOWN?
AC1D 2802	J15	DB	JRZ,CONIN3-J15-2	,JUMP IF NO
	;			
AC1F 0602		MVI	B,2	;SHFIT = 2
AC21 3A8DF2	CONIN3	LDA	SHFTST	;GET MODIFIER STATUS
AC24 E604		ANI	04H	;IS THE CONTROL KEY DOWN?
AC26 2802	J16:	DB	JRZ,CONIN4-J16-2	,JUMP IF NO
	;			
AC28 0603		MVI	B,3	;CONTROL = 3
AC2A 3A63AA	CONIN4.	LDA	LASTKY	;GET KEY POSITION
AC2D 87		ADD	A	;*2
AC2E 87		ADD	A	;*4
AC2F 80		ADD	B	;ADD IN OFFSET
AC30 2A68AA		LHLD	TBLPTR	;GET BEGINNING OF KEYTBL
AC33 85		ADD	L	;VECTOR INTO TABLE
AC34 6F		MOV	L,A	
AC35 3E00		MVI	A,0	
AC37 8C		ADC	H	
AC38 67		MOV	H,A	
AC39 7E		MOV	A,M	;GET CHARACTER FROM TABLE
AC3A FE80		CPI	80H	;MESSAGE IF >7FH
AC3C 3820	J17:	DB	JRC,CONIN7-J17-2	,JUMP IF ASCII CHAR
	;			
AC3E 2A6AAA		LHLD	MSGTBI	;GET BEGINNING OF MVTBL
AC41 E67F		ANI	7FH	;STRIP OF MESSAGE BIT
AC43 87		ADD	A	;*2
AC44 85		ADD	L	;VECTOR INTO TABLE
AC45 6F		MOV	L,A	
AC46 3E00		MVI	A,0	
AC48 8C		ADC	H	
AC49 67		MOV	H,A	
AC4A 7E		MOV	A,M	;LOW ORDER BYTE
AC4B 23		INX	H	
AC4C 66		MOV	H,M	;HIGH ORDER BYTE

AC4D 6F		MOV	L,A	
AC4E 46	CONIN5:	MOV	B,M	,GET CHARACTER
AC4F 23		INX	H	,CHECK NEXT CHARACTER
AC50 7E		MOV	A,M	
AC51 A7		ANA	A	
AC52 2003	J18:	DB	JRNZ,CONIN6-J18-2	,IF 0, B HAS LAST CHAR
	;			
AC54 210000		LXI	H,0000H	,END OF MESSAGE MODE
AC57 2266AA	CONIN6	SHLD	MSGPTR	,SAVE MESSAGE POINTER
AC5A 78		MOV	A,B	,CHECK CHARACTER
AC5B A7		ANA	A	;MAYBE 1ST IS 0
AC5C 28AC	J19:	DB	JRZ,(CONIN1-J19-2) ND OFFH	,IF<>0, NOT CHAR
	;			
AC5E F5	CONIN7.	PUSH *	PSW	,SAVE CHARACTER
AC5F 3E01		MVI	A,1	
AC61 32CCF0		STA	FLASH	,TURN OFF CURSOR
AC64 2AD1F0		LHLD	OF0D1H	,
AC67 3AD3F0		LDA	OF0D3H	
AC6A 85		ADD	L	
AC6B 6F		MOV	L,A	
AC6C 3EF0		MVI	A,0FOH	
AC6E 8C		ADC	H	
AC6F 67		MOV	H,A	
AC70 7E		MOV	A,M	
AC71 E67F		ANI	07FH	
AC73 77		MOV	M,A	
AC74 F1		POP	PSW	,GET CHARACTER
AC75 C9		RET		;DONE
	;			
	CONOUT:	,CONSOLE CHARACTER OUTPUT FROM REGISTER C		
AC76 3AFFFC		LDA	IOTYPE	,GET CONFIGURATION BYTE
AC79 E601		ANI	10H	,BIT 4 = 1 TO IGNORE FILTER
AC7B 79		MOV	A,C	;GET TO ACCUMULATOR
AC7C 202C	J20	DB	JRNZ,COUT5-J20-2	,PRINT AS RECEIVED
	,			
AC7E CDDAAC		CALL	SWAP	,EXCHANGE UPPER AND LOWER CASE
AC81 FE0C		CPI	0CH	,ASCII CLEAR SCREEN?
AC83 2004	J21.	DB	JRNZ,COUT1-J21-2	,JUMP IF NO
	;			
AC85 3E93		MVI	A,93H	;COMMODORE CLEAR SCREEN CMD

