DIGITAL RESEARCH™

CP/M Plus™

(CP/M® Version 3)

Operating System

System Guide

Dear CP/M Plus User:

Digital Research has developed the CP/M Plus Operating System to take advantage of the latest hardware in the 8 bit microcomputer world. The design of CP/M Plus is a reflection of our goal to provide you with a state of the art operating system that can be configured for a wide variety of computer hardware.

This shipment contains the version 3.0 release of our CP/M Plus system. We hope to maintain the same level of confidence that the computer industry has had in our previous CP/M operating systems.

On the basis of our experience and the experience of CP/M Plus users, we estimate that it requires less than a week to implement a simple non-banked CP/M Plus system from a copy of your CP/M 2.2 BIOS. Implementing a banked CP/M Plus system with Bank Switching, Auto Density Select, and Device Reassignment can require several weeks. Of course, the time to perform such a reconfiguration will vary widely depending on the experience of the programmer and the complexity of the hardware.

Contact the Digital Research Technical Support staff, (408) 375-6262, if you experience difficulties reconfiguring CP/M Plus. By sending in your registration card you can insure that we will mail CP/M Plus application notes and patches that correct implementation errors.

Sincerely,

TECHNICAL SUPPORT

CP/M Plus™
(CP/M® Version 3)
Operating System
System Guide

Digital Research
P.O. Box 579
160 Central Avenue
Pacific Grove, CA 93950
(408) 649-3896
TWX 910 360 5001

The CP/M 3 Operating System System Guide was prepared using the Digital Research TEX Text Formatter and printed in the United States of America.

```
***********************************
*  First Edition:  January 1983   *
***********************************
```

Foreword

CP/M® 3, also marketed as CP/M Plus™ , is a single-console operating system for 8-bit machines that use an Intel® 8080, 8085, or Zilog® Z80® CPU. CP/M 3 is upward-compatible with its predecessor, CP/M 2, and offers more features and higher performance than CP/M 2. This manual describes the steps necessary to create or modify a CP/M 3 Basic Input Output System (BIOS) tailored for a specific hardware environment.

The CP/M Plus (CP/M Version 3) Operating System System Guide assumes you are familiar with systems programming in 8080 assembly language and that you have access to a CP/M 2 system. It also assumes you understand the target hardware and that you have functioning disk I/O drivers. You should be familiar with the accompanying CP/M Plus (CP/M Version 3) Operating System User's Guide describing the operating system utilities. You should also be familiar with the CP/M Plus (CP/M Version 3) Operating System Programmer's Guide, which describes the system calls used by the applications programmer to interface with the operating system. The Programmer's Utilities Guide for the CP/M Family of Operating Systems documents the assembling and debugging utilities.

Section 1 of this manual is an overview of the component modules of the CP/M 3 operating system. Section 2 provides an overview of the functions and data structures necessary to write an interface module between CP/M 3 and specific hardware. Section 3 contains a detailed description of these functions and data structures, followed by instructions to assemble and link the distributed modules with your customized modules. Section 4 describes the modular organization of the sample CP/M 3 BIOS on your distribution diskette. Section 5 documents the procedure to generate and boot your CP/M 3 system. Section 6 is a sample debugging session.

The appendixes contain tables, and sample BIOS modules you can use, or study and modify. Appendix A discusses removable media drives. Appendix B discusses automatic density support. Appendix C describes how CP/M 3 differs from CP/M 2. Appendix D shows the format of the CPM3.SYS file.

Appendixes E through H are listings of the assembled source code for the four hardware-independent modules of the sample BIOS. Appendix E is the kernel module to use when creating a modular BIOS in the form of the distributed sample. Appendix F shows the System Control Block. Appendix G is a table of equates for the baud rate and mode byte for character I/O. Appendix H contains the macro definitions you can use to generate some of the CP/M 3 disk data structures. Appendix I lists the assembled source code for the six BIOS modules that depend on the Altos 8000-15 Computer System hardware. It also contains a sample Submit file to build a BIOS.

Appendixes J and K are tabular summaries of the public entry points and data items in the modules of the sample BIOS. Finally, Appendix L is a tabular summary of the thirty-three functions of the CP/M 3 BIOS, complete with entry parameters and returned values.

Table of Contents

Table of Contents
(continued)

Table of Contents
(continued)

Appendixes

Tables, Figures, and Listings

Tables

Tables, Figures, and Listings (continued)

Figures

Listings

Section 1
CP/M 3 Operating System Overview

This section is an overview of the CP/M 3 operating system, with a description of the system components and how they relate to each other. The section includes a discussion of memory configurations and supported hardware. The last portion summarizes the creation of a customized version of the CP/M 3 Basic Input Output System (BIOS).

1.1 Introduction to CP/M 3

CP/M 3 provides an environment for program development and execution on computer systems that use the Intel 8080, 8085, or Z80 microprocessor chip. CP/M 3 provides rapid access to data and programs through a file structure that supports dynamic allocation of space for sequential and random access files.

CP/M 3 supports a maximum of sixteen logical floppy or hard disks with a storage capacity of up to 512 megabytes each. The maximum file size supported is 32 megabytes. You can configure the number of directory entries and block size to satisfy various user needs.

CP/M 3 is supplied in two versions. One version supports nonbank-switched memory; the second version supports hardware with bank-switched memory capabilities. CP/M 3 supplies additional facilities for the bank-switched system, including extended command line editing, password protection of files, and extended error messages.

The nonbanked system requires 8.5 kilobytes of memory, plus space for your customized BIOS. It can execute in a minimum of 32 kilobytes of memory.

The bank-switched system requires a minimum of two memory banks with 11 kilobytes of memory in Bank 0 and 1.5 kilobytes in common memory, plus space for your customized BIOS. The bank-switched system provides more user memory for application programs.

CP/M 3 resides in the file CPM3.SYS, which is loaded into memory by a system loader during system initialization. The system loader resides on the first two tracks of the system disk. CPM3.SYS contains the distributed BDOS and the customized BIOS.

The CP/M 3 operating system is distributed on two single-density, single-sided, eight-inch floppy disks. Digital Research supplies a sample BIOS which is configured for an Altos 8000-15 microcomputer system with bank-switched memory and two single-density, single-sided, eight-inch floppy disk drives.

1.2 CP/M 3 System Components

The CP/M 3 operating system consists of the following three modules: the Console Command Processor (CCP), the Basic Disk Operating System (BDOS), and the Basic Input Output System (BIOS).

The CCP is a program that provides the basic user interface to the facilities of the operating system. The CCP supplies six built-in commands: DIR, DIRS, ERASE, RENAME, TYPE, and USER. The CCP executes in the Transient Program Area (TPA), the region of memory where all application programs execute. The CCP contains the Program Loader Module, which loads transient (applications) programs from disk into the TPA for execution.

The BDOS is the logical nucleus and file system of CP/M 3. The BDOS provides the interface between the application program and the physical input/output routines of the BIOS.

The BIOS is a hardware-dependent module that interfaces the BDOS to a particular hardware environment. The BIOS performs all physical I/O in the system. The BIOS consists of a number of routines that you must configure to support the specific hardware of the target computer system.

The BDOS and the BIOS modules cooperate to provide the CCP and other transient programs with hardware-independent access to CP/M 3 facilities. Because the BIOS is configured for different hardware environments and the BDOS remains constant, you can transfer programs that run under CP/M 3 unchanged to systems with different hardware configurations.

1.3 Communication Between Modules

The BIOS loads the CCP into the TPA at system cold and warm start. The CCP moves the Program Loader Module to the top of the TPA and uses the Program Loader Module to load transient programs.

The BDOS contains a set of functions that the CCP and applications programs call to perform disk and character input and output operations.

The BIOS contains a Jump Table with a set of 33 entry points that the BDOS calls to perform hardware-dependent primitive functions, such as peripheral device I/O. For example, CONIN is an entry point of the BIOS called by the BDOS to read the next console input character.

Similarities exist between the BDOS functions and the BIOS functions, particularly for simple device I/O. For example, when a transient program makes a console output function call to the BDOS, the BDOS makes a console output call to the BIOS. In the case of disk I/O, however, this relationship is more complex. The BDOS might make many BIOS function calls to perform a single BDOS file I/O function. BDOS disk I/O is in terms of 128-byte logical records. BIOS disk I/O is in terms of physical sectors and tracks.

The System Control Block (SCB) is a 100-byte decimal CP/M 3 data structure that resides in the BDOS system component. The BDOS and the BIOS communicate through fields in the SCB. The SCB contains BDOS flags and data, CCP flags and data, and other system information, such as console characteristics and the current date and time. You can access some of the System Control Block fields from the BIOS.

Note that the SCB contains critical system parameters which reflect the current state of the operating system. If a program modifies these parameters, the operating system can crash. See Section 3 of this manual, and the description of BDOS Function 49 in the CP/M Plus (CP/M Version 3) Operating System Programmer's Guide for more information on the System Control Block.

Page Zero is a region of memory that acts as an interface between transient programs and the operating system. Page Zero contains critical system parameters, including the entry to the BDOS and the entry to the BIOS Warm BOOT routine. At system start-up, the BIOS initializes these two entry points in Page Zero. All linkage between transient programs and the BDOS is restricted to the indirect linkage through Page Zero. Figure 1-1 illustrates the general memory organization of CP/M 3.

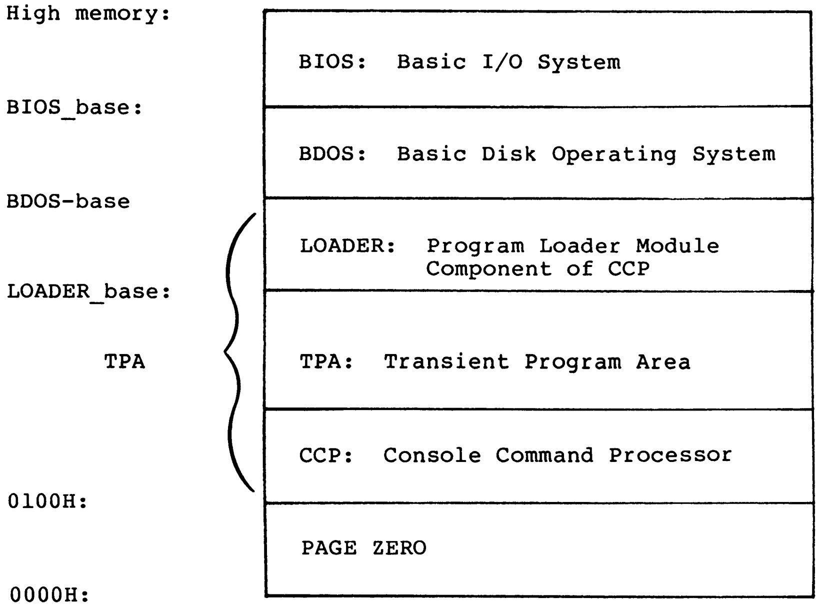

Figure 1-1. General Memory Organization of CP/M 3

Note that all memory regions in CP/M 3 are page aligned, which means that they must begin on a page boundary. Because a page is defined as 256 (100H) bytes, a page boundary always begins at a hexadecimal address where the low-order byte of the hex address is zero.

1.4 Banked and Nonbanked Systems

CP/M 3 is supplied in two versions: one for hardware that supports banked memory, and the other for hardware with a minimum of 32 kilobytes of memory. The systems are called banked and nonbanked.

Digital Research supplies System Page Relocatable (.SPR) files for both a banked BDOS and a nonbanked BDOS. A sample banked BIOS is supplied for you to use as an example when creating a customized BIOS for your set of hardware components.

The following figure shows the memory organization for a banked system. Bank 0 and common memory are for the operating system. Bank 1 is the Transient Program Area, which contains the Page Zero region of memory. You can use additional banks to enhance operating system performance.

In banked CP/M 3 systems, CPMLDR, the system loader, loads part of the BDOS into common memory and part of the BDOS into Bank 0. CPMLDR loads the BIOS in the same manner.

Figure 1-2 shows the memory organization for the banked version of CP/M 3.

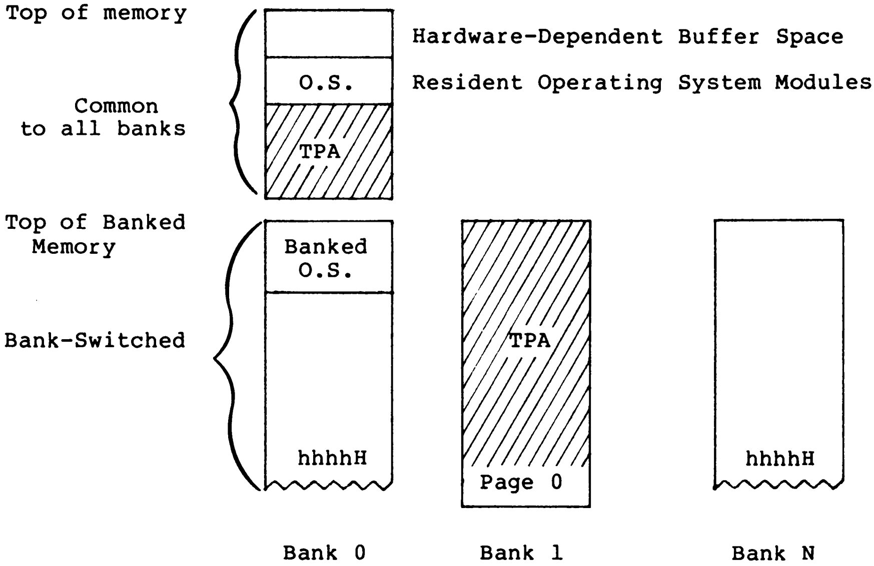

Figure 1-2. Memory Organization for Banked CP/M 3 System

In this figure, the top region of memory is called common memory. Common memory is always enabled and addressable. The operating system is divided into two modules: the resident portion, which resides in common memory, and the banked portion, which resides just below common memory in Bank 0.

The shaded areas in Figure 1-2 represent the memory available to transient programs. The clear areas are used by the operating system for disk record buffers and directory hash tables. The clear area in the common region above the operating system represents space that can be allocated for data buffers by GENCPM, the CP/M 3 system generation utility. The minimum size of the buffer area is determined by the specific hardware requirements of the host microcomputer system.

Bank 0, the system bank, is the bank that is enabled when CP/M 3 is cold started. Bank 1 is the transient program bank.

The transient program bank must be contiguous from location zero to the top of banked memory. Common memory must also be contiguous. The other banks need not begin at location zero or have contiguous memory.

Figure 1-3 shows the CP/M 3 memory organization when the TPA bank, Bank 1, is enabled in a bank-switched system.

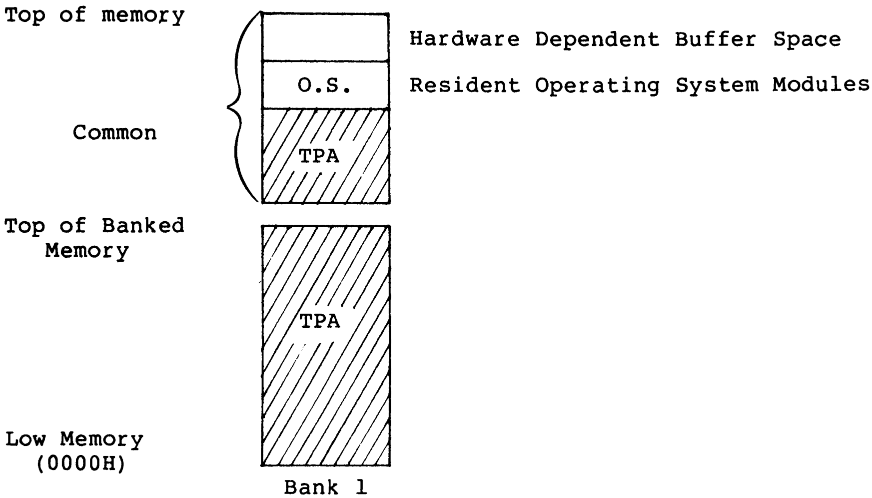

Figure 1-3. Memory Organization with Bank 1 Enabled in Banked System

The operating system switches to Bank 0 or other banks when performing operating system functions. In general, any bank switching performed by the operating system is transparent to the calling program.

The memory organization for the nonbanked version of CP/M 3 is much simpler, as shown in Figure 1-4:

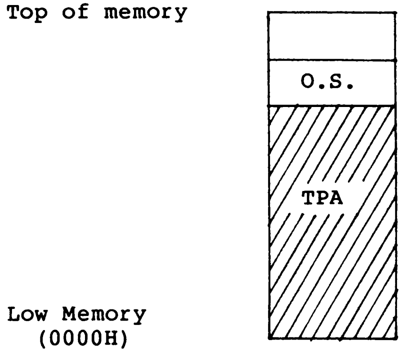

Figure 1-4. Memory Organization in Nonbanked CP/M 3 System

In the nonbanked version of CP/M 3, memory consists of a single contiguous region addressable from 0000H up to a maximum of 0FFFFH, or 64K-1. The clear area above the operating system represents space that can be allocated for data buffers and directory hash tables by the CP/M 3 system generation utility, GENCPM, or directly allocated by the BIOS. The minimum size of the buffer area is determined by the specific hardware requirements of the host microcomputer system. Again, the shaded region represents the space available for transient programs.

1.5 Memory Requirements

Table 1-1 shows typical sizes of the CP/M 3 operating system components.

Table 1-1. CP/M 3 Operating System Memory Requirements

CP/M 3 Version	Nonbanked	Banked Common	Banked Bank 0
BDOS	8.5K	1.5K	11K
BIOS (values vary)			
floppy system	1.5K	.75K	2K
hard system	2.5K	1.5K	3K

The CP/M 3 banked system requires a minimum of two banks (Bank 0 and Bank 1) and can support up to 16 banks of memory. The size of the common region is often 16K, but can be as small as 4K. Common memory must be large enough to contain the required buffers and the resident (common) portion of the operating system, which means a

1.5K BDOS and the common part of your customized BIOS.

In a banked environment, CP/M 3 maintains a cache of deblocking buffers and directory records using a Least Recently Used (LRU) buffering scheme. The LRU buffer is the first to be reused when the system runs out of buffer space. The BDOS maintains separate buffer pools for directory and data record caching.

The RSX modules shown in Figure 1-5 are Resident System Extensions (RSX) that are loaded directly below the operating system when included in an application or utility program. The Program Loader places the RSX in memory and chains BDOS calls through the RSX entry point in the RSX.

Figure 1-5 shows the memory organization in a typical bank-switched CP/M 3 system.

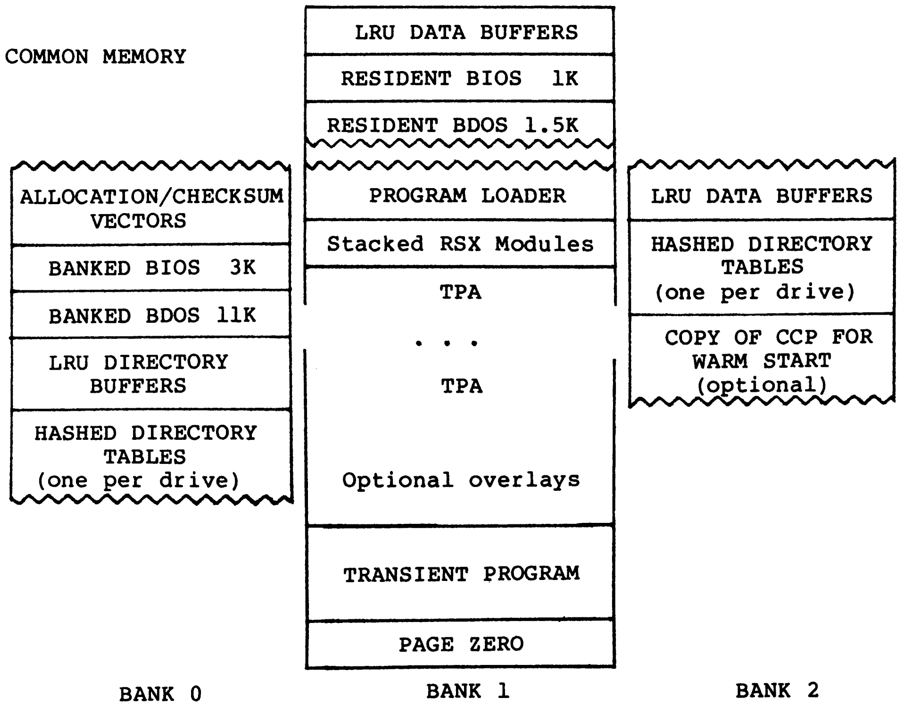

Figure 1-5. Memory Organization in Banked CP/M 3

The banked system supports a TPA of 60K or more. The banked portion of the operating system in Bank 0 requires at least 16K of memory.

In the banked system, the BDOS and the BIOS are separated into two parts: a resident portion, and a banked portion. The resident BDOS and BIOS are located in common memory. The banked BDOS and BIOS are located in the operating system bank, referred to as Bank 0 in this manual.

The TPA extends from 100H in Bank 1 up to the bottom of the resident BDOS in common memory. The banked BIOS and BDOS reside in Bank 0 with the directory buffers. Typically, all data buffers reside in common. Data buffers can reside in an alternate bank if the system has a DMA controller capable of transferring arbitrary blocks of data from one bank to another. Hashed directory tables (one per drive) can be placed in any bank except Bank 1 (TPA). Hashed directory tables require 4 bytes per directory entry.

Figure 1-6 shows a typical nonbanked system configuration.

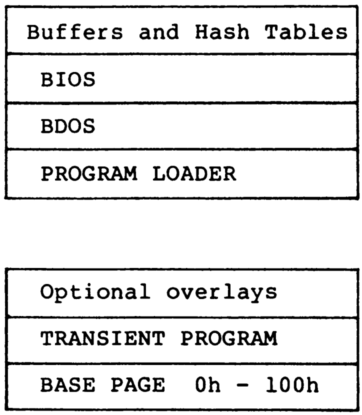

Figure 1-6. Memory Organization in Nonbanked CP/M 3

The nonbanked CP/M 3 system requires 8.5K of memory plus space for the BIOS, buffers, and hash tables, allowing a TPA size of up to 52K to 54K, depending on the size of the BIOS and the number of hash tables and buffers you are using.

1.6 Disk Organization

Figure 1-7 illustrates the organization of a CP/M 3 system disk.

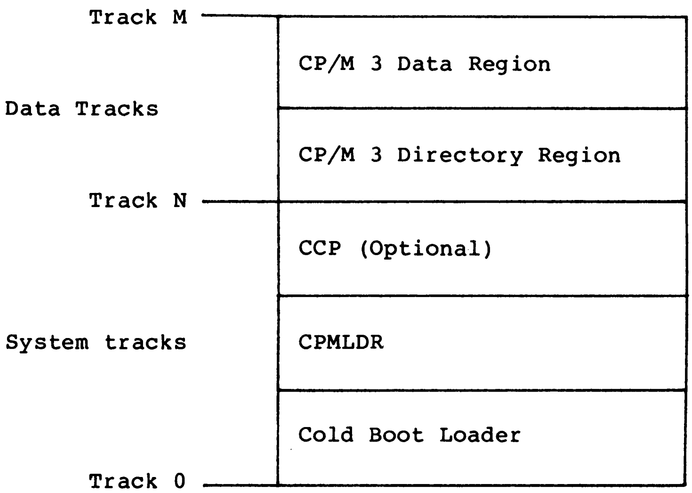

Figure 1-7. CP/M 3 System Disk Organization

In Figure 1-7, the first N tracks are the system tracks; the remaining tracks, the data tracks, are used by CP/M 3 for file storage. Note that the system tracks are used by CP/M 3 only during system cold start and warm start. All other CP/M 3 disk access is directed to the data tracks of the disk. To maintain compatibility with Digital Research products, you should use an eight-inch, single-density, IBM® 3740 formatted disk with two system tracks.

1.7 Hardware Supported

You can customize the BIOS to match any hardware environment with the following general characteristics.

1.7.1 Hardware Supported by CP/M 3 Banked System

- Intel 8080, Intel 8085, or Zilog Z80 CPU or equivalent.
- A minimum of two and up to sixteen banks of memory with the top 4K-32K in common memory. Bank 1 must have contiguous memory from address 0000H to the base of common memory. A reasonable configuration consists of two banks of 48K RAM each, with the top 16K in common memory.
- One to sixteen disk drives of up to 512 megabytes capacity each.
- Some form of ASCII console device, usually a CRT.
- One to twelve additional character input and or output devices, such as printers, communications hardware, and plotters.

1.7.2 Hardware Supported by CP/M 3 Nonbanked System

- Intel 8080, Intel 8085, or Zilog Z80 CPU or equivalent.
- A minimum of 32K and up to 64K contiguous memory addressable from location zero.
- One to sixteen disk drives of up to 512 megabytes capacity each.
- Some form of ASCII console device, usually a CRT.
- One to twelve additional input and or output devices, usually including a printer.

Because most CP/M-compatible software is distributed on eight-inch, soft-sectored, single-density floppy disks, it is recommended that a CP/M 3 hardware configuration include a minimum of two disk drives, at least one of which is a single-density floppy disk drive.

1.8 Customizing CP/M 3

Digital Research supplies the BDOS files for a banked and a nonbanked version of CP/M 3. A system generation utility, GENCPM, is provided with CP/M 3 to create a version of the operating system tailored to your hardware. GENCPM combines the BDOS and your customized BIOS files to create a CPM3.SYS file, which is loaded into memory at system start-up. The CPM3.SYS file contains the BDOS and BIOS system components and information indicating where these modules reside in memory.

Digital Research supplies a CP/M 3 loader file, CPMLDR, which you can link with your customized loader BIOS and use to load the CPM3.SYS file into memory. CPMLDR is a small, self-contained version of CP/M 3 that supports only console output and sequential file input. Consistent with CP/M 3 organization, it contains two modules: an invariant CPMLDR_BDOS, and a variant CPMLDR_BIOS, which is adapted to match the host microcomputer hardware environment.

The CPMLDR_BIOS module can perform cold start initialization of I/O ports and similar functions. CPMLDR can display a memory map of the CP/M 3 system at start-up. This is a GENCPM option.

The following steps tell you how to create a new version of CP/M 3 tailored to your specific hardware.

1) Write and assemble a customized BIOS following the specifications described in Section 3. This software module must correspond to the exact physical characteristics of the target system, including memory and port addresses, peripheral types, and drive characteristics.

2) Use the system generation utility, GENCPM, to create the CPM3.SYS file containing the CP/M 3 distributed BDOS and your customized BIOS, as described in Section 5.

3) Write a customized loader BIOS (LDRBIOS) to reside on the system tracks as part of CPMLDR. CPMLDR loads the CPM3.SYS file into memory from disk. Section 5 gives the instructions for customizing the LDRBIOS and generating CPMLDR. Link your customized LDRBIOS file with the supplied CPMLDR file.

4) Use the COPYSYS utility to put CPMLDR on the system tracks of a disk.

5) Test and debug your customized version of CP/M 3.

If you have banked memory, Digital Research recommends that you first use your customized BIOS to create a nonbanked version of the CP/M 3 operating system. You can leave your entire BIOS in common memory until you have a working system. Test all your routines in a nonbanked version of CP/M 3 before you create a banked version.

1.9 Initial Load (Cold Boot) of CP/M 3

CP/M 3 is loaded into memory as follows. Execution is initiated by a four-stage procedure. The first stage consists of loading into memory a small program, called the Cold Boot Loader, from the system tracks of the Boot disk. This load operation is typically handled by a hardware feature associated with system reset. The Cold Boot Loader is usually 128 or 256 bytes in length.

In the second stage, the Cold Boot Loader loads the memory image of the CP/M 3 system loader program, CPMLDR, from the system tracks of a disk into memory and passes control to it. For a banked system, the Cold Boot Loader loads CPMLDR into Bank 0. A PROM loader can perform stages one and two.

In the third stage, CPMLDR reads the CPM3.SYS file, which contains the BDOS and customized BIOS, from the the data area of the disk into the memory addresses assigned by GENCPM. In a banked system, CPMLDR reads the common part of the BDOS and BIOS into the common part of memory, and reads the banked part of the BDOS and BIOS into the area of memory below common_base in Bank 0. CPMLDR then transfers control to the Cold BOOT system initialization routine in the BIOS.

For the final stage, the BIOS Cold BOOT routine, BIOS Function 0, performs any remaining necessary hardware initialization, displays the sign-on message, and reads the CCP from the system tracks or from a CCP.COM file on disk into location 100H of the TPA. The Cold BOOT routine transfers control to the CCP, which then displays the system prompt.

Section 2 provides an overview of the organization of the System Control Block and the data structures and functions in the CP/M 3 BIOS.

End of Section 1

Section 2
CP/M 3 BIOS Overview

This section describes the organization of the CP/M 3 BIOS and the BIOS jump vector. It provides an overview of the System Control Block, followed by a discussion of system initialization procedures, character I/O, clock support, disk I/O, and memory selects and moves.

2.1 Organization of the BIOS

The BIOS is the CP/M 3 module that contains all hardware-dependent input and output routines. To configure CP/M 3 for a particular hardware environment, use the sample BIOS supplied with this document and adapt it to the specific hardware of the target system.