AC87 1821	J22:	DB	JR,COUT5-J22-2
	;	-	
AC89 FE08	COUT1:	CPI	08H ;ASCII BACKSPACE?
AC8B 2004	J23:	DB	JRNZ,COUT2-J23-2 ,JUMP IF NO
	;		
AC8D 3E14		MVI	A,14H ;COMMODORE BACKSPACE CMD
AC8F 1819	J24:	DB	JR,COUT5-J24-2
	;		
AC91 FE0A	COUT2:	CPI	0AH ,LINE FEED?
AC93 2004	J25:	DB	JRNZ,COUT3-J25-2
	;		
AC95 3E11		MVI	A,17 ;COMMODORE LINE FEED
AC97 1811	J26:	DB	JR,COUT5-J26-2
	;		
AC99 FE0D	COUT3:	CPI	0DH ;CARRIAGE RETURN?
AC9B 2007	J27:	DB	JRNZ,COUT4-J27-2
	;		
AC9D CDAAAC		CALL	COUT5
ACA0 3E91		MVI	A,145 ;UP 1 LINE TO NEGATE AUTO LF
ACA2 1806	J28:	DBB	JR,COUT5-J28-2
	,		
ACA4 FE20	COUT4:	CPI	20H
ACA6 D8		RC	,RETURN IF UNDECODED CONTROL CHAR
ACA7 FE80		CPI	80H
ACA9 D0		RNC	,RETURN IF NOT ASCII CHARACTER
	;		
ACAA 3201F9	COUT5	STA	DATA ,PUT DATA IN CHARACTER REGISTER
ACAD 3E03		MVI	A,VICOUT ;SCREEN OUTPUT COMMAND
ACAF 181D	J29:	DB	JR,LIST3-J29-2
	;		
	LIST:		LIST CHARACTER FROM REGISTER C
ACB1 3AFFFC		LDA	IOTYPE ;WHAT KIND OF PRINTER?
ACB4 E604		ANI	04H ;0 IF 1515, 1 IF 4022
ACB6 79		MOV	A,C ,CHARACTER TO REGISTER A
ACB7 2010	J30:	DB	JRNZ,LIST2-J30-2 ,JUMP IF NO SWAP
	;		
ACB9 3AFFFC		LDA	IOTYPE
ACBC E608		ANI	08H ,WHICH TYPE OF SWAP?

ACBE 79		MOV	A,C	;GET CHARACTER
ACBF 2005	J31:	DB	JRNZ,LIST1-J31-2	
	;			
ACC1 CDDAC		CALL	SWAP	;SWAP UPPER AND LOWER CASE
ACC4 1803	J32:	DB	JR,LIST2-J32-2	
	;			
ACC6 CDEDAC	LIST1:	CALL	SWAP2	;4022 SWAP ROUTINE
ACCB 3201F9	LIST2:	STA	DATA	,PUT DATA IN REGISTER
ACCC 3E05		MVI	A,VICPRT	,ASSUME 1540
ACCE C390AB	LIST3:	JMP	IO6510	
	,			
	LISTST:		,RETURN LIST STATUS (0 IF NOT READY, 1 IF READY)	
ACD1 3E04		MVI	A,VICPST	;PRINTER STATUS COMMAND
ACD3 CD90AB		CALL	IO6510	
ACD6 3A01F9		LDA	DATA	;DATA IS STATUS
ACD9 C9		RET		
	;			
	SWAP:		;SWAP UPPER AND LOWER CASE FOR COMMODORE-64	
ACDA FE41		CPI	41H	;LESS THAN UC 'A'?
ACDC D8		RC		;RETURN IF SO
	,			
ACDD FE5B		CPI	5BH	;UC LETTER?
ACDF 3809	J33:	DB	JRC,SWAP1-J33-2 ;JUMP IF SO	
	;			
ACE1 FE61		CPI	61H	;LESS THAN LC 'A'
ACE3 D8		RC		;RETURN IF SO
	;			
ACE4 FE7B		CPI	7BH	;LC LETTER?
ACE6 D0		RNC		;RETURN IF NO
	;			
ACE7 E65F		ANI	5FH	,TURN OFF BIT 5
ACE9 C9		RET		
	;			
ACEA F620	SWAP1:	ORI	20H	;TURN ON BIT 5
ACEC C9		RET		
	;			
ACED FE41	SWAP2:	CPI	41H	;CY IF LESS THAN UC 'A'
ACEF D8		RC		
ACF0 FE60		CPI	60H	;CY IF 40H < A < 60H
ACF2 3003	J34:	DB	JRNC,SWAP3-J34-2	
	;			

ACF4 F680	ORI	80H		
ACF6 C9	RET			
	;			
ACF7 E65F	SWAP3:	ANI	5FH	
ACF9 C9		RET		
	;			
	PUNCH:	;PUNCH CHARACTER FROM REGISTER C		
ACFA 79	MOV	A,C	,CHARACTER TO REGISTER A	
ACFB 00	NOP			
ACFC C9	RET		;NULL SUBROUTINE	
	;			
	;			
	READER:	;READ CHARACTER INTO REGISTER A FROM READER DEVICE		
ACFD 3E1A	MVI	A,1AH	,ENTER END OF FILE FOR NOW (REPLACE LATER)	
ACFF E67F	ANI	7FH	,REMEMBER TO STRIP PARITY BIT	
AD01 C9	RET			
	;			
	;			
	;* * * * *	*	*	
	;	*	*	
	;*	CP/M TO HOST DISK CONSTANTS		
	;	*	*	
	,*	*	*	
0400 =	BLKSIZ	EQU	1024	,CP/M ALLOCATION SIZE
0100 =	HSTSIZ	EQU	256	,HOST DISK SECTOR SIZE
0011 =	HSTSPT	EQU	17	,HOST DISK SECTORS/TRK
0002 =	HSTBLK	EQU	HSTSIZ/128	,CP/M SECTS/HOST BUFF
0022 =	CPMSPT	EQU	HSTBLK * HSTSPT	,CP/M SECTORS/TRACK
0001 =	SECMSK	EQU	HSTBLK-1	,SECTOR MASK
0001 =	SECSHF	EQU	1	,LOG2(HSTBLK)
	;			
	;* * * * *	*	*	
	;	*	*	
	;*	BDOS CONSTANTS ON ENTRY TO WRITE		
	;	*	*	
	,*	*	*	
0000 =	WRALL	EQU	0	,WRITE TO ALLOCATED
0001 =	WRDIR	EQU	1	,WRITE TO DIRECTORY
0002 =	WRUAL	EQU	2	,WRITE TO UNALLOCATED

; HOME THE SELECTED DISK
HOME:
 AD02 3AE2AE LDA HSTWRT ,CHECK FOR PENDING WRITE
 AD05 B7 ORA A
 AD06 2003 J35. DB JRNZ,HOMED-J35-2
 AD08 32E1AE STA HSTACT ,CLEAR HOST ACTIVE FLAG

HOMED:
 AD0B C9 RET

 ;
SELDSK:
 ;SELECT DISK
 ADOC 210000 LXI H,0000H ,ERROR RETURN CODE
 ADOF 79 MOV A,C ;SELECTED DISK NUMBER
 AD10 32D8AE STA SEKDSK ;SEEK DISK NUMBER
 AD13 FE02 CPI 2 ;MUST BE 0-1
 AD15 D0 RNC ;NO CARRY IF 2,3,
 AD16 6F MOV L,A ;DISK NUMBER TO HL
 AD17 29 DAD H ,MULTIPLY BY 16
 AD18 29 DAD H
 AD19 29 DAD H
 AD1A 29 DAD H
 AD1B 1134AA LXI D,DPBASE ,BASE OF PARM BLOCK
 AD1E 19 DAD D ,HL=.DPB(CURDSK)
 AD1F C9 RET