Alternatively, you can modify an existing CP/M 2.2 BIOS to install CP/M 3 on your target machine. Note that an unmodified CP/M 2.2 BIOS does not work with the CP/M 3 operating system. See Appendix C for a description of the modifications necessary to convert a CP/M 2.2 BIOS to a CP/M 3 BIOS.

The BIOS is a set of routines that performs system initialization, character-oriented I/O to the console and printer devices, and physical sector I/O to the disk devices. The BIOS also contains routines that manage block moves and memory selects for systems with bank-switched memory. The BIOS supplies tables that define the layout of the disk devices and allocate buffer space which the BDOS uses to perform record blocking and deblocking. The BIOS can maintain the system time and date in the System Control Block.

Table 2-1 describes the entry points into the BIOS from the Cold Start Loader and the BDOS. Entry to the BIOS is through a jump vector. The jump vector is a set of 33 jump instructions that pass program control to the individual BIOS subroutines.

You must include all of the entry points in the BIOS jump vector in your BIOS. However, if your system does not support some of the functions provided for in the BIOS, you can use empty subroutines for those functions. For example, if your system does not support a printer, JMP LIST can reference a subroutine consisting of only a RET instruction. Table 2-1 shows the elements of the jump vector.

Table 2-1. CP/M 3 BIOS Jump Vector

No.	Instruction	Description
0	JMP BOOT	Perform cold start initialization
1	JMP WBOOT	Perform warm start initialization
2	JMP CONST	Check for console input character ready
3	JMP CONIN	Read Console Character in
4	JMP CONOUT	Write Console Character out
5	JMP LIST	Write List Character out
6	JMP AUXOUT	Write Auxiliary Output Character
7	JMP AUXIN	Read Auxiliary Input Character
8	JMP HOME	Move to Track 00 on Selected Disk
9	JMP SELDSK	Select Disk Drive
10	JMP SETTRK	Set Track Number
11	JMP SETSEC	Set Sector Number
12	JMP SETDMA	Set DMA Address
13	JMP READ	Read Specified Sector
14	JMP WRITE	Write Specified Sector
15	JMP LISTST	Return List Status
16	JMP SECTRN	Translate Logical to Physical Sector
17	JMP CONOST	Return Output Status of Console
18	JMP AUXIST	Return Input Status of Aux. Port
19	JMP AUXOST	Return Output Status of Aux. Port
20	JMP DEVTBL	Return Address of Char. I/O Table
21	JMP DEVINI	Initialize Char. I/O Devices
22	JMP DRVTBL	Return Address of Disk Drive Table
23	JMP MULTIO	Set Number of Logically Consecutive sectors to be read or written
24	JMP FLUSH	Force Physical Buffer Flushing for user-supported deblocking
25	JMP MOVE	Memory to Memory Move
26	JMP TIME	Time Set/Get signal
27	JMP SELMEM	Select Bank of Memory
28	JMP SETBNK	Specify Bank for DMA Operation
29	JMP XMOVE	Set Bank When a Buffer is in a Bank other than 0 or 1
30	JMP USERF	Reserved for System Implementor
31	JMP RESERV1	Reserved for Future Use
32	JMP RESERV2	Reserved for Future Use

Each jump address in Table 2-1 corresponds to a particular subroutine that performs a specific system operation. Note that two entry points are reserved for future versions of CP/M, and one entry point is provided for OEM subroutines, accessed only by direct BIOS calls using BDOS Function 50. Table 2-2 shows the five categories of system operations and the function calls that accomplish these operations.

Table 2-2. CP/M 3 BIOS Functions

Operation	Function
System Initialization	BOOT, WBOOT, DEVTBL, DEVINI, DRVTBL
Character I/O	CONST, CONIN, CONOUT, LIST, AUXOUT, AUXIN, LISTST, CONOST, AUXIST, AUXOST
Disk I/O	HOME, SELDSK, SETTRK, SETSEC, SETDMA, READ, WRITE, SECTRN, MULTIO, FLUSH
Memory Selects and Moves	MOVE, SELMEM, SETBNK, XMOVE
Clock Support	TIME

You do not need to implement every function in the BIOS jump vector. However, to operate, the BDOS needs the BOOT, WBOOT, CONST, CONIN, CONOUT, HOME, SELDSK, SETTRK, SETSEC, SETDMA, READ, WRITE, SECTRN, MULTIO, FLUSH, and TIME subroutines. Implement SELMEM and SETBNK only in a banked environment. You can implement MULTIO and FLUSH as returns with a zero in Register A. DEVICE and some other utilities use the remaining entry points, but it is not necessary to fully implement them in order to debug and develop the system.

Note: include all routines but make the nonimplemented routines a RET instruction.

2.2 System Control Block

The System Control Block (SCB) is a data structure located in the BDOS. The SCB is a communications area referenced by the BDOS, the CCP, the BIOS, and other system components. The SCB contains system parameters and variables, some of which the BIOS an reference. The fields of the SCB are named, and definitions of these names are supplied as public variable and subroutine names in the SCB.ASM file contained on the distribution disk. See Section 3.1 for a discussion of the System Control Block.

2.3 System Initialization

When the BOOT and WBOOT routines of the BIOS get control, they must initialize two system parameters in Page Zero of memory, as shown in Table 2-3.

Table 2-3. Initialization of Page Zero

Location	Description
0,1,2	Set to JMP WBOOT (0000H: JMP BIOS+3). Location 1 and 2 must contain the address of WBOOT in the jump vector.
5,6,7	Set to JMP BDOS, the primary entry point to CP/M 3 for transient programs. The current address of the BDOS is maintained in the variable @MXTPA in the System Control Block. (See Section 3.1, System Control Block, and Section 3.4.1, BIOS Function 1: WBOOT.)

The BOOT and WBOOT routine must load the CCP into the TPA in Bank 1 at location 0100H. The CCP can be loaded in two ways. If there is sufficient space on the system tracks, the CCP can be stored on the system tracks and loaded from there. If you prefer, or if there is not sufficient space on the system tracks, the BIOS Cold BOOT routine can read the CCP into memory from the file CCP.COM on disk.

If the CCP is in a .COM file, use the BOOT and WBOOT routines to perform any necessary system initialization, then use the BDOS functions to OPEN and READ the CCP.COM file into the TPA. In bank-switched systems, the CCP must be read into the TPA in Bank 1.

In bank-switched systems, your Cold BOOT routine can place a copy of the CCP into a reserved area of an alternate bank after loading the CCP into the TPA in Bank 1. Then the Warm BOOT routine can copy the CCP into the TPA in Bank 1 from the alternate bank, rather than reloading the CCP from disk, thus avoiding all disk accesses during warm starts.

There is a 128-byte buffer in the resident portion of the BDOS in a banked system that can be used by BOOT and WBOOT. The address of this buffer is stored in the SCB variable @BNKBF. BOOT and WBOOT can use this buffer when copying the CCP to and from the alternate bank.

The system tracks for CP/M 3 are usually partitioned as shown in the following figure:

Cold Start Ldr	CPMLDR	CCP (optional)

Figure 2-1. CP/M 3 System Tracks

The cold start procedure is designed so you need to initialize the system tracks only once. This is possible because the system tracks contain the system loader and need not change when you change the CP/M 3 operating system. The Cold Start Loader loads CPMLDR into a constant memory location that is chosen when the system is configured. However, CPMLDR loads the BDOS and BIOS system components into memory as specified in the CPM3.SYS file generated by GENCPM, the system generation utility. Thus, CP/M 3 allows the user to configure a new system with GENCPM and then run it without having to update the system tracks of the system disk.

2.4 Character I/O

CP/M 3 assumes that all simple character I/O operations are performed in 8-bit ASCII, upper- and lower-case, with no parity. An ASCII CRTL-Z (1AH) denotes an end-of-file condition for an input device.

Table 2-4 lists the characteristics of the logical devices.

Table 2-4. CP/M 3 Logical Device Characteristics

Device	Characteristics
CONIN, CONOUT	The interactive console that communicates with the operator, accessed by CONST, CONIN, CONOUT, and CONOUTST. Typically, the CONSOLE is a device such as a CRT or teletype, interfaced serially, but it can also be a memory-mapped video display and keyboard. The console is an input device and an output device.
LIST	The system printer, if it exists on your system. LIST is usually a hard-copy device such as a printer or teletypewriter.
AUXOUT	The auxiliary character output device, such as a modem.
AUXIN	The auxiliary character input device, such as a modem.

Note that you can define a single peripheral as the LIST, AUXOUT, and AUXIN device simultaneously. If you assign no peripheral device as the LIST, AUXOUT, or AUXIN device, the AUXOUT and LIST routines can just return, and the AUXIN routine can return with a 1AH (CTRL-Z) in register A to indicate an immediate end-of-file.

CP/M 3 supports character device I/O redirection. This means that you can direct a logical device, such as CONIN or AUXOUT, to one or more physical devices. The DEVICE utility allows you to reassign devices and display and change the current device configurations, as described in the CP/M 3 User's Guide. The I/O redirection facility is optional. You should not implement it until the rest of your BIOS is fully functional.

2.5 Disk I/O

The BDOS accomplishes disk I/O by making a sequence of calls to the various disk access subroutines in the BIOS. The subroutines set up the disk number to access, the track and sector on a particular disk, and the Direct Memory Access (DMA) address and bank involved in the I/O operation. After these parameters are established, the BDOS calls the READ or WRITE function to perform the actual I/O operation.

Note that the BDOS can make a single call to SELDSK to select a disk drive, follow it with a number of read or write operations to the selected disk, and then select another drive for subsequent operations.

CP/M 3 supports multiple sector read or write operations to optimize rotational latency on block disk transfers. You can implement the multiple sector I/O facility in the BIOS by using the multisector count passed to the MULTIO entry point. The BDOS calls MULTIO to read or write up to 128 sectors. For every sector number 1 to n, the BDOS calls SETDMA then calls READ or WRITE.

Table 2-5 shows the sequence of BIOS calls that the BDOS makes to read or write a physical disk sector in a nonbanked and a banked system. Table 2-6 shows the sequence of calls the BDOS makes to the BIOS to read or write multiple contiguous physical sectors in a nonbanked and banked system.

Table 2-5. BDOS Calls to BIOS in Nonbanked and Banked Systems

Nonbanked BDOS	
Call	Explanation
SELDSK	Called only when disk is initially selected or reselected.
SETTRK	Called for every read or write of a physical sector.
SETSEC	Called for every read or write of a physical sector.
SETDMA	Called for every read or write of a physical sector.
READ, WRITE	Called for every read or write of a physical sector.
Banked BDOS	
Call	Explanation
SELDSK	Called only when disk is initially selected or reselected.
SETTRK	Called for every read or write of a physical sector.
SETSEC	Called for every read or write of a physical sector.
SETDMA	Called for every read or write of a physical sector.
SETBNK	Called for every read or write of a physical sector.
READ, WRITE	Called for every read or write of a physical sector.

Table 2-6. Multiple Sector I/O in Nonbanked and Banked Systems

Nonbanked BDOS	
Call	Explanation
SELDSK	Called only when disk is initially selected or reselected.
MULTIO	Called to inform the BIOS that the next n calls to disk READ or disk WRITE require a transfer of n contiguous physical sectors to contiguous memory.
SETTRK	Called for every read or write of a physical sector.
SETSEC	Called for every read or write of a physical sector.
SETDMA	Called for every read or write of a physical sector.
READ, WRITE	Called for every read or write of a physical sector.
SELDSK	Called only when disk is initially selected or reselected.
MULTIO	Called to inform the BIOS that the next n calls to disk READ or disk WRITE require a transfer of n contiguous physical sectors to contiguous memory.
SETTRK	Called for every read or write of a physical sector.
SETSEC	Called for every read or write of a physical sector.
SETDMA	Called for every read or write of a physical sector.
SETBNK	Called for every read or write of a physical sector.
READ, WRITE	Called for every read or write of a physical sector.

Table 2-7 shows the sequence of BDOS calls to read two contiguous physical sectors in a banked system.

Table 2-7. Reading Two Contiguous Sectors in Banked System

Call	Explanation
SELDSK	Called to initially select disk
MULTIO	With a value of 2
SETTRK	For first sector
SETSEC	For first sector
SETDMA	For first sector
SETBNK	
READ	
SETTRK	For second sector
SETSEC	For second sector
SETDMA	For second sector
SETBNK	
READ	

The CP/M 3 BDOS performs its own blocking and deblocking of logical 128-byte records. Unlike earlier versions of CP/M, the BIOS READ and WRITE routines always transfer physical sectors as specified in the Disk Parameter Block to or from the DMA buffer. The Disk Parameter Header defines one or more physical sector buffers which the BDOS uses for logical record blocking and deblocking.

In a banked environment, CP/M 3 maintains a cache of deblocking buffers and directory records using a Least Recently Used (LRU) buffering scheme. The LRU buffer is the first to be reused when the system runs out of buffer space. The BDOS maintains separate buffer pools for directory and data record caching.

The BIOS contains the data structures to control the data and directory buffers and the hash tables. You can either assign these buffers and tables yourself in the BIOS, or allow the GENCPM utility to generate them automatically.

Hash tables greatly speed directory searching. The BDOS can use hash tables to determine the location of directory entries and therefore reduce the number of disk accesses required to read a directory entry. The hash table allows the BDOS to directly access the sector of the directory containing the desired directory entry without having to read the directory sequentially. By eliminating a sequential read of the directory records, hashing also increases the percentage of time that the desired directory record is in a buffer, eliminating the need for any physical disk accesses in these cases. Hash tables and directory caches eliminate many of the directory accesses required when accessing large files. However, in a nonbanked system, hash tables increase the size of the operating system.

When the BIOS finds an error condition, the READ and WRITE routines should perform several retries before reporting the error condition to the BDOS. Ten retries are typical. If the BIOS returns an error condition to the BDOS, the BDOS reports the error to the user in the following form:

CP/M Error on d: Disk I/O

where d: represents the drive specification of the relevant drive.

To provide better diagnostic capabilities for the user, it is often desirable to print a more explicit error message from the BIOS READ or WRITE routines before the BIOS returns an error code to the BDOS. The BIOS should interrogate the SCB Error Mode Variable to determine if it is appropriate to print a message on the console.

2.6 Memory Selects and Moves

Four BIOS functions are provided to perform memory management. The functions are MOVE, XMOVE, SELMEM, and SETBNK. The XMOVE, SELMEM, and SETBNK memory management routines are applicable to the BIOS of banked systems.

The BDOS uses the BIOS MOVE routine to perform memory-to-memory block transfers. In a banked system, the BDOS calls XMOVE to specify the source and destination banks to be used by the MOVE routine. If you use memory that is not in the common area for data record buffers, you must implement the XMOVE routine.

The BDOS uses SELMEM when the operating system needs to execute code or access data in other than the currently selected bank.

The BDOS calls the SETBNK routine prior to calling disk READ or disk WRITE functions. The SETBNK routine must save its specified bank as the DMA bank. When the BDOS invokes a disk I/O routine, the I/O routine should save the current bank number and select the DMA bank prior to the disk READ or WRITE. After completion of the disk READ or WRITE, the disk I/O routine must reselect the current bank. Note that when the BDOS calls the disk I/O routines, Bank 0 is in context (selected).

2.7 Clock Support

If the system has a real-time clock or is capable of keeping time, possibly by counting interrupts from a counter/timer chip, then the BIOS can maintain the time of day in the System Control Block and update the time on clock interrupts. BIOS Function 26 is provided for those systems where the clock is unable to generate an interrupt.

The time of day is kept as four fields. @DATE is a binary word containing the number of days since January 1, 1978. The bytes @HOUR, @MIN, and @SEC in the System Control Block contain the hour, minute, and second in Binary Coded Decimal (BCD) format.

End of Section 2

Section 3
CP/M 3 BIOS Functional Specifications

This section contains a detailed description of the CP/M 3 BIOS. The section first discusses the BIOS data structures and their relationships, including the System Control Block, the drive table, the Disk Parameter Header, the Disk Parameter Block, the Buffer Control Blocks, and the character I/O table. The overview of the data structures is followed by a summary of the functions in the BIOS jump vector. A detailed description of the entry values and returned values for each jump instruction in the BIOS jump vector follows the summary. The last part of this section discusses the steps to follow when assembling and linking your customized BIOS.

3.1 The System Control Block

The System Control Block (SCB) is a data structure located in the BDOS. The SCB contains flags and data used by the CCP, the BDOS, the BIOS, and other system components. The BIOS can access specific data in the System Control Block through the public variables defined in the SCB.ASM file, which is supplied on the distribution disk.

Declare the variable names you want to reference in the SCB as externals in your BIOS.ASM source file. Then link your BIOS with the SCB.REL module.

In the SCB.ASM file, the high-order byte of the various SCB addresses is defined as 0FEH. The linker marks absolute external equates as page relocatable when generating a System Page Relocatable (SPR) format file. GENCPM recognizes page relocatable addresses of 0FExxH as references to the System Control Block in the BDOS. GENCPM changes these addresses to point to the actual SCB in the BDOS when it is relocating the system.

Do not perform assembly-time arithmetic on any references to the external labels of the SCB. The result of the arithmetic could alter the page value to something other than 0FEH.

Listing 3-1 shows the SCB.ASM file. The listing shows the field names of the System Control Block. A @ before a name indicates that it is a data item. A ? preceding a name indicates that it is the label of an instruction. In the listing, r/w means Read-Write, and r/o means Read-Only. The BIOS can modify a Read-Write variable, but must not modify a Read-Only variable. Table 3-1 describes each item in the System Control Block in detail.

```
        title 'System Control Block Definition for CP/M3 BIOS'

        public @civec, @covec, @aivec, @aovec, @lovec, @bnkbf
        public @crdma, @crdsk, @vinfo, @resel, @fx, @usrcd
        public @mltio, @ermde, @erdsk, @media, @bflgs
        public @date, @hour, @min, @sec, ?erjmp, @mxtpa


scb$base equu   0FE00H          ; Base of the SCB

@CIVEC  equ     scb$base+22h    ; Console Input Redirection
                                ; Vector (word, r/w)
@COVEC  equ     scb$base+24h    ; Console Output Redirection
                                ; Vector (word, r/w)
@AIVEC  equ     scb$base+26h    ; Auxiliary Input Redirection
                                ; Vector (word, r/w)
@AOVEC  equ     scb$base+28h    ; Auxiliary Output Redirection
                                ; Vector (word, r/w)
@LOVEC  equ     scb$base+2Ah    ; List Output Redirection
                                ; Vector (word, r/w)
@BNKBF  equ     scb$base+35h    ; Address of 128 Byte Buffer
                                ; for Banked BIOS (word, r/o)
@CRDMA  equ     scb$base+3Ch    ; Current DMA Address
                                ; (word, r/o)
@CRDSK  equ     scb$base+3Eh    ; Current Disk (byte, r/o)
@VINFO  equ     scb$base+3Fh    ; BDOS Variable "INFO"
                                ; (word, r/o)
@RESEL  equ     scb$base+41h    ; FCB Flag (byte, r/o)
@FX     equ     scb$base+43h    ; BDOS Function for Error
                                ; Messages (byte, r/o)
@USRCD  equ     scb$base+44h    ; Current User Code (byte, r/o)
@MLTIO  equ     scb$base+4Ah    ; Current Multisector Count
                                ; (byte,r/w)
@ERMDE  equ     scb$base+4Bh    ; BDOS Error Mode (byte, r/o)
@ERDSK  equ     scb$base+51h    ; BDOS Error Disk (byte, r/o)
@MEDIA  equ     scb$base+54h    ; Set by BIOS to indicate
                                ; open door (byte,r/w)
@BFLGS  equ     scb$base+57h    ; BDOS Message Size Flag
                                ; (byte,r/o)
@DATE   equ     scb$base+58h    ; Date in Days Since 1 Jan 78
                                ; (word, r/w)
@HOUR   equ     scb$base+5Ah    ; Hour in BCD (byte, r/w)
@MIN    equ     scb$base+5Bh    ; Minute in BCD (byte, r/w)
@SEC    equ     scb$base+5Ch    ; Second in BCD (byte, r/w)
?ERJMP  equ     scb$base+5Fh    ; BDOS Error Message Jump
                                ; (3 bytes, r/w)
@MXTPA  equ     scb$base+62h    ; Top of User TPA
                                ; (address at 6,7)(word, r/o)
        end
```

Listing 3-1. The SCB.ASM File

The following table describes in detail each of the fields of the System Control Block.

Table 3-1. System Control Block Fields

Field	Meaning
@CIVEC, @COVEC, @AIVEC, @AOVEC, @LOVEC (Read-Write Variable)	These fields are the 16 bit I/O redirection vectors for the five logical devices: console input, console output, auxiliary input, auxiliary output, and the list device. (See Section 3.4.2, Character I/O Functions.)
@BNKBF (Read-Only Variable)	@BNKBF contains the address of a 128 byte buffer in the resident portion of the BDOS in a banked system. This buffer is available for use during BOOT and WBOOT only. You can use it to transfer a copy of the CCP from an image in an alternate bank if the system does not support interbank moves.
@CRDMA, @FX, @USRCD, @ERDSK (Read-Only Variable)	These variables contain the current DMA address, the BDOS function number, the current user code, and the disk code of the drive on which the last error occurred. They can be displayed when a BDOS error is intercepted by the BIOS. See ?ERJMP.
@CRDSK (Read-Only Variable)	@CRDSK is the current default drive, set by BDOS Function 14.
@VINFO, @RESEL (Read-Only Variable)	If @RESEL is equal to 0FFH then @VINFO contains the address of a valid FCB. If @RESEL is not equal to 0FFH, then @VINFO is undefined. You can use @VINFO to display the filespec when the BIOS intercepts a BDOS error.

Table 3-1. (continued)

Field	Meaning
@MLTIO	(Read-Write Variable) @MLTIO contains the current multisector count. The BIOS can change the multisector count directly, or through BDOS Function 44. The value of the multisector count can range from 1 to 128.
@ERMDE	(Read-Only Variable) @ERMDE contains the current BDOS error mode. 0FFH indicates the BDOS is returning error codes to the application program without displaying any error messages. 0FEH indicates the BDOS is both displaying and returning errors. Any other value indicates the BDOS is displaying errors without notifying the application program.
@MEDIA	(Read-Write Variable) @MEDIA is global system flag indicating that a drive door has been opened. The BIOS routine that detects the open drive door sets this flag to 0FFH. The BIOS routine also sets the MEDIA byte in the Disk Parameter Header associated with the open-door drive to 0FFH.
@BFLGS	(Read-Only Variable) The BDOS in CP/M 3 produces two kinds of error messages: short error messages and extended error messages. Short error messages display one or two lines of text. Long error messages display a third line of text containing the filename, filetype, and BDOS Function Number involved in the error. In banked systems, GENCPM sets this flag in the System Control Block to indicate whether the BIOS displays short or extended error messages. Your error message handler should check this byte in the System Control Block. If the high-order bit, bit 7, is set to 0, the BDOS displays short error messages. If the high-order bit is set to 1, the BDOS displays the extended three-line error messages.

Table 3-1. (continued)

Field	Meaning
@BFLGS (continued)	For example, the BDOS displays the following error message if the BIOS returns an error from READ and the BDOS is displaying long error messages. CP/M Error on d: Disk I/O BDOS Function = nn File = filename.typ In the above error message, Function nn and filename.typ represent BDOS function number and file specification involved, respectively.
@DATE (Read-Write Variable)	The number of days since 1 January 1978, expressed as a 16-bit unsigned integer, low byte first. A real-time clock interrupt can update the @DATE field to indicate the current date.
@HOUR, @MIN, @SEC (Read-Write Variable)	These 2-digit Binary Coded Decimal (BCD) fields indicate the current hour, minute, and second if updated by a real-time clock interrupt.
?ERJMP (Read-Write Code Label)	The BDOS calls the error message subroutine through this jump instruction. Register C contains an error code as follows: 1 Permanent Error 2 Read Only Disk 3 Read Only File 4 Select Error 7 Password Error 8 File Exists 9 ? in Filename Error code 1 above results in the BDOS message Disk I/O.

Table 3-1. (continued)

Field	Meaning
?ERJMP (continued)	The ?ERJMP vector allows the BIOS to intercept the BDOS error messages so you can display them in a foreign language. Note that this vector is not branched to if the application program is expecting return codes on physical errors. Refer to the <u>CP/M 3 Programmer's Guide</u> for more information. ?ERJMP is set to point to the default (English) error message routine contained in the BDOS. The BOOT routine can modify the address at ?ERJMP+1 to point to an alternate message routine. Your error message handler can refer to @FX, @VINFO (if @RESEL is equal to 0FFH), @CRDMA, @CRDSK, and @USRCD to print additional error information. Your error handler should return to the BDOS with a RET instruction after printing the appropriate message.
@MXTPA (Read-Only Variable)	@MXTPA contains the address of the current BDOS entry point. This is also the address of the top of the TPA. The BOOT and WBOOT routines of the BIOS must use this address to initialize the BDOS entry JMP instruction at location 005H, during system initialization. Each time a RSX is loaded, @MXTPA is adjusted by the system to reflect the change in the available User Memory (TPA).

3.2 Character I/O Data Structures

The BIOS data structure CHRTBL is a character table describing the physical I/O devices. CHRTBL contains 6-byte physical device names and the characteristics of each physical device. These characteristics include a mode byte, and the current baud rate, if any, of the device. The DEVICE utility references the physical devices through the names and attributes contained in your CHRTBL. DEVICE can also display the physical names and characteristics in your CHRTBL.

The mode byte specifies whether the device is an input or output device, whether it has a selectable baud rate, whether it is a serial device, and if XON/XOFF protocol is enabled.

Listing 3-2 shows a sample character device table that the DEVICE utility uses to set and display I/O direction.

```
        ; sample character device table

chrtbl  db 'CRT   '               ; console VDT
        db mb$in$out+mb$serial+mb$soft$baud
        db baud$9600

        db 'LPT   '               ; system serial printer
        db mb$output+mb$serial+mb$soft$baud+mb$xon
        db baud$9600

        db 'TI810 '               ; alternate printer
        db mb$output+mb$serial+mb$soft$baud
        db baud$9600

        db 'MODEM '               ; 300 baud modem port
        db mb$in$out+mb$serial+mb$soft$baud
        db baud$300

        db 'VAX   '               ; interface to VAX 11/780
        db mb$in$out+mb$serial+mb$soft$baud
        db baud$9600

        db 'DIABLO'               ; Diablo 630 daisy wheel printer
        db mb$output+mb$serial+mb$soft$baud+mb$xon$xoff
        db baud$1200

        db 'CEN   '               ; centronics type parallel printer
        db mb$output
        db baud$none

        db 0                      ; table terminator
```

Listing 3-2. Sample Character Device Table

Listing 3-3 shows the equates for the fields contained in the sample character device table. Many systems do not support all of these baud rates.

```
        ; equates for mode byte fields

mb$input                equ 0000$0001b  ; device may do input
mb$output               equ 0000$0010b  ; device may do output
mb$in$out               equ mb$input+mb$output ; dev may do both
mb$soft$baud            equ 0000$0100b  ; software selectable
                                        ; baud rates
mb$serial               equ 0000$1000b  ; device may use protocol
mb$xon$xoff             equ 0001$0000b  ; XON/XOFF protocol
                                        ; enabled


        ; equates for baud rate byte

baud$none               equ 0           ; no baud rate
                                        ; associated with device
baud$50                 equ 1           ; 50 baud
baud$75                 equ 2           ; 75 baud
baud$110                equ 3           ; 110 baud
baud$134                equ 4           ; 134.5 baud
baud$150                equ 5           ; 150 baud
baud$300                equ 6           ; 300 baud
baud$600                equ 7           ; 600 baud
baud$1200               equ 8           ; 1200 baud
baud$1800               equ 9           ; 1800 baud
baud$2400               equ 10          ; 2400 baud
baud$3600               equ 11          ; 3600 baud
baud$4800               equ 12          ; 4800 baud
baud$7200               equ 13          ; 7200 baud
baud$9600               equ 14          ; 9600 baud
baud$19200              equ 15          ; 19.2k baud
```

Listing 3-3. Equates for Mode Byte Bit Fields

3.3 BIOS Disk Data Structures

The BIOS includes tables that describe the particular characteristics of the disk subsystem used with CP/M 3. This section describes the elements of these tables.

In general, each disk drive has an associated Disk Parameter Header (DPH) that contains information about the disk drive and provides a scratchpad area for certain BDOS operations. One of the elements of this Disk Parameter Header is a pointer to the Disk Parameter Block (DPB), which contains the actual disk description.

In the banked system, only the Disk Parameter Block must reside in common memory. The DPHs, checksum vectors, allocation vectors, Buffer Control Blocks, and Directory Buffers can reside in common memory or Bank 0. The hash tables can reside in common memory or any bank except Bank 1. The data buffers can reside in banked memory if you implement the XMOVE function.

Figure 3-1 shows the relationships between the drive table, the Disk Parameter Header, and the Data and Directory Buffer Control Block fields and their respective data structures and buffers.