 ;
SETTRK:
 ;SET TRACK GIVEN BY REGISTERS BC
 AD20 60 MOV H,B
 AD21 69 MOV L,C
 AD22 22D9AE SHLD SEKTRK ;TRACK TO SEEK
 AD25 C9 RET

 ;
SETSEC:
 ;SET SECTOR GIVEN BY REGISTER C
 AD26 79 MOV A,C
 AD27 32DBAE STA SEKSEC ,SECTOR TO SEEK
 AD2A C9 RET

 ;
SETDMA:
 ;SET DMA ADDRESS GIVEN BY BC

AD2B 60 MOV H,B
AD2C 69 MOV L,C
AD2D 22ECAE SHLD DMAADR
AD30 C9 RET

;

SECTRAN.

;TRANSLATE SECTOR NUMBER BC
AD31 60 MOV H,B
AD32 69 MOV L,C
AD33 C9 RET

;
;*
;* *
,* THE READ ENTRY POINT TAKES THE PLACE OF *
,* THE PREVIOUS BIOS DEFINITION FOR READ. *
,*
;

READ:

,READ THE SELECTED CP/M SECTOR

AD34 AF XRA A
AD35 32E3AE STA UNACNT
AD38 3E01 MVI A,1
AD3A 32EAAE STA READOP ;READ OPERATION
AD3D 32E9AE STA RSFLAG ;MUST READ DATA
AD40 3E02 MVI A,WRUAL
AD42 32EBAE STA WRTYPE ;TREAT AS UNALLOC
AD45 1864 J36: DB JR,RWOPER-J36 -2 ,TO PERFORM THE READ

;
;*
;* *
,* THE WRITE ENTRY POINT TAKES THE PLACE OF *
,* THE PREVIOUS BIOS DEFINITION FOR WRITE. *
,*
;

WRITE:

,WRITE THE SELECTED CP/M SECTOR

AD47 AF XRA A ,0 TO ACCUMULATOR
AD48 32EAAE STA READOP ,NOT A READ OPERATION
AD4B 79 MOV A,C ;WRITE TYPE IN C
AD4C 32EBAE STA WRTYPE
AD4F FF02 CPI WRUAL ;WRITE UNALLOCATED?

AD51 2017	J37:	DB	JRNZ,CHKUNA-J37-2 ;CHECK FOR UNALLOC
	;		
	;		WRITE TO UNALLOCATED, SET PARAMETERS
AD53 3E08		MVI	A,BLKSI/128;NEXT UNALLOC RECS
AD55 32E3AE		STA	UNACNT
AD58 3AD8AE		LDA	SEKDSK ;DISK TO SEEK
AD5B 32E4AE		STA	UNADSK ;UNADSK = SEKDSK
AD5E 2AD9AE		LHLD	SEKTRK
AD61 22E5AE		SHLD	UNATRK ;UNATRK = SECTRK
AD64 3ADBAE		LDA	SEKSEC
AD67 32E7AE		STA	UNASEC ;UNASEC = SEKSEC
	;		
	;		
	CHKUNA.		
			;CHECK FOR WRITE TO UNALLOCATED SECTOR
AD6A 3AE3AE		LDA	UNACNT :ANY UNALLOC REMAIN?
AD6D B7		ORA	A
AD6E 2833	J38:	DB	JRZ,ALLOC-J38-2 ;SKIP IF NOT
	;		
	;		MORE UNALLOCATED RECORDS REMAIN
AD70 3D		DCR	A ;UNACNT = UNACNT-1
AD71 32E3AE		STA	UNACNT
AD74 3AD8AE		LDA	SEKDSK ;SAME DISK?
AD77 21E4AE		LXI	H,UNADSK
AD7A BE		CMP	M ;SEKDSK = UNADSK?
AD7B 2026	J39:	DB	JRNZ,ALLOC-J39-2 ;SKIP IF NOT
	;		
	;		DISKS ARE THE SAME
AD7D 21E5AE		LXI	H,UNATRK
AD80 CD40AE		CALL	TRKCMP ;SEKTRK = UNATRK?
AD83 201E	J40:	DB	JRNZ,ALLOC-J40-2 ;SKIP IF NOT
	;		
	;		TRACKS ARE THE SAME
AD85 3ADBAE		LDA	SEKSEC ;SAME SECTOR?
AD88 21E7AE		LXI	H,UNASEC
AD8B BE		CMP	M ;SEKSEC = UNASEC?
AD8C 2015	J41:	DB	JRNZ,ALLOC-J41-2 ;SKIP IF NOT
	;		
	;		MATCH, MOVE TO NEXT SECTOR FOR FUTURE REF
AD8E 34		INR	M ;UNASEC = UNASEC+1
AD8F 7E		MOV	A,M ;END OF TRACK?

AD90 FE22	CPI	CPMSPT	;COUNT CP/M SECTORS
AD92 3809	J42:	DB	JRC,NOOVF-J42-2 ;SKIP IF NO OVERFLOW
	;		
	;	OVERFLOW TO NEXT TRACK	
AD94 3600	MVI	M,0	;UNASEC = 0
AD96 2AE5AE	LHLD	UNATRK	
AD99 23	INX	H	
AD9A 22E5AE	SHLD	UNATRK	;UNATRK = UNATRK + 1
	;		
	NOOVF;		
		;MATCH FOUND, MARK AS UNNECESSARY READ	
AD9D AF	XRA	A	;0 TO ACCUMULATOR
AD9E 32E9AE	STA	RSFLAG	;RSFLAG = 0
ADA1 1808	J43:	DB	JR,RWOPER-J43-2 ;TO PERFORM THE WRITE
	;		
	ALLOC:		
		;NOT AN UNALLOCATED RECORD, REQUIRES PRE-READ	
ADA3 AF	XRA	A	;0 TO ACCUM
ADA4 32E3AE	STA	UNACNT	;UNACNT = 0
ADA7 3C	INR	A	;1 TO ACCUM
ADA8 32E9AE	STA	RSFLAG	;RSFLAG = 1
	;		
	;* * * * *	*	*
	;	*	*
	;	COMMON CODE FOR READ AND WRITE FOLLOWS	
	;	*	*
	;	*	*
	RWOPER:		
		;ENTER HERE TO PERFORM THE READ/WRITE	
ADAB AF	XRA	A	;ZERO TO ACCUM
ADAC 32E8AE	STA	ERFLAG	;NOERRORS (YET)
ADAF 3ADBAE	LDA	SEKSEC	;COMPUTE HOST SECTOR
ADB2 B7	ORA	A	;CARRY = 0
ADB3 1F	RAR		;SHIFT RIGHT
ADB4 32EOAE	STA	SEKHST	;HOST SECTOR TO SEEK
	;	ACTIVE HOST SECTOR?	
ADB7 21E1AE	LXI	H,HSTACT	;HOST ACTIVE FLAG
ADBA 7E	MOV	A,M	
ADBB 3601	MVI	M,1	;ALWAYS BECOMES 1
ADBD B7	ORA	A	;WAS IT ALREADY?