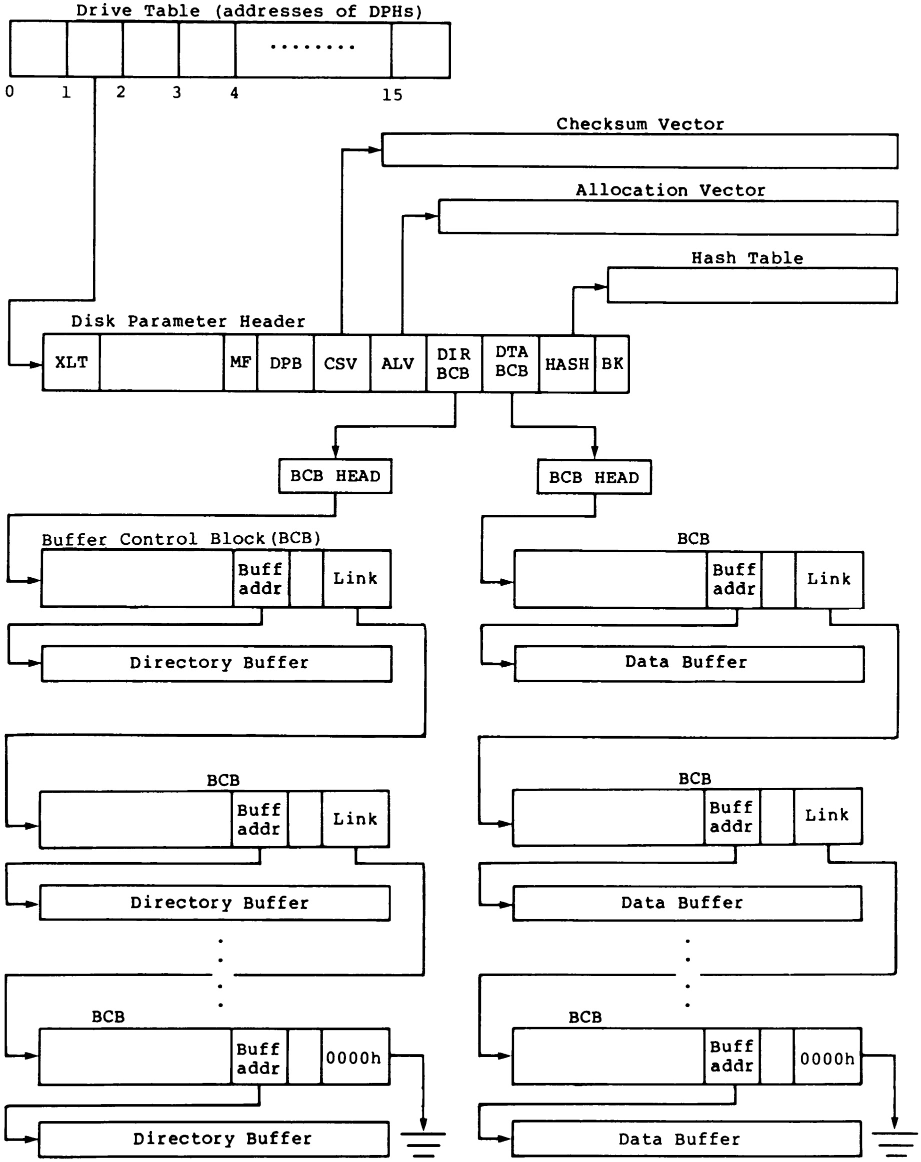

Figure 3-1. Disk Data Structures in a Banked System

3.3.1 The Drive Table

The drive table consists of 16 words containing the addresses of the Disk Parameter Headers for each logical drive name, A through P, and takes the general form:

```
drivetable dw    dph0
           dw    dph1
           dw    dph2
           .
           .
           .
           dw    dphF
```

If a logical drive does not exist in your system, the corresponding entry in the drive table must be zero.

The GENCPM utility accesses the drive table to locate the various disk parameter data structures, so that it can determine which system configuration to use, and optionally allocate the various buffers itself. You must supply a drive table if you want GENCPM to do this allocation. If certain addresses in the Disk Parameter Headers referenced by this drive table are set to 0FFFEH, GENCPM allocates the appropriate data structures and updates the DPH. You can supply the drive table even if you have performed your own memory allocation. See the BIOS DRVTBL function described in section 3.4.1.

3.3.2 Disk Parameter Header

In Figure 3-2, which shows the format of the Disk Parameter Header, b refers to bits.

XLT	-0-	MF	DPB	CSV	ALV	DIRBCB	DTABCB	HASH	HBANK
16b	72b	8b	16b	16b	16b	16b	16b	16b	8b

Figure 3-2. Disk Parameter Header Format

Table 3-2 describes the fields of the Disk Parameter Header.

Table 3-2. Disk Parameter Header Fields

Field	Comments
XLT	Set the XLT field to the address of the logical to physical sector translation table. If there is no sector translation and the physical and logical sector numbers are the same, set XLT to 0000H. Disk drives with identical sector skew factors can share the same translate table. XLT is the value passed to SECTRN in registers DE. Usually the translation table consists of one byte per physical sector. Generally, it is advisable to keep the number of physical sectors per logical track to a reasonable value to prevent the translation table from becoming too large. In the case of disks with multiple heads, you can compute the head number from the track address rather than the sector address.
-0-	These 72 bits (9 bytes) of zeroes are the scratch area the BDOS uses to maintain various parameters associated with the drive.
MF	MF is the Media Flag. The BDOS resets MF to zero when the drive is logged in. The BIOS can set this flag and @MEDIA in the SCB to 0FFH if it detects that a drive door has been opened. If the flag is set to 0FFH, the BDOS checks for a media change prior to performing the next BDOS file operation on that drive. If the BDOS determines that the drive contains a new volume, the BDOS performs a login on that drive, and resets the MF flag to 00H. Note that the BDOS checks this flag only when a system call is made, and not during an operation. Usually, this flag is used only by systems that support door-open interrupts.
DPB	Set the DPB field to the address of a Disk Parameter Block that describes the characteristics of the disk drive. Several Disk Parameter Headers can address the same Disk Parameter Block if their drive characteristics are identical. (The Disk Parameter Block is described in Section 3.3.3.)

Table 3-2. (continued)

Field	Comments
CSV	CSV is the address of a scratchpad area used to detect changed disks. This address must be different for each removable media Disk Parameter Header. There must be one byte for every 4 directory entries (or 128 bytes of directory). In other words, length(CSV) = (DRM/4)+1. (See Table 3-3 for an explanation of the DRM field.) If the drive is permanently mounted, set the CKS variable in the DPB to 8000H and set CSV to 0000H. This way, no storage is reserved for a checksum vector. The checksum vector may be located in common memory or in Bank 0. Set CSV to 0FFFEH for GENCPM to set up the checksum vector.
ALV	ALV is the address of the scratchpad area called the allocation vector, which the BDOS uses to keep disk storage allocation information. This area must be unique for each drive. The allocation vector usually requires 2 bits for each block on the drive. Thus, length(ALV) = (DSM/4) + 2. (See Table 3-3 for an explanation of the DSM field.) In the nonbanked version of CP/M 3, you can optionally specify that GENCPM reserve only one bit in the allocation vector per block on the drive. In this case, length(ALV) = (DSM/8) + 1. The GENCPM option to use single-bit allocation vectors is provided in the nonbanked version of CP/M 3 because additional memory is required by the double-bit allocation vector. This option applies to all drives on the system. With double-bit allocation vectors, CP/M 3 automatically frees, at every system warm start, all file blocks that are not permanently recorded in the directory. Note that file space allocated to a file is not permanently recorded in a directory unless the file is closed. Therefore, the allocation vectors in memory can indicate that space is allocated although directory records indicate that space is free for allocation. With single-bit allocation vectors, CP/M 3 requires that a drive be reset before this space can be reclaimed. Because it increases performance, CP/M 3 does not reset disks at system warm start. Thus, with single-bit allocation vectors, if you do not reset the disk system, DIR and SHOW can report an inaccurate amount of free space. With single-bit

Table 3-2. (continued)

Field	Comments
ALV (continued)	allocation vectors, the user must type a CTRL-C at the system prompt to reset the disk system to ensure accurate reporting of free space. Set ALV to 0FFFEH for GENCPM to automatically assign space for the allocation vector, single- or double-bit, during system generation. In the nonbanked system, GENCPM prompts for the type of allocation vector. In the banked system, the allocation vector is always double-bit and can reside in common memory or Bank 0. When GENCPM automatically assigns space for the allocation vector (ALV = 0FFFEH), it places the allocation vector in Bank 0.
DIRBCB	Set DIRBCB to the address of a single directory Buffer Control Block (BCB) in an unbanked system. Set DIRBCB to the address of a BCB list head in a banked system. Set DIRBCB to 0FFFEH for GENCPM to set up the DIRBCB field. The BDOS uses directory buffers for all accesses of the disk directory. Several DPHs can refer to the same directory BCB or BCB list head; or, each DPH can reference an independent BCB or BCB list head. Section 3.3.4 describes the format of the Buffer Control Block.
DTABCB	Set DTABCB to the address of a single data BCB in an unbanked system. Set DTABCB to the address of a data BCB list head in a banked system. Set DTABCB to 0FFFEH for GENCPM to set up the DTABCB field. The BDOS uses data buffers to hold physical sectors so that it can block and deblock logical 128-byte records. If the physical record size of the media associated with a DPH is 128 bytes, you can set the DTABCB field of the DPH to 0FFFFH, because in this case, the BDOS does not use a data buffer.
HASH	HASH contains the address of the optional directory hashing table associated with a DPH. Set HASH to 0FFFFH to disable directory hashing.

Table 3-2. (continued)

Field	Comments
HASH (continued)	Set HASH to 0FFFEH to make directory hashing on the drive a GENCPM option. Each DPH using hashing must reference a unique hash table. If a hash table is supplied, it must be 4*(DRM+1) bytes long, where DRM is one less than the length of the directory. In other words, the hash table must contain four bytes for each directory entry of the disk.
HBANK	Set HBANK to the bank number of the hash table. HBANK is not used in unbanked systems and should be set to zero. The hash tables can be contained in the system bank, common memory, or any alternate bank except Bank 1, because hash tables cannot be located in the Transient Program Area. GENCPM automatically sets HBANK when HASH is set to 0FFFEH.

3.3.3 Disk Parameter Block

Figure 3-3 shows the format of the Disk Parameter Block, where b refers to bits.

SPT	BSH	BLM	EXM	DSM	DRM	AL0	AL1	CKS	OFF	PSH	PHM
16b	8b	8b	8b	16b	16b	8b	8b	16b	16b	8b	8b

Figure 3-3. Disk Parameter Block Format

Table 3-3 describes the fields of the Disk Parameter Block.

Table 3-3. Disk Parameter Block Fields

Field	Comments
SPT	Set SPT to the total number of 128-byte logical records per track.
BSH	Data allocation block shift factor. The value of BSH is determined by the data block allocation size.
BLM	Block mask. The value of BLM is determined by the data block allocation size.

Table 3-3. (continued)

Field	Comments
EXM	Extent mask determined by the data block allocation size and the number of disk blocks.
DSM	Determines the total storage capacity of the disk drive. DSM is one less than the total number of blocks on the drive.
DRM	Total number of directory entries minus one that can be stored on this drive. The directory requires 32 bytes per entry.
AL0, AL1	Determine reserved directory blocks. See Figure 3-8 for more information.
CKS	The size of the directory check vector, (DRM/4)+1. Set bit 15 of CKS to 1 if the drive is permanently mounted. Set CKS to 8000H to indicate that the drive is permanently mounted and directory checksumming is not required. **Note:** full directory checksumming is required on removable media to support the automatic login feature of CP/M 3.
OFF	The number of reserved tracks at the beginning of the logical disk. OFF is the track on which the directory starts.
PSH	Specifies the physical record shift factor.
PHM	Specifies the physical record mask.

CP/M allocates disk space in a unit called a block. Blocks are also called allocation units, or clusters. BLS is the number of bytes in a block. The block size can be 1024, 2048, 4096, 8192, or 16384 (decimal) bytes.

A large block size decreases the size of the allocation vectors but can result in wasted disk space. A smaller block size increases the size of the allocation vectors because there are more blocks on the same size disk.

There is a restriction on the block size. If the block size is 1024, there cannot be more than 255 blocks present on a logical drive. In other words, if the disk is larger than 256K, it is necessary to use at least 2048 byte blocks.

The value of BLS is not a field in the Disk Parameter Block; rather, it is derived from the values of BSH and BLM as given in Table 3-4.

Table 3-4. BSH and BLM Values

BLS	BSH	BLM
1,024	3	7
2,048	4	15
4,096	5	31
8,192	6	63
16,384	7	127

The block mask, BLM, equals one less than the number of 128-byte records in an allocation unit, (BLS/128 - 1), or (2**BSH)-1.

The value of the Block Shift Factor, BSH, is determined by the data block allocation size. The Block Shift Factor (BSH) equals the logarithm base two of the block size in 128-byte records, or LOG2(BLS/128), where LOG2 represents the binary logarithm function.

The value of EXM depends upon both the BLS and whether the DSM value is less than 256 or greater than 255, as shown in Table 3-5.

Table 3-5. Maximum EXM Values

BLS	EXM values	
	DSM<256	DSM>255
1,024	0	N/A
2,048	1	0
4,096	3	1
8,192	7	3
16,384	15	7

The value of EXM is one less than the maximum number of 16K extents per FCB.

Set EXM to zero if you want media compatibility with an extended CP/M 1.4 system. This only applies to double-density CP/M 1.4 systems, with disk sizes greater than 256K bytes. It is preferable to copy double-density 1.4 disks to single-density, then reformat them and recreate them with the CP/M 3 system, because CP/M 3 uses directory entries more effectively than CP/M 1.4.

DSM is one less than the total number of blocks on the drive. DSM must be less than or equal to 7FFFH. If the disk uses 1024 byte blocks (BSH=3, BLM=7), DSM must be less than or equal to 00FFH. The product BLS*(DSM+1) is the total number of bytes the drive holds and must be within the capacity of the physical disk. It does not include the reserved operating system tracks.

The DRM entry is one less than the total number of 32-byte directory entries, and is a 16-bit value. DRM must be less than or equal to (BLS/32 * 16) - 1. DRM determines the values of AL0 and AL1. The two fields AL0 and AL1 can together be considered a string of 16 bits, as shown in Figure 3-4.

AL0								AL1							
00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15

Figure 3-4. AL0 and AL1

Position 00 corresponds to the high-order bit of the byte labeled AL0, and position 15 corresponds to the low-order bit of the byte labeled AL1. Each bit position reserves a data block for a number of directory entries, thus allowing a maximum of 16 data blocks to be assigned for directory entries. Bits are assigned starting at 00 and filled to the right until position 15. AL0 and AL1 overlay the first two bytes of the allocation vector for the associated drive. Table 3-6 shows DRM maximums for the various block sizes.

Table 3-6. BLS and Number of Directory Entries

BLS	Directory Entries	Maximum DRM
1,024	32 * reserved blocks	511
2,048	64 * reserved blocks	1,023
4,096	128 * reserved blocks	2,047
8,192	256 * reserved blocks	4,095
16,384	512 * reserved blocks	8,191

If DRM = 127 (128 directory entries), and BLS = 1024, there are 32 directory entries per block, requiring 4 reserved blocks. In this case, the 4 high-order bits of AL0 are set, resulting in the values AL0 = 0F0H and AL1 = 00H. The maximum directory allocation is 16 blocks where the block size is determined by BSH and BLM.

The OFF field determines the number of tracks that are skipped at the beginning of the physical disk. It can be used as a mechanism for skipping reserved operating system tracks, which on system disks contain the Cold Boot Loader, CPMLDR, and possibly the CCP. It is also used to partition a large disk into smaller segmented sections.

PSH and PHM determine the physical sector size of the disk. All disk I/O is in terms of the physical sector size. Set PSH and PSM to zero if the BIOS is blocking and deblocking instead of the BDOS.

PSH specifies the physical record shift factor, ranging from 0 to 5, corresponding to physical record sizes of 128, 256, 512, 1K, 2K, or 4K bytes. It is equal to the logarithm base two of the physical record size divided by 128, or LOG2(sector_size/128). See Table 3-7 for PSH values.

PHM specifies the physical record mask, ranging from 0 to 31, corresponding to physical record sizes of 128, 256, 512, 1K, 2K, or 4K bytes. It is equal to one less than the sector size divided by 128, or, (sector_size/128)-1. See Table 3-7 for PHM values.

Table 3-7. PSH and PHM Values

Sector size	PSH	PHM
128	0	0
256	1	1
512	2	3
1,024	3	7
2,048	4	15
4,096	5	31

3.3.4 Buffer Control Block

A Buffer Control Block (BCB) locates physical record buffers for the BDOS. The BDOS uses the BCB to manage the physical record buffers during processing. More than one Disk Parameter Header can specify the same BCB. The GENCPM utility can create the Buffer Control Block.

Note that the BANK and LINK fields of the Buffer Control Block are present only in the banked system. Therefore, the Buffer Control Block is twelve bytes long in the nonbanked system, and fifteen bytes long in the banked system. Note also that only the DRV, BUFFAD, BANK, and LINK fields need to contain initial values. In Figure 3-5, which shows the form of the Buffer Control Block, b refers to bits.

DRV	REC#	WFLG	00	TRACK	SECTOR	BUFFAD	BANK	LINK
8b	24b	8b	8b	16b	16b	16b	8b	16b

Figure 3-5. Buffer Control Block Format

Table 3-8 describes the fields of each Buffer Control Block.

Table 3-8. Buffer Control Block Fields

Field	Comment
DRV	Identifies the disk drive associated with the record contained in the buffer located at address BUFFAD. If you do not use GENCPM to allocate buffers, you must set the DRV field to OFFH.
REC#	Identifies the record position of the current contents of the buffer located at address BUFFAD. REC# consists of the absolute sector number of the record where the first record of the directory is zero.
WFLG	Set by the BDOS to OFFH to indicate that the buffer contains new data that has not yet been written to disk. When the data is written, the BDOS sets the WFLG to zero to indicate the buffer is no longer dirty.
00	Scratch byte used by BDOS.
TRACK	Contains the physical track location of the contents of the buffer.
SECTOR	Contains the physical sector location of the contents of the buffer.
BUFFAD	Specifies the address of the buffer associated with this BCB.
BANK	Contains the bank number of the buffer associated with this BCB. This field is only present in banked systems.
LINK	Contains the address of the next BCB in a linked list, or zero if this is the last BCB in the linked list. The LINK field is present only in banked systems.

The BDOS distinguishes between two kinds of buffers: data buffers referenced by DTABCB, and directory buffers referenced by DIRBCB. In a banked system, the DIRBCB and DTABCB fields of a Disk Parameter Header each contain the address of a BCB list head rather than the address of an actual BCB. A BCB list head is a word containing the address of the first BCB in a linked list. If several DPHs reference the same BCB list, they must reference the same BCB list head. Each BCB has a LINK field that contains the address of the next BCB in the list, or zero if it is the last BCB.

In banked systems, the one-byte BANK field indicates the bank in which the data buffers are located. The BANK field of directory BCBs must be zero because directory buffers must be located in Bank 0, usually below the banked BDOS module, or in common memory. The BANK field is for systems that support direct memory-to-memory transfers from one bank to another. (See the BIOS XMOVE entry point in Section 3.4.4.)

The BCB data structures in a banked system must reside in Bank 0 or in common memory. The buffers of data BCBs can be located in any bank except Bank 1 (the Transient Program Area).

For banked systems that do not support interbank block moves through XMOVE, the BANK field must be set to 0 and the data buffers must reside in common memory. The directory buffers can be in Bank 0 even if the system does not support bank-to-bank moves.

In the nonbanked system, the DPH DIRBCB and DTABCB can point to the same BCB if the DPH defines a fixed media device. For devices with removable media, the DPH DIRBCB and the DPH DTABCB must reference different BCBs. In banked systems, the DPH DIRBCB and DTABCB must point to separate list heads.

In general, you can enhance the performance of CP/M 3 by allocating more BCBs, but the enhancement reduces the amount of TPA memory in nonbanked systems.

If you set the DPH DIRBCB or the DPH DTABCB fields to 0FFFEH, the GENCPM utility creates BCBs, allocates physical record buffers, and sets these fields to the address of the BCBs. This allows you to write device drivers without regard to buffer requirements.

3.3.5 Data Structure Macro Definitions

Several macro definitions are supplied with CP/M 3 to simplify the creation of some of the data structures in the BIOS. These macros are defined in the library file CPM3.LIB on the distribution disk.

To reference these macros in your BIOS, include the following statement:

```
MACLIB    CPM3
```

DTBL Macro

Use the DTBL macro to generate the drive table, DRVTBL. It has one parameter, a list of the DPHs in your system. The list is enclosed in angle brackets.

The form of the DTBL macro call is

```
label: DTBL     <DPHA,DPHB,...,DPHP>
```

where DPHA is the address of the DPH for drive A, DPHB is the address of the DPH for drive B, up to drive P. For example,

```
DRVTBL:  DTBL    <ACSHD0,FDSD0,FDSD1>
```

This example generates the drive table for a three-drive system. The DTBL macro always generates a sixteen-word table, even if you supply fewer DPH names. The unused entries are set to zero to indicate the corresponding drives do not exist.

DPH Macro

The DPH macro routine generates a Disk Parameter Header (DPH). It requires two parameters: the address of the skew table for this drive, and the address of the Disk Parameter Block (DPB). Two parameters are optional: the maximum size of the checksum vector, and the maximum size of the allocation vector. If you omit the maximum size of the checksum vector and the maximum size of the allocation vector from the DPH macro invocation, the corresponding fields of the Disk Parameter Header are set to 0FFFEH so that GENCPM automatically allocates the vectors.

The form of the DPH macro call is

```
label:  DPH     ?trans,?dpb,[?csize],[?asize]
```

where:

- ?trans is the address of the translation vector for this drive;
- ?dpb is the address of the DPB for this drive;
- ?csize is the maximum size in bytes of the checksum vector;
- ?asize is the maximum size in bytes of the allocation vector.

The following example, which includes all four parameters, shows a typical DPH macro invocation for a standard single-density disk drive:

```
FDSD0:  DPH    SKEW6,DPB$SD,16,31
```

SKEW Macro

The SKEW macro generates a skew table and requires the following parameters: the number of physical sectors per track, the skew factor, and the first sector number on each track (usually 0 or 1).

The form of the SKEW macro call is

```
label:  SKEW    ?secs,?skf,?fsc
```

where:

```
?secs   is the number of physical sectors per track;
?skf    is the sector skew factor;
?fsc    is the first sector number on each track.
```

The following macro invocation generates the skew table for a standard single-density disk drive.

```
SKEW6:  SKEW    26,6,1
```

DPB Macro

The DPB macro generates a Disk Parameter Block specifying the characteristics of a drive type. It requires six parameters: the physical sector size in bytes, the number of physical sectors per track, the total number of tracks on the drive, the size of an allocation unit in bytes, the number of directory entries desired, and the number of system tracks to reserve at the beginning of the drive. There is an optional seventh parameter that defines the CKS field in the DPB. If this parameter is missing, CKS is calculated from the directory entries parameter.

The form of the DPB macro call is

```
label:  DPB    ?psize,?pspt,?trks,?bls,?ndirs,?off[,?ncks]
```

where:

```
?psize  is the physical sector size in bytes;
?pspt   is the number of physical sectors per track;
?trks   is the number of tracks on the drive;
?bls    is the allocation unit size in bytes;
?ndirs  is the number of directory entries;
?off    is the number of tracks to reserve;
?ncks   is the number of checked directory entries.
```

The following example shows the parameters for a standard single-density disk drive:

```
DPB$SD: DPB     128,26,77,1024,64,2
```

The DPB macro can be used only when the disk drive is under eight megabytes. DPBs for larger disk drives must be constructed by hand.

3.4 BIOS Subroutine Entry Points

This section describes the entry parameters, returned values, and exact responsibilities of each BIOS entry point in the BIOS jump vector. The routines are arranged by function. Section 3.4.1 describes system initialization. Section 3.4.2 presents the character I/O functions, followed by Section 3.4.3, discussing the disk I/O functions. Section 3.4.4 discusses the BIOS memory select and move functions. The last section, 3.4.5, discusses the BIOS clock support function. Table 3-9 shows the BIOS entry points the BDOS calls to perform each of the four categories of system functions.

Table 3-9. Functional Organization of BIOS Entry Points

Operation	Function
System Initialization	
	BOOT, WBOOT, DEVTBL, DEVINI, DRVTBL,
Character I/O	
	CONST, CONIN, CONOUT, LIST, AUXOUT, AUXIN, LISTST, CONOST, AUXIST, AUXOST
Disk I/O	
	HOME, SELDSK, SETTRK, SETSEC, SETDMA, READ, WRITE, SECTRN, MULTIO, FLUSH
Memory Selects and Moves	
	MOVE, XMOVE, SELMEM, SETBNK
Clock Support	
	TIME

Table 3-10 is a summary showing the CP/M 3 BIOS function numbers, jump instruction names, and the entry and return parameters of each jump instruction in the table, arranged according to the BIOS function number.

Table 3-10. CP/M 3 BIOS Function Jump Table Summary

No.	Function	Input	Output
0	BOOT	None	None
1	WBOOT	None	None
2	CONST	None	A=0FFH if ready A=00H if not ready
3	CONIN	None	A=Con Char
4	CONOUT	C=Con Char	None
5	LIST	C=Char	None
6	AUXOUT	C=Char	None
7	AUXIN	None	A=Char
8	HOME	None	None
9	SELDSK	C=Drive 0-15 E=Init Sel Flag	HL=DPH addr HL=000H if invalid dr.
10	SETTRK	BC=Track No	None
11	SETSEC	BC=Sector No	None
12	SETDMA	BC=.DMA	None
13	READ	None	A=00H if no Err A=01H if Non-recov Err A=0FFH if media changed
14	WRITE	C=Deblk Code	A=00H if no Err A=01H if Phys Err A=02H if Dsk is R/O A=0FFH if media changed
15	LISTST	None	A=00H if not ready A=0FFH if ready
16	SECTRN	BC=Log Sect No	HL=Phys Sect No DE=Trans Tbl Adr
17	CONOST	None	A=00H if not ready A=0FFH if ready
18	AUXIST	None	A=00H if not ready A=0FFH if ready
19	AUXOST	None	A=00H if not ready A=0FFH if ready
20	DEVTBL	None	HL=Chrtbl addr
21	DEVINI	C=Dev No 0-15	None
22	DRVTBL	None	HL=Drv Tbl addr HL=0FFFFH HL=0FFFEH HL=0FFFDH
23	MULTIO	C=Mult Sec Cnt	None
24	FLUSH	None	A=000H if no err A=001H if phys err A=002H if disk R/O
25	MOVE	HL=Dest Adr DE=Source Adr	HL & DE point to next bytes following MOVE
26	TIME	C=Get/Set Flag	None
27	SELMEM	A=Mem Bank	None
28	SETBNK	A=Mem Bank	None
29	XMOVE	B=Dest Bank C=Source Bank BC=Count	None

Table 3-10. (continued)

No.	Function	Input
30	USERF	Reserved for System Implementor
31	RESERV1	Reserved for Future Use
32	RESERV2	Reserved for Future Use

3.4.1 System Initialization Functions

This section defines the BIOS system initialization routines BOOT, WBOOT, DEVTBL, DEVINI, and DRVTBL.

BIOS Function 0: BOOT
Get Control from Cold Start Loader and Initialize System
Entry Parameters: None Returned Values: None

The BOOT entry point gets control from the Cold Start Loader in Bank 0 and is responsible for basic system initialization. Any remaining hardware initialization that is not done by the boot ROMs, the Cold Boot Loader, or the LDRBIOS should be performed by the BOOT routine.

The BOOT routine must perform the system initialization outlined in Section 2.3, System Initialization. This includes initializing Page Zero jumps and loading the CCP. BOOT usually prints a sign-on message, but this can be omitted. Control is then transferred to the CCP in the TPA at 0100H.

To initialize Page Zero, the BOOT routine must place a jump at location 0000H to BIOS_base + 3, the BIOS warm start entry point. The BOOT routine must also place a jump instruction at location 0005H to the address contained in the System Control Block variable, @MXTPA.

The BOOT routine must establish its own stack area if it calls any BDOS or BIOS routines. In a banked system, the stack is in Bank 0 when the Cold BOOT routine is entered. The stack must be placed in common memory.

BIOS Function 1: WBOOT
Get Control When a Warm Start Occurs
Entry Parameters: None Returned Values: None

The WBOOT entry point is entered when a warm start occurs. A warm start is performed whenever a user program branches to location 0000H or attempts to return to the CCP. The WBOOT routine must perform the system initialization outlined in BIOS Function 0, including initializing Page Zero jumps and loading the CCP.

When your WBOOT routine is complete, it must transfer control to the CCP at location 0100H in the TPA.

Note that the CCP does not reset the disk system at warm start. The CCP resets the disk system when a CTRL-C is pressed following the system prompt.

Note also that the BIOS stack must be in common memory to make BDOS function calls. Only the BOOT and WBOOT routines can perform BDOS function calls.

If the WBOOT routine is reading the CCP from a file, it must set the multisector I/O count, @MLTIO in the System Control Block, to the number of 128-byte records to be read in one operation before reading CCP.COM. You can directly set @MLTIO in the SCB, or you can call BDOS Function 44 to set the multisector count in the SCB.

If blocking/deblocking is done in the BIOS instead of in the BDOS, the WBOOT routine must discard all pending buffers.

BIOS Function 20: DEVTBL
Return Address of Character I/O Table
Entry Parameters: None Returned Values: HL= address of Chrtbl

The DEVTBL and ~~DEVINI~~ entry points allow you to support device assignment with a flexible, yet completely optional system. It replaces the IOBYTE facility of CP/M 2.2. Note that the CHRTBL must be in common in banked systems.