ADBE 2821	J44:	DB	JRZ,FILHST-J44-2 ;FILL HOST IF NOT
	;		
	;		HOST BUFFER ACTIVE, SAME AS SEEK BUFFER?
ADC0 3AD8AE		LDA	SEKDSK
ADC3 21DCAE		LXI	H,HSTDISK ;SAME DISK?
ADC6 BE		CMP	M ;SEKDSK = HSTDISK?
ADC7 2011	J45:	DB	JRNZ,NOMTCH-J45-2
	;		
	;		SAME DISK, SAME TRACK?
ADC9 21DDAE		LXI	H,HSTTRK
ADCC CD40AE		CALL	TRKCMP ;SEKTRK = HSTTRK?
ADCF 2009	J46.	DB	JRNZ,NOMTCH-J46-2
	;		
	;		SAME DISK, SAME TRACK, SAME BUFFER?
ADD1 3AE0AE		LDA	SEKHST
ADD4 21DFAE		LXI	H,HSTSEC ;SEKHST = HSTSEC?
ADD7 BE		CMP	M
ADD8 2824	J47.	DB	JRZ,MATCH-J47-2 ;SKIP IF MATCH
	;		
	NOMTCH.		
			;PROPER DISK, BUT NOT CORRECT SECTOR
ADDA 3AE2AE		LDA	HSTWRT ;HOST WRITTEN?
ADDD B7		ORA	A
ADDE C44CAE		CNZ	WRHST ;CLEAR HOST BUFF
	;		
	FILHST:		
			;MAY HAVE TO FILL THE HOST BUFFER
ADE1 3AD8AE		LDA	SEKDSK
ADE4 32DCAE		STA	HSTDISK
ADE7 2AD9AE		LHLD	SEKTRK
ADEA 22DDAE		SHLD	HSTTRK
ADED 3AE0AE		LDA	SEKHST
ADF0 32DFAE		STA	HSTSEC
ADF3 3AE9AE		LDA	RSFLAG ;NEED TO READ?
ADF6 B7		ORA	A
ADF7 C49DAE		CNZ	RDHST ;YES, IN 1
^DFA AF		XRA	A ;0 TO ACCUM
ADFB 32E2AE		STA	HSTWRT ;NO PENDING WRITE
	;		
	MATCH:		
			;COPY DATA TO OR FROM BUFFER