BIOS Function 21: DEVINI	
Initialize Character I/O Device	
Entry Parameters:	C=device number, 0-15
Returned Values:	None

The DEVINI routine initializes the physical character device specified in register C to the baud rate contained in the appropriate entry of the CHRTBL. It need only be supplied if I/O redirection has been implemented and is referenced only by the DEVICE utility supplied with CP/M 3.

BIOS Function 22: DRVTBL	
Return Address of Disk Drive Table	
Entry Parameters:	None
Returned Values:	HL=Address of Drive Table of Disk Parameter Headers (DPH); Hashing can be utilized if specified by the DPHs referenced by this DRVTBL. HL=0FFFFH if no Drive Table; the BDOS is responsible for blocking/deblocking; Hashing is supported. HL=0FFFEH if no Drive Table; the BDOS is responsible for blocking/deblocking; Hashing is not supported.

The first instruction of this subroutine must be an LXI H,<address> where <address> is one of the above returned values. The GENCPM utility accesses the address in this instruction to locate the drive table and the disk parameter data structures to determine which system configuration to use.

If you plan to do your own blocking/deblocking, the first instruction of the DRVTBL routine must be the following:

```
        lxi     h,0FFFEh
```

You must also set the PSH and PSM fields of the associated Disk Parameter Block to zero.

3.4.2 Character I/O Functions

This section defines the CP/M 3 character I/O routines CONST, CONIN, CONOUT, LIST, AUXOUT, AUXIN, LISTST, CONOST, AUXIST, and AUXOST.

CP/M 3 assumes all simple character I/O operations are performed in eight-bit ASCII, upper- and lower-case, with no parity. An ASCII CTRL-Z (1AH) denotes an end-of-file condition for an input device.

In CP/M 3, you can direct each of the five logical character devices to any combination of up to twelve physical devices. Each of the five logical devices has a 16-bit vector in the System Control Block (SCB). Each bit of the vector represents a physical device where bit 15 corresponds to device zero, and bit 4 is device eleven. Bits 0 through 3 are reserved for future system use.

You can use the public names defined in the supplied SCB.ASM file to reference the I/O redirection bit vectors. The names are shown in Table 3-11.

Table 3-11. I/O Redirection Bit Vectors in SCB

Name	Logical Device
@CIVEC	Console Input
@COVEC	Console Output
@AIVEC	Auxiliary Input
@AOVEC	Auxiliary Output
@LOVEC	List Output

You should send an output character to all of the devices whose corresponding bit is set. An input character should be read from the first ready device whose corresponding bit is set.

An input status routine should return true if any selected device is ready. An output status routine should return true only if all selected devices are ready.

BIOS Function 2: CONST	
Sample the Status of the Console Input Device	
Entry Parameters:	none
Returned value:	A= 0FFH if a console character is ready to read A= 00H if no console character is ready to read

Read the status of the currently assigned console device and return 0FFH in register A if a character is ready to read, and 00H in register A if no console characters are ready.

BIOS Function 3: CONIN	
Read a Character from the Console	
Entry Parameters:	None
Returned Values:	A=Console Character

Read the next console character into register A with no parity. If no console character is ready, wait until a character is available before returning.

BIOS Function 4: CONOUT	
Output Character to Console	
Entry Parameters:	C=Console Character
Returned Values:	None

Send the character in register C to the console output device. The character is in ASCII with no parity.

BIOS Function 5: LIST	
Output Character to List Device	
Entry Parameters:	C=Character
Returned Values:	None

Send the character from register C to the listing device. The character is in ASCII with no parity.

BIOS Function 6: AUXOUT	
Output a Character to the Auxiliary Output Device	
Entry Parameters:	C=Character
Returned Values:	None

Send the character from register C to the currently assigned AUXOUT device. The character is in ASCII with no parity.

BIOS Function 7: AUXIN	
Read a Character from the Auxiliary Input Device	
Entry Parameters:	None
Returned Values:	A=Character

Read the next character from the currently assigned AUXIN device into register A with no parity. A returned ASCII CTRL-Z (1AH) reports an end-of-file.

BIOS Function 15: LISTST	
Return the Ready Status of the List Device	
Entry Parameters:	None
Returned Values:	A=000H if list device is not ready to accept a character A=0FFH if list device is ready to accept a character

The BIOS LISTST function returns the ready status of the list device.

BIOS Function 17: CONOST	
Return Output Status of Console	
Entry Parameters:	None
Returned Values:	A=0FFH if ready A=00H if not ready

The CONOST routine checks the status of the console. CONOST returns an 0FFH if the console is ready to display another character. This entry point allows for full polled handshaking communications support.

BIOS Function 18: AUXIST	
Return Input Status of Auxiliary Port	
Entry Parameters:	None
Returned Values:	A=0FFH if ready A=000H if not ready

The AUXIST routine checks the input status of the auxiliary port. This entry point allows full polled handshaking for communications support using an auxiliary port.

BIOS Function 19: AUXOST	
Return Output Status of Auxiliary Port	
Entry Parameters:	None
Returned Values:	A=0FFH if ready A=000H if not ready

The AUXOST routine checks the output status of the auxiliary port. This routine allows full polled handshaking for communications support using an auxiliary port.

3.4.3 Disk I/O Functions

This section defines the CP/M 3 BIOS disk I/O routines HOME, SELDSK, SETTRK, SETSEC, SETDMA, READ, WRITE, SECTRN, MULTIO, and FLUSH.

BIOS Function 8: HOME	
Select Track 00 of the Specified Drive	
Entry Parameters:	None
Returned Values:	None

Return the disk head of the currently selected disk to the track 00 position. Usually, you can translate the HOME call into a call on SETTRK with a parameter of 0.

BIOS Function 9: SELDSK	
Select the Specified Disk Drive	
Entry Parameters:	C=Disk Drive (0-15) E=Initial Select Flag
Returned Values:	HL=Address of Disk Parameter Header (DPH) if drive exists HL=000H if drive does not exist

Select the disk drive specified in register C for further operations, where register C contains 0 for drive A, 1 for drive B, and so on to 15 for drive P. On each disk select, SELDSK must return in HL the base address of a 25-byte area called the Disk Parameter Header. If there is an attempt to select a nonexistent drive, SELDSK returns HL=0000H as an error indicator.

On entry to SELDSK, you can determine if it is the first time the specified disk is selected. Bit 0, the least significant bit in Register E, is set to 0 if the drive has not been previously selected. This information is of interest in systems that read configuration information from the disk to set up a dynamic disk definition table.

When the BDOS calls SELDSK with bit 0 in Register E set to 1, SELDSK must return the same Disk Parameter Header address as it returned on the initial call to the drive. SELDSK can only return a 000H indicating an unsuccessful select on the initial select call.

SELDSK must return the address of the Disk Parameter Header on each call. Postpone the actual physical disk select operation until a READ or WRITE is performed.

BIOS Function 10: SETTRK	
Set Specified Track Number	
Entry Parameters:	BC=Track Number
Returned Values:	None

Register BC contains the track number for a subsequent disk access on the currently selected drive. Normally, the track number is saved until the next READ or WRITE occurs.

BIOS Function 11: SETSEC	
Set Specified Sector Number	
Entry Parameters:	BC=Sector Number
Returned Values:	None

Register BC contains the sector number for the subsequent disk access on the currently selected drive. This number is the value returned by SECTRN. Usually, you delay actual sector selection until a READ or WRITE operation occurs.

BIOS Function 12: SETDMA	
Set Address for Subsequent Disk I/O	
Entry Parameters:	BC=Direct Memory Access Address
Returned Values:	None

Register BC contains the DMA (Direct Memory Access) address for the subsequent READ or WRITE operation. For example, if B = 00H and C = 80H when the BDOS calls SETDMA, then the subsequent read operation reads its data starting at 80H, or the subsequent write operation gets its data from 80H, until the next call to SETDMA occurs.

BIOS Function 13: READ	
Read a Sector from the Specified Drive	
Entry Parameters:	None
Returned Values:	A=000H if no errors occurred A=001H if nonrecoverable error condition occurred A=0FFH if media has changed

Assume the BDOS has selected the drive, set the track, set the sector, and specified the DMA address. The READ subroutine attempts to read one sector based upon these parameters, then returns one of the error codes in register A as described above.

If the value in register A is 0, then CP/M 3 assumes that the disk operation completed properly. If an error occurs, the BIOS should attempt several retries to see if the error is recoverable before returning the error code.

If an error occurs in a system that supports automatic density selection, the system should verify the density of the drive. If the density has changed, return a 0FFH in the accumulator. This causes the BDOS to terminate the current operation and relog in the disk.

BIOS Function 14: WRITE	
Write a Sector to the Specified Disk	
Entry Parameters:	C=Deblocking Codes
Returned Values:	A=000H if no error occurred A=001H if physical error occurred A=002H if disk is Read-Only A=0FFH if media has changed

Write the data from the currently selected DMA address to the currently selected drive, track, and sector. Upon each call to WRITE, the BDOS provides the following information in register C:

0 = deferred write
1 = nondeferred write
2 = deferred write to the first sector of a new data block

This information is provided for those BIOS implementations that do blocking/deblocking in the BIOS instead of the BDOS.

As in READ, the BIOS should attempt several retries before reporting an error.

If an error occurs in a system that supports automatic density selection, the system should verify the density of the drive. If the density has changed, return a 0FFH in the accumulator. This causes the BDOS to terminate the current operation and relog in the disk.

BIOS Function 16: SECTRN	
Translate Sector Number Given Translate Table	
Entry Parameters:	BC=Logical Sector Number DE=Translate Table Address
Returned Values:	HL=Physical Sector Number

SECTRN performs logical sequential sector address to physical sector translation to improve the overall response of CP/M 3. Digital Research ships standard CP/M disk with a skew factor of 6, where six physical sectors are skipped between each logical read operation. This skew factor allows enough time between sectors for most programs on a slow system to process their buffers without missing the next sector. In computer systems that use fast processors, memory, and disk subsystems, you can change the skew factor to improve overall response. Typically, most disk systems perform well with a skew of every other physical sector. You should maintain support of single-density, IBM 3740 compatible disks using a skew factor of 6 in your CP/M 3 system to allow information transfer to and from other CP/M users.

SECTRN receives a logical sector number in BC, and a translate table address in DE. The logical sector number is relative to zero. The translate table address is obtained from the Disk Parameter Block for the currently selected disk. The sector number is used as an index into the translate table, with the resulting physical sector number returned in HL. For standard, single-density, eight-inch disk systems, the tables and indexing code are provided in the sample BIOS and need not be changed.

Certain drive types either do not need skewing or perform the skewing externally from the system software. In this case, the skew table address in the DPH can be set to zero, and the SECTRN routine can check for the zero in DE and return with the physical sector set to the logical sector.

BIOS Function 23: MULTIO	
Set Count of Consecutive Sectors for READ or WRITE	
Entry Parameters:	C = Multisector Count
Returned Values:	None

To transfer logically consecutive disk sectors to or from contiguous memory locations, the BDOS issues a MULTIO call, followed by a series of READ or WRITE calls. This allows the BIOS to transfer multiple sectors in a single disk operation. The maximum value of the sector count is dependent on the physical sector size, ranging from 128 with 128-byte sectors, to 4 with 4096-byte sectors. Thus, the BIOS can transfer up to 16K directly to or from the TPA with a single operation.

The BIOS can directly transfer all of the specified sectors to or from the DMA buffer in one operation and then count down the remaining calls to READ or WRITE.

If the disk format uses a skew table to minimize rotational latency when single records are transferred, it is more difficult to optimize transfer time for multisector transfers. One way of utilizing the multisector count with a skewed disk format is to place the sector numbers and associated DMA addresses into a table until either the residual multisector count reaches zero, or the track number changes. Then you can sort the saved requests by physical sector to allow all of the required sectors on the track to be read in one rotation. Each sector must be transferred to or from its proper DMA address.

When an error occurs during a multisector transfer, you can either reset the multiple sector counters in the BIOS and return the error immediately, or you can save the error status and return it to the BDOS on the last READ or WRITE call of the MULTIO operation.

BIOS Function 24: FLUSH	
Force Physical Buffer Flushing for User-supported Deblocking	
Entry Parameters:	None
Returned Values:	A=000H if no error occurred A=001H if physical error occurred A=002H if disk is Read-Only

The flush buffers entry point allows the system to force physical sector buffer flushing when your BIOS is performing its own record blocking and deblocking.

The BDOS calls the FLUSH routine to ensure that no dirty buffers remain in memory. The BIOS should immediately write any buffers that contain unwritten data.

Normally, the FLUSH function is superfluous, because the BDOS supports blocking/deblocking internally. It is required, however, for those systems that support blocking/deblocking in the BIOS, as many CP/M 2.2 systems do.

Note: if you do not implement FLUSH, the routine must return a zero in Register 1A. You can accomplish this with the following instructions:

```
xra     a
ret
```

3.4.4 Memory Select and Move Functions

This section defines the memory management functions MOVE, XMOVE, SELMEM, and SETBNK.

BIOS Function 25: MOVE	
Memory-to-Memory Block Move	
Entry Parameters:	HL = Destination address DE = Source address BC = Count
Returned Values:	HL and DE must point to next bytes following move operation

The BDOS calls the MOVE routine to perform memory to memory block moves to allow use of the Z80 LDIR instruction or special DMA hardware, if available. Note that the arguments in HL and DE are reversed from the Z80 machine instruction, necessitating the use of XCHG instructions on either side of the LDIR. The BDOS uses this routine for all large memory copy operations. On return, the HL and DE registers are expected to point to the next bytes following the move.

Usually, the BDOS expects MOVE to transfer data within the currently selected bank or common memory. However, if the BDOS calls the XMOVE entry point before calling MOVE, the MOVE routine must perform an interbank transfer.

BIOS Function 27: SELMEM	
Select Memory Bank	
Entry Parameters:	A = Memory Bank
Returned Values:	None

The SELMEM entry point is only present in banked systems. The banked version of the CP/M 3 BDOS calls SELMEM to select the current memory bank for further instruction execution or buffer references. You must preserve or restore all registers other than the accumulator, A, upon exit.

BIOS Function 28: SETBNK	
Specify Bank for DMA Operation	
Entry Parameters:	A = Memory Bank
Returned Values:	None

SETBNK only occurs in the banked version of CP/M 3. SETBNK specifies the bank that the subsequent disk READ or WRITE routine must use for memory transfers. The BDOS always makes a call to SETBNK to identify the DMA bank before performing a READ or WRITE call. Note that the BDOS does not reference banks other than 0 or 1 unless another bank is specified by the BANK field of a Data Buffer Control Block (BCB).

BIOS Function 29: XMOVE	
Set Banks for Following MOVE	
Entry Parameters:	B=destination bank C=source bank
Returned Values:	None

XMOVE is provided for banked systems that support memory-to-memory DMA transfers over the entire extended address range. Systems with this feature can have their data buffers located in an alternate bank instead of in common memory, as is usually required. An XMOVE call affects only the following MOVE call. All subsequent MOVE calls apply to the memory selected by the latest call to SELMEM. After a call to the XMOVE function, the following call to the MOVE function is not more than 128 bytes of data. If you do not implement XMOVE, the first instruction must be a RET instruction.

3.4.5 Clock Support Function

This section defines the clock support function TIME.

BIOS Function 26: TIME	
Get and Set Time	
Entry Parameters:	C = Time Get/Set Flag
Returned values:	None

The BDOS calls the TIME function to indicate to the BIOS whether it has just set the Time and Date fields in the SCB, or whether the BDOS is about to get the Time and Date from the SCB. On entry to the TIME function, a zero in register C indicates that the BIOS should update the Time and Date fields in the SCB. A 0FFH in register C indicates that the BDOS has just set the Time and Date in the SCB and the BIOS should update its clock. Upon exit, you must restore register pairs HL and DE to their entry values.

This entry point is for systems that must interrogate the clock to determine the time. Systems in which the clock is capable of generating an interrupt should use an interrupt service routine to set the Time and Date fields on a regular basis.

3.5 Banking Considerations

This section discusses considerations for separating your BIOS into resident and banked modules. You can place part of your customized BIOS in common memory, and part of it in Bank 0. However, the following data structures and routines must remain in common memory:

- the BIOS stack
- the BIOS jump vector
- Disk Parameter Blocks
- memory management routines
- the CHRTBL data structure
- all character I/O routines
- portions of the disk I/O routines

You can place portions of the disk I/O routines in the system bank, Bank 0. In a banked environment, if the disk I/O hardware supports DMA transfers to and from banks other than the currently selected bank, the disk I/O drivers can reside in Bank 0. If the system has a DMA controller that supports block moves from memory to memory between banks, CP/M 3 also allows you to place the blocking and deblocking buffers in any bank other than Bank 1, instead of common memory.

If your disk controller supports data transfers only into the currently selected bank, then the code that initiates and performs a data transfer must reside in common memory. In this case, the disk I/O transfer routines must select the DMA bank, perform the transfer, then reselect Bank 0. The routine in common memory performs the following procedure:

1) Selects the DMA bank that SETBNK saved.
2) Performs physical I/O.
3) Reselects Bank 0.
4) Returns to the calling READ or WRITE routine in Bank 0.

Note that Bank 0 is in context (selected) when the BDOS calls the system initialization functions BOOT and DRVTBL; the disk I/O routines HOME, SELDSK, SETTRK, SETSEC, SETDMA, READ, WRITE, SECTRN, MULTIO, and FLUSH; and the memory management routines XMOVE and SETBNK.

Bank 0 or Bank 1 is in context when the BDOS calls the system initialization routines WBOOT, DEVTBL, and DEVINI; the character I/O routines CONST, CONIN, CONOUT, LIST, AUXOUT, AUXIN, LISTST, CONOST, AUXIST, and AUXOST, the memory select and move routines MOVE and SELMEM, and the clock support routine TIME.

You can place a portion of the character I/O routines in Bank 0 if you place the following procedure in common memory.

1) Swap stacks to a local stack in common.
2) Save the current bank.
3) Select Bank 0.
4) Call the appropriate character I/O routine.
5) Reselect the saved bank.
6) Restore the stack.

3.6 Assembling and Linking Your BIOS

This section assumes you have developed a BIOS3.ASM or BNKBIOS3.ASM file appropriate to your specific hardware environment. Use the Digital Research Relocatable Macro Assembler RMAC™ to assemble the BIOS. Use the Digital Research Linker LINK-80™ to create the BIOS3.SPR and BNKBIOS3.SPR files. The SPR files are part of the input to the GENCPM program.

In a banked environment, your CP/M 3 BIOS can consist of two segments: a banked segment and a common segment. This allows you to minimize common memory usage to maximize the size of the TPA. To prepare a banked BIOS, place code and data that must reside in common in the CSEG segment, and code and data that can reside in the system bank in the DSEG segment. When you link the BIOS, LINK-80 creates the BNKBIOS3.SPR file with all the CSEG code and data first, and then the DSEG code and data.

After assembling the BIOS with RMAC, link your BNKBIOS using LINK-80 with the [B] option. The [B] option aligns the DSEG on a page boundary, and places the length of the CSEG into the BNKBIOS3.SPR header page.

Use the following procedure to prepare a BIOS3.SPR or BNKBIOS3.SPR file from your customized BIOS.

1) Assemble your BIOS3.ASM or BNKBIOS3.ASM file with the relocatable assembler RMAC.COM to produce a relocatable file of type REL. Assemble SCB.ASM to produce the relocatable file SCB.REL.

   Assembling the Nonbanked BIOS:

   A>**RMAC BIOS3**

   Assembling the Banked BIOS:

   A>**RMAC BNKBIOS3**

2) Link the BIOS3.REL or BNKBIOS3.REL file and the SCB.REL file with LINK-80 to produce the BIOS3.SPR or BNKBIOS3.SPR file. The [OS] option with LINK causes the output of a System Page Relocatable (SPR) file.

   Linking the Nonbanked BIOS:

   A>**LINK BIOS3[OS]=BIOS3,SCB**

   Linking the Banked BIOS:

   A>**LINK BNKBIOS3[B]=BNKBIOS3,SCB**

The preceding examples show command lines for linking a banked and nonbanked BIOS. In these examples, the BIOS3.REL and BNKBIOS3.REL are the files of your assembled BIOS. SCB.REL contains the definitions of the System Control Block variables. The [B] option implies the [OS] option.

End of Section 3

Section 4
CP/M 3 Sample BIOS Modules

This section discusses the modular organization of the example CP/M 3 BIOS on your distribution disk. For previous CP/M operating systems, it was necessary to generate all input/output drivers from a single assembler source file. Such a file is difficult to maintain when the BIOS supports several peripherals. As a result, Digital Research is distributing the BIOS for CP/M 3 in several small modules.

The organization of the BIOS into separate modules allows you to write or modify any I/O driver independently of the other modules. For example, you can easily add another disk I/O driver for a new controller with minimum impact on the other parts of the BIOS.

4.1 Functional Summary of BIOS Modules

The modules of the BIOS are BIOSKRNL.ASM, SCB.ASM, BOOT.ASM, MOVE.ASM, CHARIO.ASM, DRVTBL.ASM, and a disk I/O module for each supported disk controller in the configuration.

BIOSKRNL.ASM is the kernel, root, or supervisor module of the BIOS. The SCB.ASM module contains references to locations in the System Control Block. You can customize the other modules to support any hardware configuration. To customize your system, add or modify external modules other than the kernel and the SCB.ASM module.

Digital Research supplies the BIOSKRNL.ASM module. This module is the fixed, invariant portion of the BIOS, and the interface from the BDOS to all BIOS functions. It is supplied in source form for reference only, and you should not modify it except for the equate statement described in the following paragraph.

You must be sure the equate statement (banked equ true) at the start of the BIOSKRNL.ASM source file is correct for your system configuration. Digital Research distributes the BIOSKRNL.ASM file for a banked system. If you are creating a BIOS for a nonbanked system, change the equate statement to the following:

```
banked equ false
```

and reassemble with RMAC. This is the only change you should make to the BIOSKRNL.ASM file.

Table 4-1 summarizes the modules in the CP/M 3 BIOS.

Table 4-1. CP/M 3 BIOS Module Function Summary

Module	Function
BIOSKRNL.ASM	Performs basic system initialization, and dispatches character and disk I/O.
SCB.ASM module	Contains the public definitions of the various fields in the System Control Block. The BIOS can reference the public variables.
BOOT.ASM module	Performs system initialization other than character and disk I/O. BOOT loads the CCP for cold starts and reloads it for warm starts.
CHARIO.ASM module	Performs all character device initialization, input, output, and status polling. CHARIO contains the character device characteristics table.
DRVTBL.ASM module	Points to the data structures for each configured disk drive. The drive table determines which physical disk unit is associated with which logical drive. The data structure for each disk drive is called an Extended Disk Parameter Header (XDPH).
Disk I/O modules	Initialize disk controllers and execute READ and WRITE code for disk controllers. You must provide an XDPH for each supported unit, and a separate disk I/O module for each controller in the system. To add another disk controller for which a prewritten module exists, add its XDPH names to the DRVTBL and link in the new module.

Table 4-1. (continued)

Module	Function
MOVE.ASM module	
	Performs memory-to-memory moves and bank selects.

4.2 Conventions Used in BIOS Modules

The Digital Research RMAC relocating assembler and LINK-80 linkage editor allow a module to reference a symbol contained in another module by name. This is called an external reference. The MicroSoft® relocatable object module format that RMAC and LINK use allows six-character names for externally defined symbols. External names must be declared PUBLIC in the module in which they are defined. The external names must be declared EXTRN in any modules that reference them.

The modular BIOS defines a number of external names for specific purposes. Some of these are defined as public in the root module, BIOSKRNL.ASM. Others are declared external in the root and must be defined by the system implementor. Section 4.4 contains a table summarizing all predefined external symbols used by the modular BIOS.

External names can refer to either code or data. All predefined external names in the modular BIOS prefixed with a @ character refer to data items. All external names prefixed with a ? character refer to a code label. To prevent conflicts with future extensions, user-defined external names should not contain these characters.

4.3 Interactions of Modules

The root module of the BIOS, BIOSKRNL.ASM, handles all BDOS calls, performs interfacing functions, and simplifies the individual modules you need to create.

4.3.1 Initial Boot

BIOSKRNL.ASM initializes all configured devices in the following order:

1) BIOSKRNL calls ?CINIT in the CHARIO module for each of the 16 character devices and initializes the devices.

2) BIOSKRNL invokes the INIT entry point of each XDPH in the FD1797SD module.

3) BIOSKRNL calls the ?INIT entry of the BOOT module to initialize other system hardware, such as memory controllers, interrupts, and clocks. It prints a sign-on message specific to the system, if desired.

4) BIOSKRNL calls ?LDCCP in the BOOT module to load the CCP into the TPA.

5) The BIOSKRNL module sets up Page Zero of the TPA with the appropriate jump vectors, and passes control to the CCP.

4.3.2 Character I/O Operation

The CHARIO module performs all physical character I/O. This module contains both the character device table (@CTBL) and the routines for character input, output, initialization, and status polling. The character device table, @CTBL, contains the ASCII name of each device, mode information, and the current baud rate of serial devices.

To support logical to physical redirection of character devices, CP/M 3 supplies a 16-bit assignment vector for each logical device. The bits in these vectors correspond to the physical devices. The character I/O interface routines in BIOSKRNL handle all device assignment, calling the appropriate character I/O routines with the correct device number. The BIOSKRNL module also handles XON/XOFF processing on output devices where it is enabled.

You can use the DEVICE utility to assign several physical devices to a logical device. The BIOSKRNL root module polls the assigned physical devices, and either reads a character from the first ready input device that is selected, or sends the character to all of the selected output devices as they become ready.

4.3.3 Disk I/O Operation

The BIOSKRNL module handles all BIOS calls associated with disk I/O. It initializes global variables with the parameters for each operation, and then invokes the READ or WRITE routine for a particular controller. The SELDSK routine in the BIOSKRNL calls the LOGIN routine for a controller when the BDOS initiates a drive login. This allows disk density or media type to be automatically determined.

The DRVTBL module contains the sixteen-word drive table, @DTBL. The order of the entries in @DTBL determines the logical to physical drive assignment. Each word in @DTBL contains the address of a DPH, which is part of an XDPH, as shown in Table 4-10. The word contains a zero if the drive does not exist. The XDPH contains the addresses of the INIT, LOGIN, READ, and WRITE entry points of the I/O driver for a particular controller. When the actual drivers are called, globally accessible variables contain the various parameters of the operation, such as the track and sector.

4.4 Predefined Variables and Subroutines

The modules of the BIOS define public variables which other modules can reference. Table 4-2 contains a summary of each public symbol and the module that defines it.

Table 4-2. Public Symbols in CP/M 3 BIOS

Symbol	Function and Use	Defined in Module
@ADRV	Byte, Absolute drive code	BIOSKRNL
@CBNK	Byte, Current CPU bank	BIOSKRNL
@CNT	Byte, Multisector count	BIOSKRNL
@CTBL	Table, Character device table	CHARIO
@DBNK	Byte, Bank for disk I/O	BIOSKRNL
@DMA	Word, DMA address	BIOSKRNL
@DTBL	Table, Drive table	DRVTBL
@RDRV	Byte, Relative drive code (UNIT)	BIOSKRNL
@SECT	Word, Sector address	BIOSKRNL
@TRK	Word, Track number	BIOSKRNL
?BANK	Bank select	MOVE
?CI	Character device input	CHARIO
?CINIT	Character device initialization	CHARIO
?CIST	Character device input status	CHARIO
?CO	Character device output	CHARIO
?COST	Character device output status	CHARIO
?INIT	General initialization	BOOT
?LDCCP	Load CCP for cold start	BOOT
?MOVE	Move memory to memory	MOVE
?PDEC	Print decimal number	BIOSKRNL
?PDERR	Print BIOS disk error header	BIOSKRNL
?PMSG	Print message	BIOSKRNL
?RLCCP	Reload CCP for warm start	BOOT
?XMOVE	Set banks for extended move	MOVE
?TIME	Set or Get time	BOOT

The System Control Block defines public variables that other modules can reference. The System Control Block variables @CIVEC, @COVEC, @AIVEC, @AOVEC, and @LOVEC are referenced by BIOSKRNL.ASM. The variable @BNKBF can be used by ?LDCCP and ?RLCCP to implement interbank block moves. The public variable names @ERMDE, @FX, @RESEL, @VINFO, @CRDSK, @USRCD, and @CRDMA are used for error routines which intercept BDOS errors. The publics @DATE, @HOUR, @MIN, and @SEC can be updated by an interrupt-driven real-time clock. @MXTPA contains the current BDOS entry point.

Disk I/O operation parameters are passed in the following global variables, as shown in Table 4-3.

Table 4-3. Global Variables in BIOSKRNL.ASM

Variable	Meaning
@ADRV	Byte; contains the absolute drive code (0 through F for A through P) that CP/M is referencing for READ and WRITE operations. The SELDSK routine in the BIOSKRNL module obtains this value from the BDOS and places it in @DRV. The absolute drive code is used to print error messages.
@RDRV	Byte; contains the relative drive code for READ and WRITE operations. The relative drive code is the UNIT number of the controller in a given disk I/O module. BIOSKRNL obtains the unit number from the XDPH. This is the actual drive code a driver should send to the controller.
@TRK	Word; contains the starting track for READ and WRITE.
@SECT	Word; contains the starting sector for READ and WRITE.
@DMA	Word; contains the starting disk transfer address.
@DBNK	Byte; contains the bank of the DMA buffer.
@CNT	Byte; contains the physical sector count for the operations that follow.
@CBNK	Byte; contains the current bank for code execution.