ADFE 3ADBAE	LDA	SEKSEC	;MASK BUFFER NUMBER
AE01 E601	ANI	SECMSK	,LEAST SIGNIF BITS
AE03 6F	MOV	L,A	,READY TO SHIFT
AE04 2600	MVI	H,0	,DOUBLE COUNT
AE06 29	DAD	H	;SHIFT LEFT 7
AE07 29	DAD	H	
AE08 29	DAD	H	
AE09 29	DAD	H	
AE0A 29	DAD	H	
AE0B 29	DAD	H	
AE0C 29	DAD	H	
	;	HL HAS RELATIVE HOST BUFFER ADDRESS	
AE0D 1100F8	LXI	D,HSTBUF	
AE10 19	DAD	D	;HL = HOST ADDRESS
AE11 EB	XCHG		;NOW IN DE
AE12 2AECAE	LHLD	DMAADR	;GET/PUT CP/M DATA
AE15 0E80	MVI	C,128	,LENGTH OF MOVE
AE17 3AEAAE	LDA	READOP	;WHICH WAY?
AE1A B7	ORA	A	
AE1B 2006	J48:	DB	JRNZ,RWMOVE-J48-2 ;SKIP IF READ
	;		
	;	WRITE OPERATION, MARK AND SWITCH DIRECTION	
AE1D 3E01	MVI	A,1	
AE1F 32E2AE	STA	HSTWRT	;HSTWRT = 1
AE22 EB	XCHG		,SOURCE/DEST SWAP
	;		
	RWMOVE-		
		,C INITIALLY 128, DE IS SOURCE, HL IS DEST	
AE23 1A	LDAX	D	;SOURCE CHARACTER
AE24 13	INX	D	
AE25 77	MOV	M,A	;TO DEST
AE26 23	INX	H	
AE27 0D	DCR	C	;LOOP 128 TIMES
AE28 20F9	J49:	DB	JRNZ,(RWMOVE-J49-2) AND OFFH
	;		
	;	DATA HAS BEEN MOVED TO/FROM HOST BUFFER	
AE2A 3AEBAE	LDA	WRTYPE	;WRITE TYPE
AE2D FE01	CPI	WRDIR	;TO DIRECTORY?
AE2F 3AE8AE	LDA	ERFLAG	;IN CASE OF ERRORS
AE32 C0	RNZ		;NO FURTHER PROCESSING
	;		
	;	CLEAR HOST BUFFER FOR DIRECTORY WRITE	

```

AE33 B7          ORA     A      ;ERRORS?
AE34 C0          RNZ     A      ;SKIP IF SO
AE35 AF          XRA     A      ;O TO ACCUM
AE36 32E2AE      STA     HSTWRT ;BUFFER WRITTEN
AE39 CD4CAE      CALL    WRHST
AE3C 3AE8AE      LDA     ERFLAG
AE3F C9          RET

;
;* * * * * * * * * * * * * * * * * * * * *
;*
;*           UTILITY SUBROUTINE FOR 16-BIT COMPARE
;*
;* * * * * * * * * * * * * * * * * * * * *
TRKCMP:
;HL = .UNATRK OR .HSTTRK, COMPARE WITH SEKTRK
AE40 EB          XCHG
AE41 21D9AE      LXI    H,SEKTRK
AE44 1A          LDAX   D      ;LOW BYTE COMPARE
AE45 BE          CMP    M      ;SAME?
AE46 C0          RNZ
;RETURN IF NOT
;LOW BYTES EQUAL, TEST HIGH IS
AE47 13          INX    D
AE48 23          INX    H
AE49 1A          LDAX   D
AE4A BE          CMP    M      ;SETS FLAGS
AE4B C9          RET

;
;* * * * * * * * * * * * * * * * * * * * *
;*
;*           WRHST PERFORMS THE PHYSICAL WRITE TO
;*           THE HOST DISK, RDHST READS THE PHYSICAL
;*           DISK.
;*
;* * * * * * * * * * * * * * * * * * * * *
WRHST:
;HSTDISK = HOST DISK #, HSTTRK = HOST TRACK #,
;HSTSEC = HOST SECT #. WRITE "HSTSIZ" BYTES
;FROM HSTBUF AND RETURN ERROR FLAG IN ERFLAG.
;RETURN ERFLAG NON-ZERO IF ERROR
AE4C 3E01          MVI    A,VICWR ;LOAD DISK WRITE COMMAND
AE4E 32EEAE        WRHST: STA    RW      ;PUT COMMAND IN REGISTER

```

AE51 3ADCAE		LDA	HSTSDK	,GET HOST DISK NUMBER
AE54 3204F9		STA	DISKNO	; AND PUT IN COMMON AREA
AE57 CD79AE		CALL	CHGDSK	;CORRECT VIRTUAL DISK?
AE5A 3ADDAAE	WRHST2:	LDA	HSTRK	;GET HOST TRACK NUMBER
AE5D 3C		INR	A	;ADD 1 FOR VIC OFFSET
AE5E FE12		CPI	18	;WE WANT TO SKIP TRACK 18
AE60 3801	J50:	DB	JRC,WRHST3-J50-2	;CARRY IF TRACK<18
AE62 3C		INR	A	
AE63 3203F9	WRHST3-	STA	TRACK	;PUT IN COMMON AREA
AE66 3ADFAE		LDA	HSTSEC	;GET HOST SECTOR NUMBER
AE69 3202F9		STA	SECTOR	;PUT IN COMMON AREA
AE6C 3AEEAE		LDA	RW	;GET DISK COMMAND
AE6F CD90AB		CALL	IO6510	
AE72 3A01F9		LDA	DATA	;GET DISK STATUS
AE75 32E8AE		STA	ERFLAG	; AND STORE IN ERFLAG
AE78 C9		RET		
;				
AE79 67	CHGDSK:	MOV	H,A	;SAVE DISK NUMBER
AE7A 3AFFFC		LDA	IOTYPE	;BIT 0=0 FOR VIRTUAL
AE7D E601		ANI	01	
AE7F C0		RNZ		,NOT ZERO IF 2 DRIVES
AE80 3204F9		STA	DISKNO	;FORCE DRIVE A
AE83 7C		MOV	A,H	,RESTORE DISK NUMBER
;				
AE84 21EFAE		LXI	H,CURDSK	;IS THIS OUR CURRENT DISK?
AE87 BE		CMP	M	
AE88 C8		RZ		;RETURN IF OK
;				
AE89 77		MOV	M,A	;SET UP NEW DISK
AE8A C641		ADI	'A'	;FORM ASCII DRIVE LETTER
AE8C 32AFAE		STA	DSKMNT	;PUT IN MESSAGE
;				
AE8F 21A1AE		LXI	H,MNTMSG	,INSERT DISK MESSAGE
AE92 CDCCAE		CALL	PMSG	;GO PRINT IT
AE95 CDFEAB	CHGD1:	CALL	CONIN	.WAIT FOR RETURN
AE98 FE0D		CPI	0DH	
AE9A 20F9	J51:	DB	JRNZ,(CHGD1-J51-2) AND OFFH	
AE9C C9		RET		
;				