Several utility subroutines are defined in the BIOSKRNL.ASM module, as shown in Table 4-4.

Table 4-4. Public Utility Subroutines in BIOSKRNL.ASM

Utility	Meaning
?PMSG	Print string starting at <HL>, stop at null (0).
?PDEC	Print binary number in decimal from HL.
?PDERR	Print disk error message header using current disk parameters: <CR><LF>BIOS Error on d:, T-nn, S-nn.

All BIOS entry points in the jump vector are declared as public for general reference by other BIOS modules, as shown in Table 4-5.

Table 4-5. Public Names in the BIOS Jump Vector

Public Name	Function
?BOOT	Cold boot entry
?WBOOT	Warm boot entry
?CONST	Console input status
?CONIN	Console input
?CONO	Console output
?LIST	List output
?AUXO	Auxiliary output
?AUXI	Auxiliary input
?HOME	Home disk drive
?SLDSK	Select disk drive
?STTRK	Set track
?STSEC	Set sector
?STDMA	Set DMA address
?READ	Read record
?WRITE	Write record
?LISTS	List status
?SCTRN	Translate sector
?CONOS	Console output status
?AUXIS	Auxiliary input status
?AUXOS	Auxiliary output status
?DVTBL	Return character device table address
?DEVIN	Initialize character device
?DRTBL	Return disk drive table address
?MLTIO	Set multiple sector count
?FLUSH	Flush deblocking buffers (not implemented)
?MOV	Move memory block
?TIM	Signal set or get time from clock
?BNKSL	Set bank for further execution
?STBNK	Set bank for DMA
?XMOV	Set banks for next move

4.5 BOOT Module

The BOOT module performs general system initialization, and loads and reloads the CCP. Table 4-6 shows the entry points of the BOOT module.

Table 4-6. BOOT Module Entry Points

Module	Meaning
?INIT	The BIOSKRNL module calls ?INIT during cold start to perform hardware initialization other than character and disk I/O. Typically, this hardware can include time-of-day clocks, interrupt systems, and special I/O ports used for bank selection.
?LDCCP	BIOSKRNL calls ?LDCCP during cold start to load the CCP into the TPA. The CCP can be loaded either from the system tracks of the boot device or from a file, at the discretion of the system implementor. In a banked system, you can place a copy of the CCP in a reserved area of another bank to increase the performance of the ?RLCCP routine.
?RLCCP	BIOSKRNL calls ?RLCCP during warm start to reload the CCP into the TPA. In a banked system, the CCP can be copied from an alternate bank to eliminate any disk access. Otherwise, the CCP should be loaded from either the system tracks of the boot device or from a file.

4.6 Character I/O

The CHARIO module handles all character device interfacing. The CHARIO module contains the character device definition table @CTBL, the character input routine ?CI, the character output routine ?CO, the character input status routine ?CIST, the character output status routine ?COST, and the character device initialization routine ?CINIT.

The BIOS root module, BIOSKRNL.ASM, handles all character I/O redirection. This module determines the appropriate devices to perform operations and executes the actual operation by calling ?CI, ?CO, ?CIST, and ?COST with the proper device number(s).

@CTBL is the external name for the structure CHRTBL described in Section 3 of this manual. @CTBL contains an 8-byte entry for each physical device defined by this BIOS. The table is terminated by a zero byte after the last entry.

The first field of the character device table, @CTBL, is the 6-byte device name. This device name should be all upper-case, left-justified, and padded with ASCII spaces (20H).

The second field of @CTBL is 1 byte containing bits that indicate the type of device and its current mode, as shown in Table 4-7.

Table 4-7. Mode Bits

Mode Bits	Meaning
00000001	Input device (such as a keyboard)
00000010	Output device (such as a printer)
00000011	Input/output device (such as a terminal or modem)
00000100	Device has software-selectable baud rates
00001000	Device may use XON protocol
00010000	XON/XOFF protocol enabled

The third field of @CTBL is 1 byte and contains the current baud rate for serial devices. The high-order nibble of this field is reserved for future use and should be set to zero. The low-order four bits contain the current baud rate as shown in Table 4-8. Many systems do not support all of these baud rates.

Table 4-8 Baud Rates for Serial Devices

Decimal	Binary	Baud Rate
0	0000	none
1	0001	50
2	0010	75
3	0011	110
4	0100	134.5
5	0101	150
6	0110	300
7	0111	600
8	1000	1200
9	1001	1800
10	1010	2400
11	1011	3600
12	1100	4800
13	1101	7200
14	1110	9600
15	1111	19200

Table 4-9 shows the entry points to the routines in the CHARIO module. The BIOSKRNL module calls these routines to perform machine-dependent character I/O.

Table 4-9. Character Device Labels

Label	Meaning
?CI	Character Device Input ?CI is called with a device number in register B. It should wait for the next available input character, then return the character in register A. The character should be in 8-bit ASCII with no parity.
?CO	Character Device Output ?CO is called with a device number in register B and a character in register C. It should wait until the device is ready to accept another character and then send the character. The character is in 8-bit ASCII with no parity.
?CIST	Character Device Input Status ?CIST is called with a device number in register B. It should return with register A set to zero if the device specified has no input character ready; and should return with A set to 0FFH if the device specified has an input character ready to be read.
?COST	Character Device Output Status ?COST is called with a device number in register B. It should return with register A set to zero if the device specified cannot accept a character immediately, and should return with A set to 0FFH if the device is ready to accept a character.
?CINIT	Character Device Initialization ?CINIT is called for each of the 16 character devices, and initializes the devices. Register C contains the device number. The ?CINIT routine initializes the physical character device specified in register C to the baud rate contained in the appropriate entry of the CHRTBL. You only need to supply this routine if I/O redirection has been implemented. It is referenced only by the DEVICE utility supplied with CP/M 3.

4.7 Disk I/O

The separation of the disk I/O section of the BIOS into several modules allows you to support each particular disk controller independently from the rest of the system. A manufacturer can supply the code for a controller in object module form, and you can link it into any existing modular BIOS to function with other controllers in the system.

The data structure called the Extended Disk Parameter Header, or XDPH, contains all the necessary information about a disk drive. BIOSKRNL.ASM locates the XDPH for a particular logical drive using the Drive Table. The XDPH contains the addresses of the READ, WRITE, initialization, and login routines. The XDPH also contains the relative unit number of the drive on the controller, the current media type, and the Disk Parameter Header (DPH) that the BDOS requires. Section 3 of this manual describes the Disk Parameter Header.

The code to read and write from a particular drive is independent of the actual CP/M logical drive assignment, and works with the relative unit number of the drive on the controller. The position of the XDPH entry in the DRVTBL determines the actual CP/M 3 drive code.

4.7.1 Disk I/O Structure

The BIOS requires a DRVTBL module to locate the disk driver. It also requires a disk module for each controller that is supported.

The drive table module, DRVTBL, contains the addresses of each XDPH defined in the system. Each XDPH referenced in the DRVTBL must be declared external to link the table with the actual disk modules.

The XDPHs are the only public entry points in the disk I/O modules. The root module references the XDPHs to locate the actual I/O driver code to perform sector READS and WRITES. When the READ and WRITE routines are called, the parameters controlling the READ or WRITE operation are contained in a series of global variables that are declared public in the root module.

4.7.2 Drive Table Module (DRVTBL)

The drive table module, DRVTBL, defines the CP/M absolute drive codes associated with the physical disks.

The DRVTBL module contains one public label, @DTBL. @DTBL is a 16-word table containing the addresses of up to 16 XDPH's. Each XDPH name must be declared external in the DRVTBL. The first entry corresponds to drive A, and the last to drive P. You must set an entry to 0 if the corresponding drive is undefined. Selecting an undefined drive causes a BDOS SELECT error.

4.7.3 Extended Disk Parameter Headers (XDPHs)

An Extended Disk Parameter Header (XDPH) consists of a prefix and a regular Disk Parameter Header as described in Section 3. The label of a XDPH references the start of the DPH. The fields of the prefix are located at relative offsets from the XDPH label.

The XDPHs for each unit of a controller are the only entry points in a particular disk drive module. They contain both the DPH for the drive and the addresses of the various action routines for that drive, including READ, WRITE, and initialization. Figure 4-1 below shows the format of the Extended Disk Parameter Header.

ADDRESS	LOW BYTE (0 – 7)	HIGH BYTE (8 – 15)	
XDPH-10	addr of sector WRITE		
XDPH-8	addr of sector READ		
XDPH-6	addr of drive LOGIN		
XDPH-4	addr of drive INIT		
XDPH-2	unit	type	
XDPH+0	addr of translate table		start of <--regular DPH
XDPH+2	0	0	
XDPH+4	0	0	
XDPH+6	0	0	
XDPH+8	0	0	
XDPH+10	Media Flag <->	0	
XDPH+12	addr of DPB		
XDPH+14	addr of CSV		
XDPH+16	addr of ALV		
XDPH+18	addr of DIRBCB		
XDPH+20	addr of DTABCB		
XDPH+22	addr of HASH		
XDPH+24	hash bank		

Figure 4-1. XDPH Format

Table 4-10 describes the fields of each Extended Disk Parameter Header.

Table 4-10. Fields of Each XDPH

Field	Meaning
WRITE	The WRITE word contains the address of the sector WRITE routine for the drive.
READ	The READ word contains the address of the sector READ routine for the drive.
LOGIN	The LOGIN word contains the address of the LOGIN routine for the drive.
INIT	The INIT word contains the address of the first-time initialization code for the drive.
UNIT	The UNIT byte contains the drive code relative to the disk controller. This is the value placed in @RDRV prior to calling the READ, WRITE, and LOGIN entry points of the drive.
TYPE	The TYPE byte is unused by the BIOS root, and is reserved for the driver to keep the current density or media type to support multiple-format disk subsystems.
regular DPH	The remaining fields of the XDPH comprise a standard DPH, as discussed in Section 3 of this manual.

4.7.4 Subroutine Entry Points

The pointers contained in the XDPH reference the actual code entry points to a disk driver module. These routines are not declared public. Only the XDPH itself is public. The BIOS root references the XDPHs only through the @DTBL. Table 4-11 shows the BIOS subroutine entry points.

Table 4-11. Subroutine Entry Points

Entry Point	Meaning
WRITE	When the WRITE routine is called, the address of the XDPH is passed in registers DE. The parameters for the WRITE operation are contained in the public variables @ADRV, @RDRV, @TRK, @SECT, @DMA, and @DBNK. The WRITE routine should return an error code in register A. The code 00 means a successful operation, 01 means a permanent error occurred, and 02 means the drive is write-protected if that feature is supported.
READ	When the READ routine is called, the address of the XDPH is contained in registers DE. The parameters for the READ operation are contained in the public variables @ADRV, @RDRV, @TRK, @SECT, @DMA, and @DBNK. The READ routine should return an error code in register A. A code of 00 means a successful operation and 01 means a permanent error occurred.
LOGIN	The LOGIN routine is called before the BDOS logs into the drive, and allows the automatic determination of density. The LOGIN routine can alter the various parameters in the DPH, including the translate table address (TRANS) and the Disk Parameter Block (DPB). The LOGIN routine can also set the TYPE byte. On single media type systems, the LOGIN routine can simply return. When LOGIN is called, the registers DE point to the XDPH for this drive.
INIT	The BOOT entry of the BIOSKRNL module calls each INIT routine during cold start and prior to any other disk accesses. INIT can perform any necessary hardware initialization, such as setting up the controller and interrupt vectors, if any.

4.7.5 Error Handling and Recovery

The READ and WRITE routines should perform several retries of an operation that produces an error. If the error is related to a seek operation or a record not found condition, the retry routine can home or restore the drive, and then seek the correct track. The exact sequence of events is hardware-dependent.

When a nonrecoverable error occurs, the READ or WRITE routines can print an error message informing the operator of the details of the error. The BIOSKRNL module supplies a subroutine, ?PDERR, to print a standard BIOS error message header. This routine prints the following message:

```
BIOS Err on D: T-nn S-nn
```

where D: is the selected drive, and T-nn and S-nn display the track and sector number for the operation. The READ and WRITE routines should print the exact cause of the error after this message, such as Not Ready, or Write Protect. The driver can then ask the operator if additional retries are desired, and return an error code to the BDOS if they are not.

However, if the @ERMDE byte in the System Control Block indicates the BDOS is returning error codes to the application program without printing error messages, the BIOS should simply return an error without any message.

4.7.6 Multiple Section I/O

The root module global variable @CNT contains the multisector count. Refer to Sections 2.5 and 3.4.3 for a discussion of the considerations regarding multirecord I/O.

4.8 MOVE Module

The MOVE Module performs memory-to-memory block moves and controls bank selection. The ?MOVE and ?XMOVE entry points correspond directly to the MOVE and XMOVE jump vector routines documented in Section 3. Table 4-12 shows the entry points for the MOVE module.

Table 4-12. Move Module Entry Points

Entry Point	Meaning
?MOVE	Memory-to-memory move ?MOVE is called with the source address for the move in register DE, the destination address in register HL, and the byte count in register BC. If ?XMOVE has been called since the last call to ?MOVE, an interbank move must be performed. On return, registers HL and DE must point to the next bytes after the MOVE. This routine can use special DMA hardware for the interbank move capability, and can use the Z80 LDIR instruction for intrabank moves.
?XMOVE	Set banks for one following ?MOVE ?XMOVE is passed to the source bank in register B and the destination bank in register C. Interbank moves are only invoked if the DPHs specify deblocking buffers in alternate banks. ?XMOVE only applies to one call to ?MOVE.
?BANK	Set bank for execution ?BANK is called with the bank address in register A. This bank address has already been stored in @CBNK for future reference. All registers except A must be maintained upon return.

4.9 Linking Modules into the BIOS

The following lines are examples of typical link commands to build a modular BIOS ready for system generation with GENCPM:

```
LINK BNKBIOS3[b]=BNKBIOS,SCB,BOOT,CHARIO,MOVE,DRVTBL,<disk_modules>

LINK BIOS3[b]=BIOS,SCB,BOOT,CHARIO,MOVE,DRVTBL,<disk_modules>
```

End of Section 4

CP/M Plus™ (CP/M® Version 3)
Operating System System Guide
Release Note

Following are corrections to the CP/M Plus™ (CP/M® Version 3) Operating System System Guide.

Page 82

Section 4.7.3 Extended Disk Parameter Headers (XDPHs)

Figure 4-1., XDPH Format, is incorrect. The Media Flag shown at Address XDPH+10 should be in the High Byte column, and 0 should be in the Low Byte column.

Page 86

Section 4.9 Linking Modules into the BIOS

The option shown in the second link command example is incorrect. The command line should read as follows:

```
LINK BIOS3[os]=BIOS,SCB,BOOT,CHARIO,MOVE,DRVTBL,<disk_modules>
```

Section 5
System Generation

This section describes the use of the GENCPM utility to create a memory image CPM3.SYS file containing the elements of the CP/M 3 operating system. This section also describes customizing the LDRBIOS portion of the CPMLDR program, and the operation of CPMLDR to read the CPM3.SYS file into memory. Finally, this section describes the procedure to follow to boot CP/M 3.

In the nonbanked system, GENCPM creates the CPM3.SYS file from the BDOS3.SPR and your customized BIOS3.SPR files. In the banked system, GENCPM creates the CPM3.SYS file from the RESBDOS3.SPR file, the BNKBDOS3.SPR file, and your customized BNKBIOS3.SPR file.

If your BIOS contains a segment that can reside in banked memory, GENCPM separates the code and data in BNKBIOS3.SPR into a banked portion which resides in Bank 0 just below common memory, and a resident portion which resides in common memory.

GENCPM relocates the system modules, and can allocate physical record buffers, allocation vectors, checksum vectors, and hash tables as requested in the BIOS data structures. GENCPM accepts its command input from a file, GENCPM.DAT, or interactively from the console.

5.1 GENCPM Utility

Syntax:

    GENCPM {AUTO | AUTO DISPLAY}

Purpose:

GENCPM creates a memory image CPM3.SYS file, containing the CP/M 3 BDOS and customized BIOS. The GENCPM utility performs late resolution of intermodule references between system modules. GENCPM can accept its command input interactively from the console or from a file GENCPM.DAT.

In the nonbanked system, GENCPM creates a CPM3.SYS file from the BDOS3.SPR and BIOS3.SPR files. In the banked system, GENCPM creates the CPM3.SYS file from the RESBDOS3.SPR, the BNKBDOS3.SPR and the BNKBIOS3.SPR files. Remember to back up your CPM3.SYS file before executing GENCPM, because GENCPM deletes any existing CPM3.SYS file before it generates a new system.

Input Files:

Banked System	Nonbanked System
BNKBIOS3.SPR	BIOS3.SPR
RESBDOS3.SPR	BDOS3.SPR
BNKBDOS3.SPR	

Optionally GENCPM.DAT

Output File:

CPM3.SYS

Optionally GENCPM.DAT

GENCPM determines the location of the system modules in memory and, optionally, the number of physical record buffers allocated to the system. GENCPM can specify the location of hash tables requested by the Disk Parameter Headers (DPHs) in the BIOS. GENCPM can allocate all required disk buffer space and create all the required Buffer Control Blocks (BCBs). GENCPM can also create checksum vectors and allocation vectors.

GENCPM can get its input from a file GENCPM.DAT. The values in the file replace the default values of GENCPM. If you enter the AUTO parameter in the command line GENCPM gets its input from the file GENCPM.DAT and generates a new system displaying only its sign-on and sign-off messages on the console. If AUTO is specified and a GENCPM.DAT file does not exist on the current drive, GENCPM reverts to manual generation.

If you enter the AUTO DISPLAY parameter in the command line, GENCPM automatically generates a new system and displays all questions on the console. If AUTO DISPLAY is specified and a GENCPM.DAT file does not exist on the current drive, GENCPM reverts to manual generation. If GENCPM is running in AUTO mode and an error occurs, it reverts to manual generation and starts from the beginning.

The GENCPM.DAT file is an ASCII file of variable names and their associated values. In the following discussion, a variable name in the GENCPM.DAT file is referred to as a Question Variable. A line in the GENCPM.DAT file takes the following general form:

```
Question Variable = value | ? | ?value <CR><LF>

     value = #decimal value
             or hexadecimal value
             or drive letter (A - P)
             or Yes, No, Y, or N
```

You can specify a default value by following a question mark with the appropriate value, for example ?A or ?25 or ?Y. The question mark tells GENCPM to stop and prompt the user for input, then continue automatically. At a ?value entry, GENCPM displays the default value and stops for verification.

The following pages display GENCPM questions. The items in parentheses are the default values. The Question Variable associated with the question is shown below the explanation of the answers to the questions.

<u>Program Questions:</u>

Use GENCPM.DAT for defaults (Y) ?

> Enter Y - GENCPM gets its default values from the file GENCPM.DAT.
>
> Enter N - GENCPM uses the built-in default values.
>
> No Question Variable is associated with this question.

Create a new GENCPM.DAT file (N) ?

> Enter N - GENCPM does not create a new GENCPM.DAT file.
>
> Enter Y - After GENCPM generates the new CPM3.SYS file it creates a new GENCPM.DAT file containing the default values.
>
> Question Variable: CRDATAF

Display Load Table at Cold Boot (Y) ?

> Enter Y - On Cold Boot the system displays the load table containing the filename, filetype, hex starting address, length of system modules, and the TPA size.
>
> Enter N - System displays only the TPA size on cold boot.
>
> Question Variable: PRTMSG

Number of console columns (#80) ?

> Enter the number of columns (characters-per-line) for your console.
>
> A character in the last column must not force a new line for console editing in CP/M 3. If your terminal forces a new line automatically, decrement the column count by one.
>
> Question Variable: PAGWID

Number of lines per console page (#24) ?

Enter the number of the lines per screen for your console.

Question Variable: PAGLEN

Backspace echoes erased character (N) ?

Enter N - Backspace (Ctrl-H, 08H) moves back one column and erases the previous character.

Enter Y - Backspace moves forward one column and displays the previous character.

Question Variable: BACKSPC

Rubout echoes erased character (Y) ?

Enter Y - Rubout (7FH) moves forward one column and displays the previous character.

Enter N - Rubout moves back one column and erases the previous character.

Question Variable: RUBOUT

Initial default drive (A:) ?

Enter the drive code the prompt is to display at cold boot.

Question Variable: BOOTDRV

Top page of memory (FF) ?

Enter the page address that is to be the top of the operating system. 0FFH is the top of a 64K system.

Question Variable: MEMTOP

Bank-switched memory (Y) ?

Enter Y - GENCPM uses the banked system files.

Enter N - GENCPM uses the nonbanked system files.

Question Variable: BNKSWT

Common memory base page (C0) ?

This question is displayed only if you answered Y to the previous question. Enter the page address of the start of common memory.

Question Variable: COMBAS

Long error messages (Y) ?

This question is displayed only if you answered Y to bank-switched memory.

Enter Y - CP/M 3 error messages contain the BDOS function number and the name of the file on which the operation was attempted.

Enter N - CP/M 3 error messages do not display the function number or file.

Question Variable: LERROR

Double allocation vectors (Y) ?

This question is displayed only if you answered N to bank-switched memory. For more information about double allocation vectors, see the definition of the Disk Parameter Header ALV field in Section 3.

Enter Y - GENCPM creates double-bit allocation vectors for each drive.

Enter N - GENCPM creates single-bit allocation vectors for each drive.

Question Variable: DBLALV

Accept new system definition (Y) ?

Enter Y - GENCPM proceeds to the next set of questions.

Enter N - GENCPM repeats the previous questions and displays your previous input in the default parentheses. You can modify your answers.

No Question Variable is associated with this question.

Number of memory segments (#3) ?

GENCPM displays this question if you answered Y to bank-switched memory.

Enter the number of memory segments in the system. Do not count common memory or memory in Bank 1, the TPA bank, as a memory segment. A maximum of 16 (0 - 15) memory segments are allowed. The memory segments define to GENCPM the memory available for buffer and hash table allocation. Do not include the part of Bank 0 that is reserved for the operating system.

Question Variable: NUMSEGS

```
CP/M 3  Base,size,bank (8E,32,00)

Enter memory segment table:
 Base,size,bank (00,8E,00) ?
 Base,size,bank (00,C0,02) ?
 Base,size,bank (00,C0,03) ?
```

Enter the base page, the length, and the bank of the memory segment.

Question Variable: MEMSEG0# where # = 0 to F hex

Accept new memory segment table entries (Y) ?

Enter Y - GENCPM displays the next group of questions.

Enter N - GENCPM displays the memory segment table definition questions again.

No Question Variable is associated with this question.

Setting up directory hash tables:

Enable hashing for drive d: (Y) :

GENCPM displays this question if there is a Drive Table and if the DPHs for a given drive have an 0FFFEH in the hash table address field of the DPH. The question is asked for every drive d: defined in the BIOS.

Enter Y - Space is allocated for the Hash Table. The address and bank of the Hash Table is entered into the DPH.

Enter N - No space is allocated for a Hash Table for that drive.

Question Variable: HASHDRVd where d = drives A-P.

Setting up Blocking/Deblocking buffers:

GENCPM displays the next set of questions if either or both the DTABCB field or the DIRBCB field contain 0FFFEH.

Number of directory buffers for drive d: (#1) ? 10

This question appears only if you are generating a banked system. Enter the number of directory buffers to allocate for the specified drive. In a banked system, directory buffers are allocated only inside Bank 0. In a nonbanked system, one directory buffer is allocated above the BIOS.

Question Variable: NDIRRECd where d = drives A-P.

Number of data buffers for drive d: (#1) ? 1

This question appears only if you are generating a Banked system. Enter the number of data buffers to allocate for the specified drive. In a banked system, data buffers can only be allocated outside Bank 1, and in common. You can only allocate data buffers in alternate banks if your BIOS supports interbank moves. In a nonbanked system, data buffers are allocated above the BIOS.

Question Variable: NDTARECd where d = drives A-P.

Share buffer(s) with which drive (A:) ?

This question appears only if you answered zero to either of the above questions. Enter the drive letter (A-P) of the drive with which you want this drive to share a buffer.

Question Variable: ODIRDRVd for directory records where d = drives A-P.

Question Variable: ODTADRVd for data records where d = drives A-P.

Allocate buffers outside of Commom (N) ?

This question appears if the BIOS XMOVE routine is implemented.

Answer Y - GENCPM allocates data buffers outside of common and Bank 0.

Answer N - GENCPM allocates data buffers in common.

Question Variable: ALTBNKSd where d = drives A-P.

Overlay Directory buffer for drive d: (Y) ?

This question appears only if you are generating a nonbanked system.

Enter Y - this drive shares a directory buffer with another drive.

Enter N - GENCPM allocates an additional directory buffer above the BIOS.

Question Variable: OVLYDIRd where d = drives A-P.

Overlay Data buffer for drive d: (Y) ?

This question appears only if you are generating a nonbanked system.

Enter Y - this drive shares a data buffer with another drive.

Enter N - GENCPM allocates an additional data buffer above the BIOS.

Question Variable: OVLYDTAd for directory records where d = drives A-P.

Accept new buffer definitions (Y) ?

Enter Y - GENCPM creates the CPM3.SYS file and terminates.

Enter N - GENCPM redisplays all of the buffer definition questions.

No Question Variable is associated with this question.

Examples:

The following section contains examples of two system generation sessions. If no entry follows a program question, assume RETURN was entered to select the default value in parentheses. Entries different from the default appear after the question mark.

```
EXAMPLE OF CONTENTS OF GENCPM.DAT FILE

combas = c0 <CR>
lerror = ? <CR>
numsegs = 3 <CR>
memseg00 = 00,80,00 <CR>
memseg01 = 0d,b3,02 <CR>
memseg0f = ?00,c0,10 <CR>
hashdrva = y <CR>
hashdrvd = n <CR>
ndirreca = 20 <CR>
ndtarecf = 10 <CR>


EXAMPLE OF SYSTEM GENERATION WITH BANKED MEMORY

A>GENCPM

CP/M 3.0 System Generation
Copyright (C) 1982, Digital Research

Default entries are shown in (parens).
Default base is Hex, precede entry with # for decimal
```

```
Use GENCPM.DAT for defaults (Y) ?

Create a new GENCPM.DAT file (N) ?

Display Load Map at Cold Boot (Y) ?

Number of console columns (#80) ?
Number of lines in console page (#24) ?
Backspace echoes erased character (N) ?
Rubout echoes erased character (N) ?

Initial default drive (A:) ?

Top page of memory (FF) ?
Bank switched memory (Y) ?
Common memory base page (C0) ?

Long error messages (Y) ?

Accept new system definition (Y) ?

Setting up Allocation vector for drive A:
Setting up Checksum vector for drive A:
Setting up Allocation vector for drive B:
Setting up Checksum vector for drive B:
Setting up Allocation vector for drive C:
Setting up Checksum vector for drive C:
Setting up Allocation vector for drive D:
Setting up Checksum vector for drive D:

*** Bank 1 and Common are not included ***
*** in the memory segment table.       ***

Number of memory segments (#3) ?

CP/M 3 Base,size,bank (8B,35,00)

Enter memory segment table:
 Base,size,bank (00,8B,00) ?
 Base,size,bank (0D,B3,02) ?
 Base,size,bank (00,C0,03) ?

 CP/M 3 Sys    8B00H 3500H  Bank 00
 Memseg No. 00 0000H 8B00H  Bank 00
 Memseg No. 01 0D00H B300H  Bank 02
 Memseg No. 02 0000H C000H  Bank 03

Accept new memory segment table entries (Y) ?

Setting up directory hash tables:
 Enable hashing for drive A: (Y) ?
 Enable hashing for drive B: (Y) ?
 Enable hashing for drive C: (Y) ?
 Enable hashing for drive D: (Y) ?
```

```
Setting up Blocking/Deblocking buffers:

The physical record size is 0200H:

     Available space in 256 byte pages:
     TPA = 00F4H, Bank 0 = 008BH, Other banks = 0166H

               Number of directory buffers for drive A: (#32) ?

     Available space in 256 byte pages:
     TPA = 00F4H, Bank 0 = 0049H, Other banks = 0166H

               Number of data buffers for drive A: (#2) ?
               Allocate buffers outside of Common (N) ?

     Available space in 256 byte pages:
     TPA = 00F0H, Bank 0 = 0049H, Other banks = 0166H

               Number of directory buffers for drive B: (#32) ?

     Available space in 256 byte pages:
     TPA = 00F0H, Bank 0 = 0007H, Other banks = 0166H

               Number of data buffers for drive B: (#0) ?
               Share buffer(s) with which drive (A:) ?

The physical record size is 0080H:

     Available space in 256 byte pages:
     TPA = 00F0H, Bank 0 = 0007H, Other banks = 0166H

               Number of directory buffers for drive C: (#10) ?

     Available space in 256 byte pages:
     TPA = 00F0H, Bank 0 = 0001H, Other banks = 0166H

               Number of directory buffers for drive D: (#0) ?
               Share buffer(s) with which drive (C:) ?

     Available space in 256 byte pages:
     TPA = 00F0H, Bank 0 = 0001H, Other banks = 0166H


Accept new buffer definitions (Y) ?

 BNKBIOS3 SPR  F600H  0600H
 BNKBIOS3 SPR  B100H  0F00H
 RESBDOS3 SPR  F000H  0600H
 BNKBDOS3 SPR  8700H  2A00H

*** CP/M 3.0 SYSTEM GENERATION DONE ***
```

In the preceding example GENCPM displays the resident portion of BNKBIOS3.SPR first, followed by the banked portion.

```
EXAMPLE OF SYSTEM GENERATION WITH NONBANKED MEMORY

A>GENCPM

CP/M 3.0 System Generation
Copyright (C) 1982, Digital Research

Default entries are shown in (parens).
Default base is Hex, precede entry with # for decimal

Use GENCPM.DAT for defaults (Y) ?

Create a new GENCPM.DAT file (N) ?

Display Load Map at Cold Boot (Y) ?

Number of console columns (#80) ?
Number of lines in console page (#24) ?
Backspace echoes erased character (N) ?
Rubout echoes erased character (N) ?

Initial default drive (A:) ?

Top page of memory (FF) ?
Bank switched memory (Y) ? N

Double allocation vectors (Y) ?

Accept new system definition (Y) ?

Setting up Blocking/Deblocking buffers:

The physical record size is 0200H:

     Available space in 256 byte pages:
     TPA = 00D8H

     *** Directory buffer required  ***
     *** and allocated for drive A: ***

     Available space in 256 byte pages:
     TPA = 00D5H

               Overlay Data buffer for drive A: (Y) ?

     Available space in 256 byte pages:
     TPA = 00D5H

               Overlay Directory buffer for drive B: (Y) ?
               Share buffer(s) with which drive (A:) ?

     Available space in 256 byte pages:
     TPA = 00D5H
```

```
                Overlay Data buffer for drive B: (Y) ?
                Share buffer(s) with which drive (A:) ?

The physical record size is 0080H:

     Available space in 256 byte pages:
     TPA = 00D5H

                Overlay Directory buffer for drive C: (Y) ?
                Share buffer(s) with which drive (A:) ?

     Available space in 256 byte pages:
     TPA = 00D5H

                Overlay Directory buffer for drive D: (Y) ?
                Share buffer(s) with which drive (C:) ?

     Available space in 256 byte pages:
     TPA = 00D5H


Accept new buffer definitions (Y) ?

 BIOS3    SPR  F300H  0B00H
 BDOS3    SPR  D600H  1D00H

*** CP/M 3.0 SYSTEM GENERATION DONE ***

A>
```

5.2 Customizing the CPMLDR

The CPMLDR resides on the system tracks of a CP/M 3 system disk, and loads the CPM3.SYS file into memory to cold start the system. CPMLDR contains the LDRBDOS supplied by Digital Research, and must contain your customized LDRBIOS.

The system tracks for CP/M 3 contain the customized Cold Start Loader, CPMLDR with the customized LDRBIOS, and possibly the CCP.

The COPYSYS utility places the Cold Start Loader, the CPMLDR, and optionally the CCP on the system tracks, as shown in Table 5-1.

Table 5-1. Sample CP/M 3 System Track Organization

Track	Sector	Page	Memory Address	CP/M 3 Module Name
00	01		Boot Address	Cold Start Loader
00	02	00	0100H	CPMLDR
.				
.				and
.				
00	21	09	0A80H	LDRBDOS
00	22	10	0B00H	LDRBIOS
.				
.				
00	26	12	0D00H	and
01	01	12	0D80H	
.				
.				
01	26	25	1A00H	CCP

Typically the Cold Start Loader is loaded into memory from Track 0, Sector 1 of the system tracks when the reset button is depressed. The Cold Start Loader then loads CPMLDR from the system tracks into memory.

Alternatively, if you are starting from an existing CP/M 2 system, you can run CPMLDR.COM as a transient program. CP/M 2 loads CPMLDR.COM into memory at location 100H. CPMLDR then reads the CPM3.SYS file from User 0 on drive A and loads it into memory.

Use the following procedure to create a customized CPMLDR.COM file, including your customized LDRBIOS:

1) Prepare a LDRBIOS.ASM file.

2) Assemble the LDRBIOS file with RMAC to produce a LDRBIOS.REL file.

3) Link the supplied CPMLDR.REL file with the LDRBIOS.REL file you created to produce a CPMLDR.COM file.

   A>**LINK CPMLDR[L100]=CPMLDR,LDRBIOS**

   Replace the address 100 with the load address to which your boot loader loads CPMLDR.COM. You must include a bias of 100H bytes for buffer space when you determine the load address.

The CPMLDR requires a customized LDRBIOS to perform disk input and console output. The LDRBIOS is essentially a nonbanked BIOS. The LDRBIOS has the same JMP vector as the regular CP/M 3 BIOS. The LDRBIOS is called only to perform disk reads (READ) from one drive, console output (CONOUT) for sign-on messages, and minimal system initialization.

The CPMLDR calls the BOOT entry point at the beginning of the LDRBIOS to allow it to perform any necessary hardware initialization. The BOOT entry point should return to CPMLDR instead of loading and branching to the CCP, as a BIOS normally does. Note that interrupts are not disabled when the LDRBIOS BOOT routine is called.

Test your LDRBIOS completely to ensure that it properly performs console character output and disk reads. Check that the proper tracks and sectors are addressed on all reads and that data is transferred to the proper memory locations.

You should assemble the LDRBIOS.ASM file with a relocatable origin of 0000H. Assemble the LDRBIOS with RMAC to produce a LDRBIOS.REL file. Link the LDRBIOS.REL file with the CPMLDR.REL file supplied by Digital Research to create a CPMLDR.COM file. Use the L option in LINK to specify the load origin (address) to which the boot loader on track 0 sector 1 loads the CPMLDR.COM file.

Unnecessary BIOS functions can be deleted from the LDRBIOS to conserve space. There is one absolute restriction on the length of the LDRBIOS: it cannot extend above the base of the banked portion of CP/M 3. (GENCPM lists the base address of CP/M 3 in its load map.) If you plan to boot CP/M 3 from standard, single-density, eight-inch floppy disks, your CPMLDR must not be longer than 1980H to place the CPMLDR.COM file on two system tracks with the boot sector. If the CCP resides on the system tracks with the Cold Start Loader and CPMLDR, the combined lengths must not exceed 1980H.

5.3 The CPMLDR Utility

Syntax:

CPMLDR

Purpose:

CPMLDR loads the CP/M 3 system file CPM3.SYS into Bank 0 and transfers control to the BOOT routine in the customized BIOS. You can specify in GENCPM for CPMLDR to display a load table containing the names and addresses of the system modules.

The CPM3.SYS file contains the CP/M 3 BDOS and customized BIOS. The file CPM3.SYS must be on drive A in USER 0. You can execute CPMLDR under SID™ or DDT™ to help debug the BIOS. A $B in the default File Control Block (FCB) causes CPMLDR to execute a RST 7

(SID breakpoint) just before jumping to the CP/M 3 Cold Boot BIOS entry point.

Input File:

```
CPM3.SYS
```

Examples:

```
A>CPMLDR
CP/M V3.0 Loader
Copyright (C) 1982, Digital Research

 BNKBIOS3 SPR  F600H  0A00H
 BNKBIOS3 SPR  BB00H  0500H
 RESBDOS3 SPR  F100H  0500H
 BNKBDOS3 SPR  9A00H  2100H

 60K TPA
A>
```

In the preceding example, CPMLDR displays its name and version number, the Digital Research copyright message, and a four-column load table containing the filename, filetype, hex starting address, and length of the system modules. CPMLDR completes its sign-on message by indicating the size of the Transient Program Area (TPA) in kilobytes. The CCP then displays the system prompt, A>.

5.4 Booting CP/M 3

The CP/M 3 cold start operation loads the CCP, BDOS, and BIOS modules into their proper locations in memory and passes control to the cold start entry point (BIOS Function 0: BOOT) in the BIOS. Typically, a PROM-based loader initiates a cold start by loading sector 0 on track 1 of the system tracks into memory and jumping to it. This first sector contains the Cold Start Loader. The Cold Start Loader loads the CPMLDR.COM program into memory and jumps to it. CPMLDR loads the CPM3.SYS file into memory and jumps to the BIOS cold start entry point.

To boot the CP/M 3 system, use the following procedure:

1) Create the CPM3.SYS file.

2) Copy the CPM3.SYS file to the boot drive.

3) Create a CPMLDR.COM for your machine.

4) Place the CPMLDR.COM file on your system tracks using SYSGEN with CP/M 2 or COPYSYS with CP/M 3. The boot loader must place the CPMLDR.COM file at the address at which it originated. If CPMLDR has been linked to load at 100H, you can run CPMLDR under CP/M 2.

The COPYSYS utility handles initialization of the system tracks. The source of COPYSYS is included with the standard CP/M 3 system because you need to customize COPYSYS to support nonstandard system disk formats. COPYSYS copies the Cold Start Loader, the CPMLDR.COM file, and optionally the CCP to the system tracks. Refer to the COPYSYS.ASM source file on the distribution disk.

End of Section 5

Section 6
Debugging the BIOS

This section describes a sample debugging session for a nonbanked CP/M 3 BIOS. You must create and debug your nonbanked system first, then bring up the banked system. Note that your system probably displays addresses that differ from the addresses in the following example.

You can use SID, Digital Research's Symbolic Debugger Program, running under CP/M 2.2, to help debug your customized BIOS. The following steps outline a sample debugging session.

1) Determine the amount of memory available to CP/M 3 when the debugger and CP/M 2.2 are in memory. To do this, load the debugger under CP/M 2.2 and list the jump instruction at location 0005H. In the following example of a 64K system, C500 is the base address of the debugger, and also the maximum top of memory that you can specify in GENCPM for your customized CP/M 3 system.

```
A>SID
CP/M 3 SID - Version 3.0
#L5
0005  JMP  C500
         .
         .
         .
```

2) Running under CP/M 2.2, use GENCPM to generate a CPM3.SYS file, which specifies a top of memory that is less than the base address of the debugger, as determined by the previous step. Allow at least 256K bytes for a patch area. In this example, you can specify C3 to GENCPM as the top of memory for your CP/M 3 system.

```
A>
GENCPM
.
.
.
Top page of memory (FF)?
C3
.
.
.
```

3) Now you have created a system small enough to debug under SID. Use SID to load the CPMLDR.COM file, as shown in the following example:

```
A>SID CPMLDR.COM
CP/M 3 SID - Version 3.0
NEXT MSZE  PC  END
0E80 0E80 0100 D4FF
   #
```

4) Use the I command in SID, as shown in the next example, to place the characters $B into locations 005DH and 005EH of the default FCB based at 005CH. The $B causes CPMLDR.COM to break after loading the CPM3.SYS file into memory.

```
#I$B
```

5) Transfer control to CPMLDR using the G command:

```
#G
```

At this point, the screen clears and the following information appears:

```
CP/M  V3.0 LOADER
Copyright (c) 1982, Digital Research

 BIOS3    SPR  AA00  0B00
 BDOS3    SPR  8B00  1F00

 34K  TPA

* 01A9
#
```

6) With the CP/M 3 system in the proper location, you can set passpoints in your BIOS. Use the L command with the address specified as the beginning of the BIOS by the CPMLDR load table as shown in step 5 above. This L command causes SID to display the BIOS jump vector which begins at that address. The jump vector indicates the beginning address of each subroutine in the table. For example, the first jump instruction in the example below is to the Cold Boot subroutine.

```
#LAA00
```

The output from your BIOS might look like this:

```
JMP AA68
JMP AA8E
JMP ABA4
JMP ABAF
JMP ABCA
     .
     .
     .
```

7) Now set a passpoint in the Cold BOOT routine. Use the P command with an address to set a passpoint at that address.

   #PAA68

8) Continue with the CPMLDR.COM program by entering the G command, followed by the address of Cold Boot, the first entry in the BIOS jump vector.

   #GAA00

9) In response to the G command, the CPMLDR transfers control to the CP/M 3 operating system. If you set a passpoint in the Cold BOOT routine, the program stops executing, control transfers to SID, and you can begin tracing the BOOT routine.

10) When you know the BOOT routine is functioning correctly, enter passpoints for the other routines you want to trace, and begin tracing step by step to determine the location of problems.

Refer to the Digital Research Symbolic Instruction Debugger User's Guide (SID) in the Programmer's Utilities Guide for the CP/M Family of Operating Systems for a discussion of all the SID commands.

End of Section 6

Appendix A
Removable Media Considerations

All disk drives under CP/M 3 are classified as either permanent or removable. In general, removable drives support media changes; permanent drives do not. Setting the high-order bit in the CKS field in a drive's Disk Parameter Block (DPB) marks the drive as a permanent drive.

The BDOS file system distinguishes between permanent and removable drives. If a drive is permanent, the BDOS always accepts the contents of physical record buffers as valid. In addition, it also accepts the results of hash table searches on the drive.

On removable drives, the status of physical record buffers is more complicated. Because of the potential for media change, the BDOS must discard directory buffers before performing most directory related BDOS function calls. This is required because the BDOS detects media changes by reading directory records. When it reads a directory record, the BDOS computes a checksum for the record, and compares the checksum to the currently stored value in the drive's checksum vector. If the checksum values do not match, the BDOS assumes the media has changed. Thus, the BDOS can only detect a media change by an actual directory READ operation.

A similar situation occurs with directory hashing on removable drives. Because the directory hash table is a memory-resident table, the BDOS must verify all unsuccessful hash table searches on removable drives by accessing the directory.

The net result of these actions is that there is a significant performance penalty associated with removable drives as compared to permanent drives. In addition, the protection provided by classifying a drive as removable is not total. Media changes are only detected during directory operations. If the media is changed on a drive during BDOS WRITE operations, the new disk can be damaged.

The BIOS media flag facility gives you another option for supporting drives with removable media. However, to use this option, the disk controller must be capable of generating an interrupt when the drive door is opened. If your hardware provides this support, you can improve the handling of removable media by implementing the following procedure:

1) Mark the drive as a permanent drive and set the DPB CKS parameter to the total number of directory entries, divided by four. For example, set the CKS field for a disk with 96 directory entries to 8018H.

2) Implement an interrupt service routine that sets the @MEDIA flag in the System Control Block and the DPH MEDIA byte for the drive that signaled the door open condition.

By using the media flag facility, you gain the performance advantage associated with permanent drives on drives that support removable media. The BDOS checks the System Control Block @MEDIA flag on entry for all disk-related function calls. If the flag has not been set, it implies that no disks on the system have been changed. If the flag is set, the BDOS checks the DPH MEDIA flag of each currently logged-in disk. If the DPH MEDIA flag of a drive is set, the BDOS reads the entire directory on the drive to determine whether the drive has had a media change before performing any other operations on the drive. In addition, it temporarily classifies any permanent disk with the DPH MEDIA flag set as a removable drive. Thus, the BDOS discards all directory physical record buffers when a drive door is opened to force all directory READ operations to access the disk.

To summarize, using the BIOS MEDIA flag with removable drives offers two important benefits. First, because a removable drive can be classified as permanent, performance is enhanced. Second, because the BDOS immediately checks the entire directory before performing any disk-related function on the drive if the drive's DPH MEDIA flag is set, disk integrity is enhanced.

End of Appendix A

Appendix B
Auto-Density Support

Auto-density support refers to the capability of CP/M 3 to support different types of media on a single drive. For example, some floppy-disk drives accept single-sided and double-sided disks in both single-density and double-density formats. Auto-density support requires that the BIOS be able to determine the current density when SELDSK is called and to subsequently be able to detect a change in disk format when the READ or WRITE routines are called.

To support multiple disk formats, the drive's BIOS driver must include a Disk Parameter Block (DPB) for each type of disk or include code to generate the proper DPB parameters dynamically. In addition, the BIOS driver must determine the proper format of the disk when the SELDSK entry point is called with register E bit 0 equal to 0 (initial SELDSK calls). If the BIOS driver cannot determine the format, it can return 0000H in register pair HL to indicate the select was not successful. Otherwise, it must update the Disk Parameter Header (DPH) to address a DPB that describes the current media, and return the address of the DPH to the BDOS.

Note: All subsequent SELDSK calls with register E bit 0 equal to 1, the BIOS driver must continue to return the address of the DPH returned in the initial SELDSK call. The value 0000H is only a legal return value for initial SELDSK calls.

After a driver's SELDSK routine has determined the format of a disk, the driver's READ and WRITE routines assume this is the correct format until an error is detected. If an error is detected and the driver determines that the media has been changed to another format, it must return the value 0FFH in register A. This signals the BDOS that the media has changed and the next BIOS call to the drive will be an initial SELDSK call. Do not modify the drive's DPH or DPB until the initial SELDSK call is made. Note that the BDOS can detect a change in media and will make an initial SELDSK call, even though the BIOS READ and WRITE routines have not detected a disk format change. However, the SELDSK routine must always determine the format on initial calls.

A drive's Disk Parameter Header (DPH) has associated with it several uninitialized data areas: the allocation vector, the checksum vector, the directory hash table, and physical record buffers. The size of these areas is determined by DPB parameters. If space for these areas is explicitly allocated in the BIOS, the DPB that requires the most space determines the amount of memory to allocate. If the BIOS defers the allocation of these areas to GENCPM, the DPH must be initialized to the DPB with the largest space requirements. If one DPB is not largest in all of the above categories, a false one must be constructed so that GENCPM allocates sufficient space for each data area.

End of Appendix B

Appendix C
Modifying a CP/M 2 BIOS

If you are modifying an existing CP/M 2.2 BIOS, you must note the following changes.

- The BIOS jump vector is expanded from 17 entry points in CP/M 2.2 to 33 entry points in CP/M 3. You must implement the necessary additional routines.
- The Disk Parameter Header and Disk Parameter Block data structures are expanded.

See Section 3 of this manual, "CP/M 3 BIOS Functional Specifications", for details of the BIOS data structures and subroutines. The following table shows all CP/M 3 BIOS functions with the changes necessary to support CP/M 3.

Table C-1. CP/M 3 BIOS Functions

Function	Meaning
BIOS Function 00: BOOT	The address for the JMP at location 5 must be obtained from @MXTPA in the System Control Block.
BIOS Function 01: WBOOT	The address for the JMP at location 5 must be obtained from @MXTPA in the System Control Block. The CCP can be reloaded from a file.
BIOS Function 02: CONST	Can be implemented unchanged.
BIOS Function 03: CONIN	Can be implemented unchanged. Do not mask the high-order bit.

Table C-1. (continued)

Function	Meaning
BIOS Function 04: CONOUT	Can be implemented unchanged.
BIOS Function 05: LIST	Can be implemented unchanged.
BIOS Function 06: AUXOUT	Called PUNCH in CP/M 2. Can be implemented unchanged.
BIOS Function 07: AUXIN	Called READER in CP/M 2. Can be implemented unchanged. Do not mask the high-order bit.
BIOS Function 08: HOME	No change.
BIOS Function 09: SELDSK	Can not return a select error when SELDSK is called with bit 0 in register E equal to 1.
BIOS Function 10: SETTRK	No change.
BIOS Function 11: SETSEC	Sectors are physical sectors, not logical 128-byte sectors.
BIOS Function 12: SETDMA	Now called for every READ or WRITE operation. The DMA buffer can now be greater than 128 bytes.

Table C-1. (continued)

Function	Meaning
BIOS Function 13: READ	READ operations are in terms of physical sectors. READ can return a 0FFH error code if it detects that the disk format has changed.
BIOS Function 14: WRITE	WRITE operations are in terms of physical sectors. If write detects that the disk is Read-Only, it can return error code 2. WRITE can return a 0FFH error code if it detects that the disk format has changed.
BIOS Function 15: LISTST	Can be implemented unchanged.
BIOS Function 16: SECTRN	Sectors are physical sectors, not logical 128-byte sectors.

The following is a list of new BIOS functions:

BIOS Function 17: CONOST

BIOS Function 18: AUXIST

BIOS Function 19: AUXOST

BIOS Function 20: DEVTBL

BIOS Function 21: DEVINI

BIOS Function 22: DRVTBL

BIOS Function 23: MULTIO

BIOS Function 24: FLUSH

BIOS Function 25: MOVE

BIOS Function 26: TIME

BIOS Function 27: SELMEM

BIOS Function 28: SETBNK

BIOS Function 29: XMOVE

BIOS Function 30: USERF

BIOS Function 31: RESERV1

BIOS Function 32: RESERV2

End of Appendix C

Appendix D
CPM3.SYS File Format

Table D-1. CPM3.SYS File Format

Record	Contents
0	Header Record (128 bytes)
1	Print Record (128 bytes)
2-n	CP/M 3 operating system in reverse order, top down.

Table D-2. Header Record Definition

Byte	Contents
0	Top page plus one, at which the resident portion of CP/M 3 is to be loaded top down.
1	Length in pages (256 bytes) of the resident portion of CP/M 3.
2	Top page plus one, at which the banked portion of CP/M 3 is to be loaded top down.
3	Length in pages (256 bytes) of the banked portion of CP/M 3.
4-5	Address of CP/M 3 Cold Boot entry point.
6-1	Reserved.
16-51	Copyright Message.
52	Reserved.
53-58	Serial Number.
59-127	Reserved.

The Print Record is the CP/M 3 Load Table in ASCII, terminated by a dollar sign ($).

End of Appendix D

Appendix E
Root Module of the Relocatable BIOS for CP/M 3

All the listings in Appendixes E through I are assembled with RMAC, the CP/M Relocating Macro Assembler, and cross-referenced with XREF, an assembly language cross-reference program used with RMAC. These listings are output from the XREF program. The assembly language sources are on your distribution disk as .ASM files.

```
                                title   'Root module of relocatable BIOS for CP/M 3.0'

                                ; version 1.0 15 Sept 82

FFFF =                  true    equ -1
0000 =                  false   equ not true

FFFF =                  banked  equ true


                        ;               Copyright (C), 1982
                        ;              Digital Research, Inc
                        ;                  P.O. Box 579
                        ;             Pacific Grove, CA  93950


                        ;   This is the invariant portion of the modular BIOS and is
                        ;       distributed as source for informational purposes only.
                        ;       All desired modifications should be performed by
                        ;       adding or changing externally defined modules.
                        ;       This allows producing "standard" I/O modules that
                        ;       can be combined to support a particular system
                        ;       configuration.

000D =                  cr      equ 13
000A =                  lf      equ 10
0007 =                  bell    equ 7
0011 =                  ctlQ    equ 'Q'-'@'
0013 =                  ctlS    equ 'S'-'@'

0100 =                  ccp     equ 0100h       ; Console Command Processor gets loaded into the TPA

                                cseg            ; GENCPM puts CSEG stuff in common memory


                            ; variables in system data page

                                extrn @covec,@civec,@aovec,@aivec,@lovec ; I/O redirection vectors
                                extrn @mxtpa                             ; addr of system entry point
                                extrn @bnkbf                             ; 128 byte scratch buffer

                            ; initialization

                                extrn ?init                     ; general initialization and signon
                                extrn ?ldccp,?rlccp             ; load & reload CCP for BOOT & WBOOT

                            ; user defined character I/O routines

                                extrn ?ci,?co,?cist,?cost       ; each take device in <B>
                                extrn ?cinit                    ; (re)initialize device in <C>
                                extrn @ctbl                     ; physical character device table

                            ; disk communication data items

                                extrn @dtbl                     ; table of pointers to XDPHs
                                public @adrv,@rdrv,@trk,@sect   ; parameters for disk I/O
                                public @dma,@dbnk,@cnt          ;    ''       ''   ''  ''

                            ; memory control
```

Listing E-1. Root Module of Relocatable BIOS for CP/M 3

```
                        public @cbnk                    ; current bank
                        extrn ?xmove,?move              ; select move bank, and block move
                        extrn ?bank                     ; select CPU bank
                    ; clock support
                        extrn ?time                     ; signal time operation
                    ; general utility routines
                        public ?pmsg,?pdec      ; print message, print number from 0 to 65535
                        public ?pderr           ; print BIOS disk error message header
                        maclib modebaud         ; define mode bits
                    ; External names for BIOS entry points
                        public ?boot,?wboot,?const,?conin,?cono,?list,?auxo,?auxi
                        public ?home,?sldsk,?sttrk,?stsec,?stdma,?read,?write
                        public ?lists,?sctrn
                        public ?conos,?auxis,?auxos,?dvtbl,?devin,?drtbl
                        public ?mltio,?flush,?mov,?tim,?bnksl,?stbnk,?xmov
                    ; BIOS Jump vector.
                                ; All BIOS routines are invoked by calling these
                                ;       entry points.
0000 C30000     ?boot:  jmp boot        ; initial entry on cold start
0003 C36C00     ?wboot: jmp wboot       ; reentry on program exit, warm start
0006 C37701     ?const: jmp const       ; return console input status
0009 C39201     ?conin: jmp conin       ; return console input character
000C C3DA00     ?cono:  jmp conout      ; send console output character
000F C3E600     ?list:  jmp list        ; send list output character
0012 C3E000     ?auxo:  jmp auxout      ; send auxilliary output character
0015 C39801     ?auxi:  jmp auxin       ; return auxilliary input character
0018 C36E00     ?home:  jmp home        ; set disks to logical home
001B C33F00     ?sldsk: jmp seldsk      ; select disk drive, return disk parameter info
001E C37100     ?sttrk: jmp settrk      ; set disk track
0021 C37700     ?stsec: jmp setsec      ; set disk sector
0024 C37D00     ?stdma: jmp setdma      ; set disk I/O memory address
0027 C39400     ?read:  jmp read        ; read physical block(s)
002A C3AA00     ?write: jmp write       ; write physical block(s)
002D C31201     ?lists: jmp listst      ; return list device status
0030 C38900     ?sctrn: jmp sectrn      ; translate logical to physical sector
0033 C30601     ?conos: jmp conost      ; return console output status
0036 C37D01     ?auxis: jmp auxist      ; return aux input status
0039 C30C01     ?auxos: jmp auxost      ; return aux output status
003C C3D200     ?dvtbl: jmp devtbl      ; return address of device def table
003F C30000     ?devin: jmp ?cinit      ; change baud rate of device
0042 C3D600     ?drtbl: jmp getdrv      ; return address of disk drive table
0045 C3CB00     ?mltio: jmp multio      ; set multiple record count for disk I/O
0048 C3CF00     ?flush: jmp flush       ; flush BIOS maintained disk caching
004B C30000     ?mov:   jmp ?move       ; block move memory to memory
004E C30000     ?tim:   jmp ?time       ; Signal Time and Date operation
0051 C32502     ?bnksl: jmp bnksel      ; select bank for code execution and default DMA
0054 C38500     ?stbnk: jmp setbnk      ; select different bank for disk I/O DMA operations.
0057 C30000     ?xmov:  jmp ?xmove      ; set source and destination banks for one operation
005A C30000             jmp 0           ; reserved for future expansion
005D C30000             jmp 0           ; reserved for future expansion
0060 C30000             jmp 0           ; reserved for future expansion
                        ; BOOT
                        ;       Initial entry point for system startup.
                        dseg    ; this part can be banked
                boot:
0000 31D200             lxi sp,boot$stack
0003 0E0F               mvi c,15        ; initialize all 16 character devices
                c$init$loop:
0005 C5CD0000C1         push b ! call ?cinit ! pop b
000A 0DF20500           dcr c ! jp c$init$loop
```

Listing E-1. (continued)

```
000E CD0000             call ?init      ; perform any additional system initialization
                                        ; and print signon message

0011 0100102100         lxi b,16*256+0 ! lxi h,@dtbl    ; init all 16 logical disk drives
                d$init$loop:
0017 C5                 push b          ; save remaining count and abs drive
0018 5E235623           mov e,m ! inx h ! mov d,m ! inx h       ; grab @drv entry
001C 7BB2CA3600         mov a,e ! ora d ! jz d$init$next        ; if null, no drive
0021 E5                 push h                                  ; save @drv pointer
0022 EB                 xchg                                    ; XDPH address in <HL>
0023 2B2B7E32EE         dcx h ! dcx h ! mov a,m ! sta @RDRV     ; get relative drive code
0029 7932ED00           mov a,c ! sta @ADRV                     ; get absolute drive code
002D 2B                 dcx h                                   ; point to init pointer
002E 562B5E             mov d,m ! dcx h ! mov e,m               ; get init pointer
0031 EBCDB601           xchg ! call ipchl                       ; call init routine
0035 E1                 pop h                                   ; recover @drv pointer
                d$init$next:
0036 C1                 pop b                                   ; recover counter and drive #
0037 0C05C21700         inr c ! dcr b ! jnz d$init$loop         ; and loop for each drive
003C C36300             jmp boot$1

                        cseg    ; following in resident memory

                boot$1:
0063 CD7800             call set$jumps
0066 CD0000             call ?ldccp                             ; fetch CCP for first time
0069 C30001             jmp ccp


                        ; WBOOT
                        ;       Entry for system restarts.

                wboot:
006C 31D200             lxi sp,boot$stack
006F CD7800             call set$jumps          ; initialize page zero
0072 CD0000             call ?rlccp             ; reload CCP
0075 C30001             jmp ccp                 ; then reset jmp vectors and exit to ccp


                set$jumps:

                  if banked
0078 3E01CD5100         mvi a,1 ! call ?bnksl
                  endif

007D 3EC3               mvi a,JMP
007F 3200003205         sta 0 ! sta 5           ; set up jumps in page zero
0085 2103002201         lxi h,?wboot ! shld 1   ; BIOS warm start entry
008B 2A00002206         lhld @MXTPA ! shld 6    ; BDOS system call entry
0091 C9                 ret


0092                            ds 64
00D2 =          boot$stack      equ $


                        ; DEVTBL
                        ;       Return address of character device table

                devtbl:
00D2 210000C9           lxi h,@ctbl ! ret


                        ; GETDRV
                        ;       Return address of drive table

                getdrv:
00D6 210000C9           lxi h,@dtbl ! ret



                        ; CONOUT
                        ;       Console Output.  Send character in <C>
                        ;                        to all selected devices

                conout:

00DA 2A0000             lhld @covec     ; fetch console output bit vector
00DD C3E900             jmp out$scan
```