RDHST.

,HSTSDK = HOST DISK #, HSTRK = HOST TRACK #,
,HSTSEC = HOST SECT #. READ "HSHSIZ" BYTES

AEE7	UNASEC:	DS	1	,LAST UNALLOC SECTOR
	;			
AEE8	ERFLAG:	DS	1	,ERROR REPORTING
AEE9	RSFLAG:	DS	1	,READ SECTOR FLAG
AEAA	READOP	DS	1	;1 IF READ OPERATION
AEBB	WRTYPE:	DS	1	;WRITE OPERATION TYPE
AEEC	DMAADR:	DS	2	;LAST DMA ADDRESS
AEED	RW:	DS	1	,TEMPORARY COMMAND
				REGISTER
AEEF	CURDSK:	DS	1	,VIRTUAL DISK POINTER
	;			
	,	SCRATCH RAM AREA FOR BDOS USE		
AEFO =	BEGDAT	EQU	\$	'BEGINNING OF DATA AREA
AEFO	DIRBF:	DS	128	,SCRATCH DIRECTORY AREA
AF70	ALL00:	DS	31	;ALLOCATION VECTOR 0
AF8F	ALL01:	DS	31	;ALLOCATION VECTOR 1
AFAE	CHK00:	DS	16	,CHECK VECTOR 0
AFBE	CHK01:	DS	16	,CHECK VECTOR 1
	;			
AFCE =	ENDDAT	EQU	\$,END OF DATA AREA
00DE =	DATSIZ	EQU	\$-BEGDAT	;SIZE OF DATA AREA
AFCE		END		

ABOUT THE COMMODORE 64 CP/M® OPERATING SYSTEM USER'S GUIDE...

The Commodore Z80 microprocessor and CP/M® operating system let you turn your Commodore 64 into a dual processor home microcomputer.

CP/M® lets you use more than 15,000 CP/M® application programs. CP/M® software includes widely used business applications such as financial reporting and analysis, investment planning, word processing, farm and restaurant management, data base, exotic language compilers, and much, much more.

The *Commodore 64 CP/M® Operating System User's Guide* tells you how to use the Z80 cartridge and the CP/M® operating system. This manual gives you detailed information on how to bring up CP/M® on your system. We also give you a detailed reference section with descriptions of all the CP/M® commands and utility programs.

For the beginner, this manual offers simple, step-by-step instructions with all the information you need to use CP/M® on your Commodore 64.

For the advanced user, this manual provides detailed information on the technical workings of CP/M® on your Commodore 64 and the engineering details of your Z80 cartridge.

This manual is written in an easy-to-read style and is designed to help you get the most out of the Z80 microprocessor and the CP/M® operating system.

 **commodore**
COMPUTER

Commodore Business Machines, Inc.—Computer Systems Division,
950 Airport Rd, West Chester, PA 19380

DISTRIBUTED BY

Howard W. Sams & Co., Inc.
4300 W. 62nd Street, Indianapolis, Indiana 46268 USA

\$12.95/22098

ISBN: 0-672-22098-9