Listing E-1. (continued)

```

                            ; AUXOUT
                            ;       Auxiliary Output. Send character in <C>
                            ;                       to all selected devices

                    auxout:
00E0 2A0000                 lhld @aovec     ; fetch aux output bit vector
00E3 C3E900                 jmp out$scan


                            ; LIST
                            ;       List Output.  Send character in <C>
                            ;                       to all selected devices.

                    list:
00E6 2A0000                 lhld @lovec     ; fetch list output bit vector

                    out$scan:
00E9 060F                   mvi b,15        ; start with device 15
                    co$next:
00EB 29                     dad h           ; shift out next bit
00EC D2FF00                 jnc not$out$device
00EF E5                     push h          ; save the vector
00F0 C5                     push b          ; save the count and character
                    not$out$ready:
00F1 CD2C01B7CA             call coster ! ora a ! jz not$out$ready
00F8 C1C5                   pop b ! push b  ; restore and resave the character and device
00FA CD0000                 call ?co        ; if device selected, print it
00FD C1                     pop b           ; recover count and character
00FE E1                     pop h           ; recover the rest of the vector
                    not$out$device:
00FF 05                     dcr b           ; next device number
0100 7CB5                   mov a,h ! ora l ; see if any devices left
0102 C2EB00                 jnz co$next     ; and go find them...
0105 C9                     ret


                            ; CONOST
                            ;       Console Output Status.  Return true if
                            ;               all selected console output devices
                            ;               are ready.

                    conost:
0106 2A0000                 lhld @covec     ; get console output bit vector
0109 C31501                 jmp ost$scan


                            ; AUXOST
                            ;       Auxiliary Output Status.  Return true if
                            ;               all selected auxiliary output devices
                            ;               are ready.

                    auxost:
010C 2A0000                 lhld @aovec     ; get aux output bit vector
010F C31501                 jmp ost$scan


                            ; LISTST
                            ;       List Output Status.  Return true if
                            ;               all selected list output devices
                            ;               are ready.

                    listst:
0112 2A0000                 lhld @lovec     ; get list output bit vector

                    ost$scan:
0115 060F                   mvi b,15        ; start with device 15
                    cos$next:
0117 29                     dad h           ; check next bit
0118 E5                     push h          ; save the vector
0119 C5                     push b          ; save the count
011A 3EFF                   mvi a,0FFh      ; assume device ready
011C DC2C01                 cc coster       ; check status for this device
011F C1                     pop b           ; recover count
0120 E1                     pop h           ; recover bit vector
0121 B7                     ora a           ; see if device ready
0122 C8                     rz              ; if any not ready, return false
0123 05                     dcr b           ; drop device number
0124 7CB5                   mov a,h ! ora l ; see if any more selected devices
0126 C21701                 jnz cos$next
0129 F6FF                   ori 0FFh        ; all selected were ready, return true
012B C9                     ret

```

Listing E-1. (continued)

```
                          coster:         ; check for output device ready, including optional
                                          ;        xon/xoff support
012C 682600                     mov l,b ! mvi h,0       ; make device code 16 bits
012F E5                         push h                  ; save it in stack
0130 292929                     dad h ! dad h ! dad h   ; create offset into device characteristics tbl
0133 11060019                   lxi d,@ctbl+6 ! dad d   ; make address of mode byte
0137 7EE610                     mov a,m ! ani mb$xonxoff
013A E1                         pop h                   ; recover console number in <HL>
013B CA0000                     jz ?cost                ; not a xon device, go get output status direct
013E 112B0219                   lxi d,xofflist ! dad d  ; make pointer to proper xon/xoff flag
0142 CD5D01                     call cistl              ; see if this keyboard has character
0145 7EC46F01                   mov a,m ! cnz cil       ; get flag or read key if any
0149 FE11C25001                 cpi ctlq ! jnz not$q    ; if its a ctl-Q,
014E 3EFF                       mvi a,0FFh              ;       set the flag ready
                          not$q:
0150 FE13C25701                 cpi ctls ! jnz not$s    ; if its a ctl-S,
0155 3E00                       mvi a,00h               ;       clear the flag
                          not$s:
0157 77                         mov m,a                 ; save the flag
0158 CD6601                     call costl              ; get the actual output status,
015B A6                         ana m                   ; and mask with ctl-Q/ctl-S flag
015C C9                         ret                     ; return this as the status

                          cistl:                ; get input status with <BC> and <HL> saved
015D C5E5                       push b ! push h
015F CD0000                     call ?cist
0162 E1C1                       pop h ! pop b
0164 B7                         ora a
0165 C9                         ret

                          costl:                ; get output status, saving <BC> & <HL>
0166 C5E5                       push b ! push h
0168 CD0000                     call ?cost
016B E1C1                       pop h ! pop b
016D B7                         ora a
016E C9                         ret

                          cil:                  ; get input, saving <BC> & <HL>
016F C5E5                       push b ! push h
0171 CD0000                     call ?ci
0174 E1C1                       pop h ! pop b
0176 C9                         ret


                                ; CONST
                                ;       Console Input Status.  Return true if
                                ;               any selected console input device
                                ;               has an available character.

                          const:
0177 2A0000                     lhld @civec     ; get console input bit vector
017A C38001                     jmp ist$scan


                                ; AUXIST
                                ;       Auxiliary Input Status.  Return true if
                                ;               any selected auxiliary input device
                                ;               has an available character.

                          auxist:
017D 2A0000                     lhld @aivec     ; get aux input bit vector

                          ist$scan:
0180 060F                       mvi b,15        ; start with device 15
                          cis$next:
0182 29                         dad h           ; check next bit
0183 3E00                       mvi a,0         ; assume device not ready
0185 DC5D01                     cc cistl        ; check status for this device
0188 B7C0                       ora a ! rnz     ; if any ready, return true
018A 05                         dcr b           ; drop device number
018B 7CB5                       mov a,h ! ora l ; see if any more selected devices
018D C28201                     jnz cis$next
0190 AF                         xra a           ; all selected were not ready, return false
0191 C9                         ret


                                ; CONIN
                                ;       Console Input.  Return character from first
                                ;               ready console input device.

                          conin:
0192 2A0000                     lhld @civec
0195 C39B01                     jmp in$scan
```

Listing E-1. (continued)

```
                          ; AUXIN
                          ;       Auxiliary Input.  Return character from first
                          ;               ready auxiliary input device.

                  auxin:
0198 2A0000               lhld @aivec

                  in$scan:
019B E5                   push h          ; save bit vector
019C 060F                 mvi b,15
                  ci$next:
019E 29                   dad h           ; shift out next bit
019F 3E00                 mvi a,0         ; insure zero a  (nonexistant device not ready).
01A1 DC5D01               cc cistl        ; see if the device has a character
01A4 B7                   ora a
01A5 C2B201               jnz ci$rdy      ; this device has a character
01A8 05                   dcr b           ; else, next device
01A9 7CB5                 mov a,h ! ora l ; see if any more devices
01AB C29E01               jnz ci$next     ; go look at them
01AE E1                   pop h           ; recover bit vector
01AF C39B01               jmp in$scan     ; loop til we find a character

                  ci$rdy:
01B2 E1                   pop h           ; discard extra stack
01B3 C30000               jmp ?ci


                  ;       Utility Subroutines


                  ipchl:          ; vectored CALL point
01B6 E9                   pchl


                  ?pmsg:          ; print message @<HL> up to a null
                                  ; saves <BC> & <DE>
01B7 C5                   push b
01B8 D5                   push d
                  pmsg$loop:
01B9 7EB7CAC801           mov a,m ! ora a ! jz pmsg$exit
01BE 4FE5                 mov c,a ! push h
01C0 CD0C00E1             call ?cono ! pop h
01C4 23C3B901             inx h ! jmp pmsg$loop
                  pmsg$exit:
01C8 D1                   pop d
01C9 C1                   pop b
01CA C9                   ret

                  ?pdec:          ; print binary number 0-65535 from <HL>
01CB 01F30111F0           lxi b,table10! lxi d,-10000
                  next:
01D1 3E2F                 mvi a,'0'-1
                  pdecl:
01D3 E53C19D2DE           push h! inr a! dad d! jnc stoploop
01D9 3333C3D301           inx sp! inx sp! jmp pdecl
                  stoploop:
01DE D5C5                 push d! push b
01E0 4FCD0C00             mov c,a! call ?cono
01E4 C1D1                 pop b! pop d
                  nextdigit:
01E6 E1                   pop h
01E7 0A5F03               ldax b! mov e,a! inx b
01EA 0A5703               ldax b! mov d,a! inx b
01ED 7BB2C2D101           mov a,e! ora d! jnz next
01F2 C9                   ret

                  table10:
01F3 18FC9CFFF6           dw      -1000,-100,-10,-1,0

                  ?pderr:
01FD 21D100CDB7           lxi h,drive$msg ! call ?pmsg                    ; error header
0203 3AED00C641           lda @adrv ! adi 'A' ! mov c,a ! call ?cono      ; drive code
020C 21E300CDB7           lxi h,track$msg ! call ?pmsg                    ; track header
0212 2AEF00CDCB           lhld @trk ! call ?pdec                          ; track number
0218 21E800CDB7           lxi h,sector$msg ! call ?pmsg                   ; sector header
021E 2AF100CDCB           lhld @sect ! call ?pdec                         ; sector number
0224 C9                   ret


                          ; BNKSEL
                          ;       Bank Select.  Select CPU bank for further execution.

```

Listing E-1. (continued)

```
                    bnksel:
0225 323B02                 sta @cbnk                       ; remember current bank
0228 C30000                 jmp ?bank                       ; and go exit through users
                                                            ; physical bank select routine

022B FFFFFFFFFFxofflist         db      -1,-1,-1,-1,-1,-1,-1,-1         ; ctl-s clears to zero
0233 FFFFFFFFFF                 db      -1,-1,-1,-1,-1,-1,-1,-1

                            dseg    ; following resides in banked memory

                            Disk I/O interface routines

                            ; SELDSK
                            ;       Select Disk Drive.  Drive code in <C>.
                            ;               Invoke login procedure for drive
                            ;               if this is first select.  Return
                            ;               address of disk parameter header
                            ;               in <HL>

                    seldsk:
003F 7932ED00               mov a,c ! sta @adrv                     ; save drive select code
0043 69260029               mov l,c ! mvi h,0 ! dad h               ; create index from drive code
0047 01000009               lxi b,@dtbl ! dad b                     ; get pointer to dispatch table
004B 7E23666F               mov a,m ! inx h ! mov h,m ! mov l,a     ; point at disk descriptor
004F B4C8                   ora h ! rz                              ; if no entry in table, no disk
0051 7BE601C26D             mov a,e ! ani 1 ! jnz not$first$select  ; examine login bit
0057 E5EB                   push h ! xchg                           ; put pointer in stack & <DE>
0059 21FEFF197E             lxi h,-2 ! dad d ! mov a,m ! sta @RDRV  ; get relative drive
0061 21FAFF19               lxi h,-6 ! dad d                        ; find LOGIN addr
0065 7E23666F               mov a,m ! inx h ! mov h,m ! mov l,a     ; get address of LOGIN routine
0069 CDB601                 call ipchl                              ; call LOGIN
006C E1                     pop h                                   ; recover DPH pointer
                    not$first$select:
006D C9                     ret

                            ; HOME
                            ;       Home selected drive.  Treated as SETTRK(0).

                    home:
006E 010000                 lxi b,0         ; same as set track zero

                            ; SETTRK
                            ;       Set Track. Saves track address from <BC>
                            ;               in @TRK for further operations.

                    settrk:
0071 6960                   mov l,c ! mov h,b
0073 22EF00                 shld @trk
0076 C9                     ret

                            ; SETSEC
                            ;       Set Sector.  Saves sector number from <BC>
                            ;               in @sect for further operations.

                    setsec:
0077 6960                   mov l,c ! mov h,b
0079 22F100                 shld @sect
007C C9                     ret

                            ; SETDMA
                            ;       Set Disk Memory Address.  Saves DMA address
                            ;               from <BC> in @DMA and sets @DBNK to @CBNK
                            ;               so that further disk operations take place
                            ;               in current bank.

                    setdma:
007D 6960                   mov l,c ! mov h,b
007F 22F300                 shld @dma

0082 3A3B02                 lda @cbnk       ; default DMA bank is current bank
                                            ; fall through to set DMA bank
```

Listing E-1. (continued)

```

                                ; SETBNK
                                ;       Set Disk Memory Bank.  Saves bank number
                                ;               in @DBNK for future disk data
                                ;               transfers.

                        setbnk:
 0085 32F600                    sta @dbnk
 0088 C9                        ret


                                ; SECTRN
                                ;       Sector Translate.  Indexes skew table in <DE>
                                ;               with sector in <BC>.  Returns physical sector
                                ;               in <HL>.  If no skew table (<DE>=0) then
                                ;               returns physical=logical.

                        sectrn:
 0089 6960                      mov l,c ! mov h,b
 008B 7AB3C8                    mov a,d ! ora e ! rz
 008E EB096E2600                xchg ! dad b ! mov l,m ! mvi h,0
 0093 C9                        ret


                                ; READ
                                ;       Read physical record from currently selected drive.
                                ;               Finds address of proper read routine from
                                ;               extended disk parameter header (XDPH).

                        read:
 0094 2AED002600                lhld @adrv ! mvi h,0 ! dad h    ; get drive code and double it
 009A 11000019                  lxi d,@dtbl ! dad d             ; make address of table entry
 009E 7E23666F                  mov a,m ! inx h ! mov h,m ! mov l,a     ; fetch table entry
 00A2 E5                        push h                          ; save address of table
 00A3 11F8FF19                  lxi d,-8 ! dad d                ; point to read routine address
 00A7 C3BD00                    jmp rw$common                   ; use common code


                                ; WRITE
                                ;       Write physical sector from currently selected drive.
                                ;               Finds address of proper write routine from
                                ;               extended disk parameter header (XDPH).

                        write:
 00AA 2AED002600                lhld @adrv ! mvi h,0 ! dad h    ; get drive code and double it
 00B0 11000019                  lxi d,@dtbl ! dad d             ; make address of table entry
 00B4 7E23666F                  mov a,m ! inx h ! mov h,m ! mov l,a     ; fetch table entry
 00B8 E5                        push h                          ; save address of table
 00B9 11F6FF19                  lxi d,-10 ! dad d               ; point to write routine address

                        rw$common:
 00BD 7E23666F                  mov a,m ! inx h ! mov h,m ! mov l,a     ; get address of routine
 00C1 D1                        pop d                           ; recover address of table
 00C2 1B1B                      dcx d ! dcx d                   ; point to relative drive
 00C4 1A32EE00                  ldax d ! sta @rdrv              ; get relative drive code and post it
 00C8 1313                      inx d ! inx d                   ; point to DPH again
 00CA E9                        pchl                            ; leap to driver


                                ; MULTIO
                                ;       Set multiple sector count. Saves passed count in
                                ;               @CNT

                        multio:
 00CB 32F500C9                  sta @cnt ! ret


                                ; FLUSH
                                ;       BIOS deblocking buffer flush.  Not implemented.

                        flush:
 00CF AFC9                      xra a ! ret             ; return with no error



                                ; error message components
 00D1 0D0A074249drive$msg       db      cr,lf,bell,'BIOS Error on ',0
 00E3 3A20542D00track$msg       db      ': T-',0
 00E8 2C20532D00sector$msg      db      ', S-',0


                          ; disk communication data items
```

Listing E-1. (continued)

```
00ED            @adrv   ds      1               ; currently selected disk drive
00EE            @rdrv   ds      1               ; controller relative disk drive
00EF            @trk    ds      2               ; current track number
00F1            @sect   ds      2               ; current sector number
00F3            @dma    ds      2               ; current DMA address
00F5 00         @cnt    db      0               ; record count for multisector transfer
00F6 00         @dbnk   db      0               ; bank for DMA operations


                        cseg    ; common memory

023B 00         @cbnk   db      0               ; bank for processor operations


023C                    end
AUXIN           0198    99   397#
AUXIST          017D   113   367#
AUXOST          010C   114   277#
AUXOUT          00E0    98   230#
BANKED          FFFF     8#  186
BAUD110         0003
BAUD1200        0008
BAUD134         0004
BAUD150         0005
BAUD1800        0009
BAUD19200       000F
BAUD2400        000A
BAUD300         0006
BAUD3600        000B
BAUD4800        000C
BAUD50          0001
BAUD600         0007
BAUD7200        000D
BAUD75          0002
BAUD9600        000E
BAUDNONE        0000
BELL            0007    27#  632
BNKSEL          0225   124   475#
BOOT            0000    91   138#
BOOT1           0063   164   168#
BOOTSTACK       00D2   139   178   198#
CCP             0100    31#  171   181
CI1             016F   319   345#
CINEXT          019E   403#  411
CINITLOOP       0005   141#  143
CIRDY           01B2   408   415#
CISNEXT         0182   372#  379
CIST1           015D   318   331#  375   406
CONEXT          00EB   244#  258
CONIN           0192    95   388#
CONOST          0106   112   267#
CONOUT          00DA    96   220#
CONST           0177    94   357#
COSNEXT         0117   292#  304
COST1           0166   327   338#
COSTER          012C   250   297   308#
CR              000D    25#  632
CTLQ            0011    28#  320
CTLS            0013    29#  323
DEVTBL          00D2   115   204#
DINITLOOP       0017   149#  163
DINITNEXT       0036   152   161#
DRIVEMSG        00D1   463   632#
FALSE           0000     6#
FLUSH           00CF   120   626#
GETDRV          00D6   118   211#
HOME            006E   101   520#
INSCAN          019B   390   400#  413
IPCHL           01B6   159   423#  511
ISTSCAN         0180   359   370#
LF              000A    26#  632
LIST            00E6    97   239#
LISTST          0112   109   287#
MBINOUT         0003
MBINPUT         0001
MBOUTPUT        0002
MBSERIAL        0008
MBSOFTBAUD      0004
MBXONXOFF       0010   314
MULTIO          00CB   119   619#
```

Listing E-1. (continued)

NEXT	01D1	443#	456					
NEXTDIGIT	01E6	452#						
NOTFIRSTSELECT	006D	506	513#					
NOTOUTDEVICE	00FF	246	255#					
NOTOUTREADY	00F1	249#	250					
NOTQ	0150	320	322#					
NOTS	0157	323	325#					
OSTSCAN	0115	269	279	290#				
OUTSCAN	00E9	223	232	242#				
PDECL	01D3	445#	447					
PMSGEXIT	01C8	432	436#					
PMSGLOOP	01B9	431#	435					
READ	0094	106	585#					
RWCOMMON	00BD	591	606#					
SECTORMSG	00E8	467	634#					
SECTRN	0089	110	573#					
SELDSK	003F	102	500#					
SETBNK	0085	125	562#					
SETDMA	007D	105	550#					
SETJUMPS	0078	169	179	184#				
SETSEC	0077	104	538#					
SETTRK	0071	103	528#					
STOPLOOP	01DE	446	448#					
TABLE10	01F3	442	459#					
TRACKMSG	00E3	465	633#					
TRUE	FFFF	5#	6	8				
WBOOT	006C	92	177#					
WRITE	00AA	107	599#					
XOFFLIST	022B	317	481#					
?AUXI	0015	79	99#					
?AUXIS	0036	82	113#					
?AUXO	0012	79	98#					
?AUXOS	0039	82	114#					
?BANK	0000	63	477					
?BNKSL	0051	83	124#	187				
?BOOT	0000	79	91#					
?CI	0000	49	347	417				
?CINIT	0000	50	116	142				
?CIST	0000	49	333					
?CO	0000	49	252					
?CONIN	0009	79	95#					
?CONO	000C	79	96#	434	450	464		
?CONOS	0033	82	112#					
?CONST	0006	79	94#					
?COST	0000	49	316	340				
?DEVIN	003F	82	116#					
?DRTBL	0042	82	118#					
?DVTBL	003C	82	115#					
?FLUSH	0048	83	120#					
?HOME	0018	80	101#					
?INIT	0000	44	145					
?LDCCP	0000	45	170					
?LIST	000F	79	97#					
?LISTS	002D	81	109#					
?MLTIO	0045	83	119#					
?MOV	004B	83	122#					
?MOVE	0000	62	122					
?PDEC	01CB	71	441#	466	468			
?PDERR	01FD	72	462#					
?PMSG	01B7	71	427#	463	465	467		
?READ	0027	80	106#					
?RLCCP	0000	45	180					
?SCTRN	0030	81	110#					
?SLDSK	001B	80	102#					
?STBNK	0054	83	125#					
?STDMA	0024	80	105#					
?STSEC	0021	80	104#					
?STTRK	001E	80	103#					
?TIM	004E	83	123#					
?TIME	0000	67	123					
?WBOOT	0003	79	92#	192				
?WRITE	002A	80	107#					
?XMOV	0057	83	126#					
?XMOVE	0000	62	126					
@ADRV	00ED	56	156	464	501	586	600	639#
@AIVEC	0000	38	368	398				
@AOVEC	0000	38	231	278				
@BNKBF	0000	40						
@CBNK	023B	61	476	554	650#			
@CIVEC	0000	38	358	389				
@CNT	00F5	57	620	644#				
@COVEC	0000	38	222	268				

Listing E-1. (continued)

```
@CTBL           0000    51    205    313
@DBNK           00F6    57    563    645#
@DMA            00F3    57    552    643#
@DTBL           0000    55    148    212    503    587    601
@LOVEC          0000    38    240    288
@MXTPA          0000    39    193
@RDRV           00EE    56    155    508    610    640#
@SECT           00F1    56    468    540    642#
@TRK            00EF    56    466    530    641#
```

Listing E-1. (continued)

End of Appendix E

Appendix F
System Control Block Definition for CP/M 3 BIOS

The SCB.ASM module contains the public definitions of the various fields in the System Control Block. The BIOS can reference the public variables.

```
                        title 'System Control Block Definition for CP/M3 BIOS'

                        public @civec, @covec, @aivec, @aovec, @lovec, @bnkbf
                        public @crdma, @crdsk, @vinfo, @resel, @fx, @usrcd
                        public @mltio, @ermde, @erdsk, @media, @bflgs
                        public @date, @hour, @min, @sec, ?erjmp, @mxtpa


FE00 =          scb$base equu   OFEOOH          ; Base of the SCB

FE22 =          @CIVEC  equ     scb$base+22h    ; Console Input Redirection
                                                ; Vector (word, r/w)
FE24 =          @COVEC  equ     scb$base+24h    ; Console Output Redirection
                                                ; Vector (word, r/w)
FE26 =          @AIVEC  equ     scb$base+26h    ; Auxiliary Input Redirection
                                                ; Vector (word, r/w)
FE28 =          @AOVEC  equ     scb$base+28h    ; Auxiliary Output Redirection
                                                ; Vector (word, r/w)
FE2A =          @LOVEC  equ     scb$base+2Ah    ; List Output Redirection
                                                ; Vector (word, r/w)
FE35 =          @BNKBF  equ     scb$base+35h    ; Address of 128 Byte Buffer
                                                ; for Banked BIOS (word, r/o)
FE3C =          @CRDMA  equ     scb$base+3Ch    ; Current DMA Address
                                                ; (word, r/o)
FE3E =          @CRDSK  equ     scb$base+3Eh    ; Current Disk (byte, r/o)
FE3F =          @VINFO  equ     scb$base+3Fh    ; BDOS Variable "INFO"
                                                ; (word, r/o)
FE41 =          @RESEL  equ     scb$base+41h    ; FCB Flag (byte, r/o)
FE43 =          @FX     equ     scb$base+43h    ; BDOS Function for Error
                                                ; Messages (byte, r/o)
FE44 =          @USRCD  equ     scb$base+44h    ; Current User Code (byte, r/o)
FE4A =          @MLTIO  equ     scb$base+4Ah    ; Current Multi-Sector Count
                                                ; (byte,r/w)
FE4B =          @ERMDE  equ     scb$base+4Bh    ; BDOS Error Mode (byte, r/o)
FE51 =          @ERDSK  equ     scb$base+51h    ; BDOS Error Disk (byte,r/o)
FE54 =          @MEDIA  equ     scb$base+54h    ; Set by BIOS to indicate
                                                ; open door (byte,r/w)
FE57 =          @BFLGS  equ     scb$base+57h    ; BDOS Message Size Flag (byte,r/o)
FE58 =          @DATE   equ     scb$base+58h    ; Date in Days Since 1 Jan 78
                                                ; (word, r/w)
FE5A =          @HOUR   equ     scb$base+5Ah    ; Hour in BCD (byte, r/w)
FE5B =          @MIN    equ     scb$base+5Bh    ; Minute in BCD (byte, r/w)
FE5C =          @SEC    equ     scb$base+5Ch    ; Second in BCD (byte, r/w)
FE5F =          ?ERJMP  equ     scb$base+5Fh    ; BDOS Error Message Jump
                                                ; (word, r/w)
FE62 =          @MXTPA  equ     scb$base+62h    ; Top of User TPA
                                                ; (address at 6,7)(word, r/o)
0000                    end
```

Listing F-1. System Control Block Definition for CP/M 3 BIOS

```
SCBBASE          FE00     9#   11   13   15   17   19   21   23   25   26
                         28   29   31   32   34   35   36   38   39   41
                         42   43   44   46
?ERJMP           FE5F     6   44#
@AIVEC           FE26     3   15#
@AOVEC           FE28     3   17#
@BFLGS           FE57     5   38#
@BNKBF           FE35     3   21#
@CIVEC           FE22     3   11#
@COVEC           FE24     3   13#
@CRDMA           FE3C     4   23#
@CRDSK           FE3E     4   25#
@DATE            FE58     6   39#
@ERDSK           FE51     5   35#
@ERMDE           FE4B     5   34#
@FX              FE43     4   29#
@HOUR            FE5A     6   41#
@LOVEC           FE2A     3   19#
@MEDIA           FE54     5   36#
@MIN             FE5B     6   42#
@MLTIO           FE4A     5   32#
@MXTPA           FE62     6   46#
@RESEL           FE41     4   28#
@SEC             FE5C     6   43#
@USRCD           FE44     4   31#
@VINFO           FE3F     4   26#
```

Listing F-1. (continued)

End of Appendix F

Appendix G
Equates for Mode Byte Bit Fields

```
        ; equates for mode byte bit fields

mb$input                equ 0000$0001b  ; device may do input
mb$output               equ 0000$0010b  ; device may do output
mb$in$out               equ mb$input+mb$output
mb$soft$baud            equ 0000$0100b  ; software selectable baud rates
mb$serial               equ 0000$1000b  ; device may use protocol
mb$xon$xoff             equ 0001$0000b  ; XON/XOFF protocol enabled

baud$none               equ 0           ; no baud rate associated with device
baud$50                 equ 1           ; 50 baud
baud$75                 equ 2           ; 75 baud
baud$110                equ 3           ; 110 baud
baud$134                equ 4           ; 134.5 baud
baud$150                equ 5           ; 150 baud
baud$300                equ 6           ; 300 baud
baud$600                equ 7           ; 600 baud
baud$1200               equ 8           ; 1200 baud
baud$1800               equ 9           ; 1800 baud
baud$2400               equ 10          ; 2400 baud
baud$3600               equ 11          ; 3600 baud
baud$4800               equ 12          ; 4800 baud
baud$7200               equ 13          ; 7200 baud
baud$9600               equ 14          ; 9600 baud
baud$19200              equ 15          ; 19.2k baud
```

Listing G-1. Equates for Mode Byte Fields: MODEBAUD.LIB

End of Appendix G

Appendix H
Macro Definitions for CP/M 3 BIOS Data Structures

```
;       Macro Definitions for CP/M3 BIOS Data Structures.

        ; dtbl  <dph0,dph1,...>         - drive table

        ; dph   translate$table,        - disk parameter header
        ;       disk$parameter$block,
        ;       checksum$size,                  (optional)
        ;       alloc$size                      (optional)

        ; skew  sectors,                - skew table
        ;       skew$factor,
        ;       first$sector$number

        ; dpb   physical$sector$size,   - disk parameter block
        ;       physical$sectors$per$track,
        ;       number$tracks,
        ;       block$size,
        ;       number$dir$entries,
        ;       track$offset,
        ;       checksum$vec$size               (optional)


;       Drive Table.  Contains 16 one word entries.

dtbl macro ?list
    local ?n
?n  set 0
    irp ?drv,<?list>
?n  set ?n+1
        dw      ?drv
    endm

    if ?n > 16
.' Too many drives.  Max 16 allowed'
        exitm
    endif

    if ?n < 16
        rept (16-?n)
        dw      0
        endm
    endif
 endm

dph macro ?trans,?dpb,?csize,?asize
    local ?csv,?alv
        dw ?trans               ; translate table address
        db 0,0,0,0,0,0,0,0,0    ; BDOS Scratch area
        db 0                    ; media flag


        dw ?dpb                 ; disk parameter block
    if not nul ?csize
        dw ?csv                 ; checksum vector
    else
        dw 0FFFEh               ; checksum vector allocated by GENCPM
    endif
    if not nul ?asize
        dw ?alv                 ; allocation vector
    else
        dw 0FFFEh               ; alloc vector allocated by GENCPM
    endif
        dw 0fffeh,0fffeh,0fffeh ; dirbcb, dtabcb, hash alloc'd by GENCPM
        db 0                    ; hash bank
```

Listing H-1. Macro Definitions for CP/M 3 BIOS Data Structures

```
    if not nul ?csize
?csv    ds      ?csize          ; checksum vector
    endif
    if not nul ?asize
?alv    ds      ?asize          ; allocation vector
    endif

    endm

dpb macro ?psize,?pspt,?trks,?bls,?ndirs,?off,?ncks
    local ?spt,?bsh,?blm,?exm,?dsm,?drm,?al0,?all,?cks,?psh,?psm
    local ?n
;; physical sector mask and physical sector shift
    ?psh        set 0
    ?n          set ?psize/128
    ?psm        set ?n-1
        rept 8
        ?n      set ?n/2
            if ?n = 0
            exitm
            endif
        ?psh    set ?psh + 1
        endm
    ?spt        set ?pspt*(?psize/128)

    ?bsh        set 3
    ?n          set ?bls/1024
        rept 8
        ?n      set ?n/2
            if ?n = 0
            exitm
            endif
        ?bsh    set ?bsh + 1
        endm
    ?blm        set ?bls/128-1
    ?size       set (?trks-?off)*?spt
    ?dsm        set ?size/(?bls/128)-1

    ?exm        set ?bls/1024
        if ?dsm > 255
            if ?bls = 1024

.'Error, can''t have this size disk with 1k block size'
            exitm
            endif
        ?exm    set ?exm/2
        endif
    ?exm        set ?exm-1
    ?all        set 0
    ?n          set (?ndirs*32+?bls-1)/?bls
        rept ?n
        ?all    set (?all shr 1) or 8000h
        endm
    ?al0        set high ?all
    ?all        set low ?all
    ?drm        set ?ndirs-1
    if not nul ?ncks
        ?cks    set ?ncks
    else
        ?cks    set ?ndirs/4
    endif
        dw      ?spt            ; 128 byte records per track
        db      ?bsh,?blm       ; block shift and mask
        db      ?exm            ; extent mask
        dw      ?dsm            ; maximum block number
        dw      ?drm            ; maximum directory entry number
        db      ?al0,?all       ; alloc vector for directory
        dw      ?cks            ; checksum size
        dw      ?off            ; offset for system tracks
        db      ?psh,?psm       ; physical sector size shift and mask
    endm
```

Listing H-1. (continued)

```
;
gcd macro ?m,?n
            ;;  greatest common divisor of m,n
                    ;;  produces value gcdn as result
                    ;;  (used in sector translate table generation)
    ?gcdm       set ?m  ;;variable for m
    ?gcdn       set ?n  ;;variable for n
    ?gcdr       set 0   ;;variable for r
        rept 65535
        ?gcdx   set ?gcdm/?gcdn
        ?gcdr   set ?gcdm - ?gcdx*?gcdn
            if ?gcdr = 0
            exitm
            endif
        ?gcdm   set ?gcdn
        ?gcdn   set ?gcdr
        endm
    endm

skew macro ?secs,?skf,?fsc
;;      generate the translate table
    ?nxtsec     set 0   ;;next sector to fill
    ?nxtbas     set 0   ;;moves by one on overflow
    gcd %?secs,?skf
    ;;  ?gcdn = gcd(?secs,skew)
    ?neltst     set ?secs/?gcdn
    ;;  neltst is number of elements to generate
    ;;  before we overlap previous elements
    ?nelts      set ?neltst     ;;counter
        rept ?secs      ;;once for each sector
        db      ?nxtsec+?fsc
        ?nxtsec set ?nxtsec+?skf
            if ?nxtsec >= ?secs
            ?nxtsec     set ?nxtsec-?secs
            endif
        ?nelts  set ?nelts-1
            if ?nelts = 0
            ?nxtbas     set ?nxtbas+1
            ?nxtsec     set ?nxtbas
            ?nelts      set ?neltst
            endif
        endm
    endm
```

Listing H-1. (continued)

End of Appendix H

Appendix I
ACS 8000-15 BIOS Modules

I.1 Boot Loader Module for CP/M 3

The BOOT.ASM module performs system initialization other than character and disk I/O. BOOT loads the CCP for cold starts and reloads it for warm starts. Note that the device drivers in the Digital Research sample BIOS initialize devices for a polled, and not an interrupt-driven, environment.

```
                                title   'Boot loader module for CP/M 3.0'

FFFF =          true equ -1
0000 =          false equ not true

FFFF =          banked  equ true

                        public  ?init,?ldccp,?rlccp,?time
                        extrn   ?pmsg,?conin
                        extrn   @civec,@covec,@aivec,@aovec,@lovec
                        extrn   @cbnk,?bnksl

                        maclib ports
                        maclib z80

0005 =          bdos    equ 5

                        if banked
0001 =          tpa$bank        equ 1
                        else
                tpa$bank        equ 0
                        endif

                        dseg    ; init done from banked memory

                ?init:
0000 2101002200         lxi h,1 ! shld @civec ! shld @covec     ; assign console to CRT:
0009 2102002200         lxi h,2 ! shld @lovec                   ; assign printer to LPT:
000F 2104002200         lxi h,4 ! shld @aivec ! shld @aovec     ; assign AUX to CRT1:
0018 21EF00CD25         lxi h,init$table ! call out$blocks      ; set up misc hardware
001E 218700CD00         lxi h,signon$msg ! call ?pmsg           ; print signon message
0024 C9                 ret

                out$blocks:
0025 7EB7C847           mov a,m ! ora a ! rz ! mov b,a
0029 234E23             inx h ! mov c,m ! inx h
                        outir
002C+EDB3               DB      0EDH,0B3H
002E C32500             jmp out$blocks


                        cseg    ; boot loading most be done from resident memory

                    ;   This version of the boot loader loads the CCP from a file
                    ;   called CCP.COM on the system drive (A:).


                ?ldccp:
                        ; First time, load the A:CCP.COM file into TPA
0000 AF32DB00           xra a ! sta ccp$fcb+15          ; zero extent
0004 21000022EC         lxi h,0 ! shld fcb$nr           ; start at beginning of file
000A 11CC00CD73         lxi d,ccp$fcb ! call open       ; open file containing CCP
0010 3CCA4A00           inr a ! jz no$CCP               ; error if no file...
0014 110001CD78         lxi d,0100h ! call setdma       ; start of TPA
001A 118000CD7D         lxi d,128 ! call setmulti       ; allow up to 16k bytes
0020 11CC00CD82         lxi d,ccp$fcb ! call read       ; load the thing
                                                        ; now,
                                                        ;   copy CCP to bank 0 for reloading
0026 2100010100         lxi h,0100h ! lxi b,0C00h       ; clone 3K, just in case
002C 3A0000F5           lda @cbnk ! push psw            ; save current bank
                ld$1:
0030 3E01CD0000         mvi a,tpa$bank ! call ?bnksl    ; select TPA
0035 7EF5               mov a,m ! push psw              ; get a byte
```

Listing I-1. Boot Loader Module for CP/M 3

```
  64   0037 3E02CD0000         mvi a,2 ! call ?bnksl          ; select extra bank
  65   003C F177               pop psw ! mov m,a              ; save the byte
  66   003E 230B               inx h ! dcx b                  ; bump pointer, drop count
  67   0040 78B1               mov a,b ! ora c                ; test for done
  68   0042 C23000             jnz ld$1
  69   0045 F1CD0000           pop psw ! call ?bnksl          ; restore original bank
  70   0049 C9                 ret
  71
  72                     no$CCP:                ; here if we couldn't find the file
  73   004A 21AB00CD00         lxi h,ccp$msg ! call ?pmsg     ; report this...
  74   0050 CD0000             call ?conin                    ; get a response
  75   0053 C30000             jmp ?ldccp                     ; and try again
  76
  77
  78                     ?rlccp:
  79   0056 2100010100         lxi h,0100h ! lxi b,0C00h      ; clone 3K
  80                     rl$1:
  81   005C 3E02CD0000         mvi a,2 ! call ?bnksl          ; select extra bank
  82   0061 7EF5               mov a,m ! push psw             ; get a byte
  83   0063 3E01CD0000         mvi a,tpa$bank ! call ?bnksl   ; select TPA
  84   0068 F177               pop psw ! mov m,a              ; save the byte
  85   006A 230B               inx h ! dcx b                  ; bump pointer, drop count
  86   006C 78B1               mov a,b ! ora c                ; test for done
  87   006E C25C00             jnz rl$1
  88   0071 C9                 ret
  89
  90                         ; No external clock.
  91                     ?time:
  92   0072 C9                 ret
  93
  94                         ; CP/M BDOS Function Interfaces
  95
  96                     open:
  97   0073 0E0FC30500         mvi c,15 ! jmp bdos            ; open file control block
  98
  99                     setdma:
 100   0078 0E1AC30500         mvi c,26 ! jmp bdos            ; set data transfer address
 101
 102                     setmulti:
 103   007D 0E2CC30500         mvi c,44 ! jmp bdos            ; set record count
 104
 105                     read:
 106   0082 0E14C30500         mvi c,20 ! jmp bdos            ; read records
 107
 108
 109   0087 0D0A0D0A43signon$msg     db     13,10,13,10,'CP/M Version 3.0, sample BIOS',13,10,0
 110
 111   00AB 0D0A42494Fccp$msg        db     13,10,'BIOS Err on A: No CCP.COM file',0
 112
 113
 114   00CC 0143435020ccp$fcb        db     1,'CCP     ','COM',0,0,0,0
 115   00DC                          ds     16
 116   00EC 000000     fcb$nr        db     0,0,0
 117
 118   00EF 0326CFFF07init$table     db     3,p$zpio$3a,0CFh,0FFh,07h      ; set up config port
 119   00F4 0327CF0007               db     3,p$zpio$3b,0CFh,000h,07h      ; set up bank port
 120   00F9 012500                   db     1,p$bank$select,0        ; select bank 0
 121   00FC 00                       db     0                        ; end of init$table
 122
 123   00FD                    end
BANKED          FFFF    6#    18
BC              0000
BDOS            0005    16#   97    100   103   106
CCPFCB          00CC    50    52    56    114#
CCPMSG          00AB    73    111#
DE              0002
FALSE           0000     4#
FCBNR           00EC    51    116#
HL              0004
INITTABLE       00EF    30    118#
IX              0004
IY              0004
LD1             0030    61#   68
NOCCP           004A    53    72#
OPEN            0073    52    96#
OUTBLOCKS       0025    30    34#   39
PBANKSELECT     0025    120
PBAUDCON1       000C
PBAUDCON2       0030
PBAUDCON34      0031
PBAUDLPT1       000E
```

Listing I-1. (continued)

```
PBAUDLPT2         0032
PBOOT             0014
PCENTDATA         0011
PCENTSTAT         0010
PCON2DATA         002C
PCON2STAT         002D
PCON3DATA         002E
PCON3STAT         002F
PCON4DATA         002A
PCON4STAT         002B
PCONFIGURATION    0024
PCRTDATA          001C
PCRTSTAT          001D
PFDCMND           0004
PFDDATA           0007
PFDINT            0008
PFDMISC           0009
PFDSECTOR         0006
PFDSTAT           0004
PFDTRACK          0005
PINDEX            000F
PLPT2DATA         0028
PLPT2STAT         0029
PLPTDATA          001E
PLPTSTAT          001F
PRTC              0033
PSELECT           0008
PWD1797           0004
PZCTC1            000C
PZCTC2            0030
PZDART            001C
PZDMA             0000
PZPIO1            0008
PZPIO1A           000A
PZPIO1B           000B
PZPIO2            0010
PZPIO2A           0012
PZPIO2B           0013
PZPIO3            0024
PZPIO3A           0026   118
PZPIO3B           0027   119
PZSIO1            0028
PZSIO2            002C
READ              0082    56   105#
RL1               005C    80#   87
SETDMA            0078    54    99#
SETMULTI          007D    55   102#
SIGNONMSG         0087    31   109#
TPABANK           0001    19#   21#   62    83
TRUE              FFFF     3#    4     6
?BNKSL            0000    11    62    64    69    81    83
?CONIN            0000     9    74
?INIT             0000     8    26#
?LDCCP            0000     8    48#   75
?PMSG             0000     9    31    73
?RLCCP            0056     8    78#
?TIME             0072     8    91#
@AIVEC            0000    10    29
@AOVEC            0000    10    29
@CBNK             0000    11    60
@CIVEC            0000    10    27
@COVEC            0000    10    27
@LOVEC            0000    10    28
```

Listing I-1. (continued)

I.2 Character I/O Handler for Z80 Chip-based System

The CHARIO.ASM module performs all character device initialization, input, output, and status polling. CHARIO contains the character device characteristics table.

```
                                title 'Character I/O handler for z80 chip based system'

                        ; Character I/O for the Modular CP/M 3 BIOS

                                ; limitations:

                                ;               baud rates 19200,7200,3600,1800 and 134
                                ;                       are approximations.

                                ;               9600 is the maximum baud rate that is likely
                                ;                       to work.

                                ;               baud rates 50, 75, and 110 are not supported


                                public  ?cinit,?ci,?co,?cist,?cost
                                public  @ctbl

                                maclib Z80      ; define Z80 op codes
                                maclib ports    ; define port addresses
                                maclib modebaud ; define mode bits and baud equates

 0006 =                 max$devices     equ 6

                                cseg

                        ?cinit:
 0000 79FE06CA42                mov a,c ! cpi max$devices ! jz cent$init ; init parallel printer
 0006 D0                        rnc                             ; invalid device
 0007 692600                    mov l,c ! mvi h,0               ; make 16 bits from device number
 000A E5                        push h                          ; save device in stack
 000B 292929                    dad h ! dad h ! dad h           ; *8
 000E 11E900196E                lxi d,@ctbl+7 ! dad d ! mov l,m ; get baud rate
 0013 7DFE07                    mov a,l ! cpi baud$600          ; see if baud > 300
 0016 3E44D21D00                mvi a,44h ! jnc hi$speed        ; if >= 600, use *16 mode
 001B 3EC4                      mvi a,0C4h                      ;    else, use *64 mode
                        hi$speed:
 001D 323501                    sta sio$reg$4
 0020 2600111B01                mvi h,0 ! lxi d,speed$table ! dad d     ; point to counter entry
 0026 7E322E01                  mov a,m ! sta speed             ; get and save ctc count
 002A E1                        pop h                           ; recover
 002B 11DC0019                  lxi d,data$ports ! dad d        ; point at SIO port address
 002F 7E3C323001                mov a,m ! inr a ! sta sio$port  ; get and save port
 0034 11FAFF19                  lxi d,baud$ports-data$ports ! dad d     ; offset to baud rate port
 0038 7E322C01                  mov a,m ! sta ctc$port          ; get and save
 003C 212B01                    lxi h,serial$init$tbl
 003F C34500                    jmp stream$out

                        cent$init:
 0042 213901                    lxi h,pio$init$tbl

                        stream$out:
 0045 7EB7C8                    mov a,m ! ora a ! rz
 0048 47234E23                  mov b,a ! inx h ! mov c,m ! inx h
                                outir
 004C+EDB3                      DB      0EDH,0B3H
 004E C34500                    jmp stream$out


                        ?ci:            ; character input

 0051 78FE06D263                mov a,b ! cpi 6 ! jnc null$input ; can't read from centronics
                        cil:
 0057 CD6600CA57                call ?cist ! jz cil             ; wait for character ready
 005D 0D                        dcr c ! inp a                   ; get data
 005E+ED78                      DB      0EDH,A*8+40H
 0060 E67F                      ani 7Fh                         ; mask parity
 0062 C9                        ret
```

Listing I-2. Character I/O Handler for Z80 Chip-based System

```
                        null$input:
 0063 3E1A                      mvi a,1Ah                       ; return a ctl-Z for no device
 0065 C9                        ret
                        ?cist:          ; character input status
 0066 78FE06D27D                mov a,b ! cpi 6 ! jnc null$status ; can't read from centronics
 006C 682600                    mov l,b ! mvi h,0               ; make device number 16 bits
 006F 11DC0019                  lxi d,data$ports ! dad d        ; make pointer to port address
 0073 4E0C                      mov c,m ! inr c                 ; get SIO status port
                                inp a                           ; read from status port
 0075+ED78                      DB      0EDH,A*8+40H
 0077 E601                      ani 1                   ; isolate RxRdy
 0079 C8                        rz                              ; return with zero
 007A F6FF                      ori 0FFh
 007C C9                        ret
                        null$status:
 007D AFC9                      xra a ! ret
                        ?co:            ; character output
 007F 78FE06CA9E                mov a,b ! cpi 6 ! jz centronics$out
 0085 D29D00                    jnc null$output
 0088 79F5                      mov a,c ! push psw              ; save character from <C>
 008A C5                        push b                          ; save device number
                        co$spin:
 008B CDB300CA8B                call ?cost ! jz co$spin         ; wait for TxEmpty
 0091 E16C2600                  pop h ! mov l,h ! mvi h,0       ; get device number in <HL>
 0095 11DC0019                  lxi d,data$ports ! dad d        ; make address of port address
 0099 4E                        mov c,m                         ; get port address
 009A F1                        pop psw ! outp a                ; send data
 009B+ED79                      DB      0EDH,A*8+41H
                        null$output:
 009D C9                        ret
                        centronics$out:
 009E DB10E620C2                in p$centstat ! ani 20h ! jnz centronics$out
 00A5 79D311                    mov a,c ! out p$centdata        ; give printer data
 00A8 DB10F601D3                in p$centstat ! ori 1 ! out p$centstat  ; set strobe
 00AE E67ED310                  ani 7Eh ! out p$centstat                ; clear strobe
 00B2 C9                        ret
                        ?cost:          ; character output status
 00B3 78FE06CACD                mov a,b ! cpi 6 ! jz cent$stat
 00B9 D27D00                    jnc null$status
 00BC 682600                    mov l,b ! mvi h,0
 00BF 11DC0019                  lxi d,data$ports ! dad d
 00C3 4E0C                      mov c,m ! inr c
                                inp a                           ; get input status
 00C5+ED78                      DB      0EDH,A*8+40H
 00C7 E604C8                    ani 4 ! rz                      ; test transmitter empty
 00CA F6FFC9                    ori 0FFh ! ret                  ; return true if ready
                        cent$stat:
 00CD DB102F                    in p$centstat ! cma
 00D0 E620C8                    ani 20h ! rz
 00D3 F6FFC9                    ori 0FFh ! ret
                        baud$ports:             ; CTC ports by physical device number
 00D6 0C0E3031                  db      p$baud$con1,p$baud$lpt1,p$baud$con2,p$baud$con34
 00DA 3132                      db      p$baud$con34,p$baud$lpt2
                        data$ports:             ; serial base ports by physical device number
 00DC 1C1E2C2E                  db      p$crt$data,p$lpt$data,p$con2data,p$con3data
 00E0 2A28                      db      p$con4data,p$lpt2data
 00E2 4352542020@ctbl           db 'CRT   '     ; device 0, CRT port 0
 00E8 0F                        db mb$in$out+mb$serial+mb$softbaud
 00E9 0E                        db baud$9600
 00EA 4C50542020                db 'LPT   '     ; device 1, LPT port 0
 00F0 1F                        db mb$in$out+mb$serial+mb$softbaud+mb$xonxoff
 00F1 0E                        db baud$9600
 00F2 4352543120                db 'CRT1  '     ; device 2, CRT port 1
 00F8 0F                        db mb$in$out+mb$serial+mb$softbaud
 00F9 0E                        db baud$9600
 00FA 4352543220                db 'CRT2  '     ; device 3, CRT port 2
 0100 0F                        db mb$in$out+mb$serial+mb$softbaud
 0101 0E                        db baud$9600
```

Listing I-2. (continued)

```
 150   0102 4352543320         db 'CRT3  '      ; device 4, CRT port 3
 151   0108 0F                 db mb$in$out+mb$serial+mb$softbaud
 152   0109 0E                 db baud$9600
 153   010A 5641582020         db 'VAX   '      ; device 5, LPT port 1 used for VAX interface
 154   0110 0F                 db mb$in$out+mb$serial+mb$softbaud
 155   0111 0E                 db baud$9600
 156   0112 43454E2020         db 'CEN   '      ; device 6, Centronics parallel printer
 157   0118 02                 db mb$output
 158   0119 00                 db baud$none
 159   011A 00                 db 0                     ; table terminator
 160
 161
 162   011B 00FFFFFFE9speed$table     db      0,255,255,255,233,208,104,208,104,69,52,35,26,17,13,7
 163
 164                      serial$init$tbl
 165   012B 02                        db 2             ; two bytes to CTC
 166   012C               ctc$port    ds 1             ; port address of CTC
 167   012D 47                        db 47h           ; CTC mode byte
 168   012E               speed       ds 1             ; baud multiplier
 169   012F 07                        db 7             ; 7 bytes to SIO
 170   0130               sio$port    ds 1             ; port address of SIO
 171   0131 1803E104                  db 18h,3,0E1h,4
 172   0135               sio$reg$4   ds 1
 173   0136 05EA                      db 5,0EAh
 174   0138 00                        db 0             ; terminator
 175
 176   0139 02130F07  pio$init$tbl    db      2,p$zpio$2b,0Fh,07h
 177   013D 0312CFF807                db      3,p$zpio$2a,0CFh,0F8h,07h
 178   0142 00                        db 0
 179
 180   0143                   end
BAUD110          0003
BAUD1200         0008
BAUD134          0004
BAUD150          0005
BAUD1800         0009
BAUD19200        000F
BAUD2400         000A
BAUD300          0006
BAUD3600         000B
BAUD4800         000C
BAUD50           0001
BAUD600          0007    34
BAUD7200         000D
BAUD75           0002
BAUD9600         000E   140    143    146    149    152    155
BAUDNONE         0000   158
BAUDPORTS        00D6    44    129#
BC               0000
CENTINIT         0042    28     49#
CENTRONICSOUT    009E    91    105#   106
CENTSTAT         00CD   113    124#
CI1              0057    63#    64
COSPIN           008B    95#    96
CTCPORT          012C    45    166#
DATAPORTS        00DC    42     44     78     98    116    133#
DE               0002
HISPEED          001D    35     37#
HL               0004
IX               0004
IY               0004
MAXDEVICES       0006    23#    28
MBINOUT          0003   139    142    145    148    151    154
MBINPUT          0001
MBOUTPUT         0002   157
MBSERIAL         0008   139    142    145    148    151    154
MBSOFTBAUD       0004   139    142    145    148    151    154
MBXONXOFF        0010   142
NULLINPUT        0063    62     70#
NULLOUTPUT       009D    92    102#
NULLSTATUS       007D    76     87#   114
PBANKSELECT      0025
PBAUDCON1        000C   130
PBAUDCON2        0030   130
PBAUDCON34       0031   130    131
PBAUDLPT1        000E   130
PBAUDLPT2        0032   131
PBOOT            0014
PCENTDATA        0011   107
PCENTSTAT        0010   106    108    108    109    125
PCON2DATA        002C   134
```

Listing I-2. (continued)

```
PCON2STAT          002D
PCON3DATA          002E    134
PCON3STAT          002F
PCON4DATA          002A    135
PCON4STAT          002B
PCONFIGURATION     0024
PCRTDATA           001C    134
PCRTSTAT           001D
PFDCMND            0004
PFDDATA            0007
PFDINT             0008
PFDMISC            0009
PFDSECTOR          0006
PFDSTAT            0004
PFDTRACK           0005
PINDEX             000F
PIOINITTBL         0139     50    176#
PLPT2DATA          0028    135
PLPT2STAT          0029
PLPTDATA           001E    134
PLPTSTAT           001F
PRTC               0033
PSELECT            0008
PWD1797            0004
PZCTC1             000C
PZCTC2             0030
PZDART             001C
PZDMA              0000
PZPIO1             0008
PZPIO1A            000A
PZPIO1B            000B
PZPIO2             0010
PZPIO2A            0012    177
PZPIO2B            0013    176
PZPIO3             0024
PZPIO3A            0026
PZPIO3B            0027
PZSIO1             0028
PZSIO2             002C
SERIALINITTBL      012B     46    164#
SIOPORT            0130     43    170#
SIOREG4            0135     38    172#
SPEED              012E     40    168#
SPEEDTABLE         011B     39    162#
STREAMOUT          0045     47     52#     57
?CI                0051     16     60#
?CINIT             0000     16     27#
?CIST              0066     16     64      74#
?CO                007F     16     90#
?COST              00B3     16     96     112#
@CTBL              00E2     17     33     138#
```

Listing I-2. (continued)

I.3 Drive Table

The DRVTBL.ASM module points to the data structures for each configured disk drive. The drive table determines which physical disk unit is associated with which logical drive. The data structure for each disk drive is called an Extended Disk Parameter Header (XDPH).

```
                                public @dtbl
                                extrn fdsd0,fdsd1

                                cseg

    0000 00000000   @dtbl       dw fdsd0,fdsd1
    0004 0000000000             dw 0,0,0,0,0,0,0,0,0,0,0,0,0,0         ; drives C-P non-existent

    0020                        end
FDSD0           0000      2     6
FDSD1           0000      2     6
@DTBL           0000      1     6#
```

Listing I-3. Drive Table

I.4 Z80 DMA Single-density Disk Handler

The FD1797SD module initializes the disk controllers for the disks described in the Disk Parameter Headers and Disk Parameter Blocks contained in this module. FD1797SD is written for hardware that supports Direct Memory Access (DMA).

```
                        title 'wd1797 w/ Z80 DMA Single density diskette handler'

        ;    CP/M-80 Version 3     --  Modular BIOS

        ;       Disk I/O Module for wd1797 based diskette systems

                ;       Initial version 0.01,
                ;               Single density floppy only.     - jrp, 4 Aug 82

                dseg

        ; Disk drive dispatching tables for linked BIOS

                public  fdsd0,fdsd1

        ; Variables containing parameters passed by BDOS

                extrn   @adrv,@rdrv
                extrn   @dma,@trk,@sect
                extrn   @dbnk

        ; System Control Block variables

                extrn   @ermde          ; BDOS error mode

        ; Utility routines in standard BIOS
```

Listing I-4. Z80 DMA Single-density Disk Handler

```

                          extrn   ?wboot  ; warm boot vector
                          extrn   ?pmsg   ; print message @<HL> up to 00, saves <BC> & <DE>
                          extrn   ?pdec   ; print binary number in <A> from 0 to 99.
                          extrn   ?pderr  ; print BIOS disk error header
                          extrn   ?conin,?cono     ; con in and out
                          extrn   ?const           ; get console status


                        ; Port Address Equates

                          maclib ports

                        ; CP/M 3 Disk definition macros

                          maclib cpm3

                        ; Z80 macro library instruction definitions

                          maclib z80

                        ; common control characters

000D =          cr        equ 13
000A =          lf        equ 10
0007 =          bell      equ 7


                        ; Extended Disk Parameter Headers (XPDHs)

0000 E600                 dw      fd$write
0002 DC00                 dw      fd$read
0004 DB00                 dw      fd$login
0006 BE00                 dw      fd$init0
0008 0000                 db      0,0                ; relative drive zero
                fdsd0     dph     trans,dpbsd,16,31
000A+A400                 DW TRANS                   ; TRANSLATE TABLE ADDRESS
000C+0000000000           DB 0,0,0,0,0,0,0,0,0       ; BDOS SCRATCH AREA
0015+00                   DB 0                       ; MEDIA FLAG
0016+0000                 DW DPBSD                           ; DISK PARAMETER BLOCK
0018+2300                 DW ??0001                          ; CHECKSUM VECTOR
001A+3300                 DW ??0002                          ; ALLOCATION VECTOR
001C+FEFFFEFFFE           DW 0FFFEH,0FFFEH,0FFFEH ; DIRBCB, DTABCB, HASH ALLOC'D BY GENCPM
0022+00                   DB 0                       ; HASH BANK
0023+           ??0001    DS      16                 ; CHECKSUM VECTOR
0033+           ??0002    DS      31                 ; ALLOCATION VECTOR

0052 E600                 dw      fd$write
0054 DC00                 dw      fd$read
0056 DB00                 dw      fd$login
0058 CD00                 dw      fd$init1
005A 0100                 db      1,0                ; relative drive one
                fdsd1     dph     trans,dpbsd,16,31
005C+A400                 DW TRANS                   ; TRANSLATE TABLE ADDRESS
005E+0000000000           DB 0,0,0,0,0,0,0,0,0       ; BDOS SCRATCH AREA
0067+00                   DB 0                       ; MEDIA FLAG
0068+0000                 DW DPBSD                           ; DISK PARAMETER BLOCK
006A+7500                 DW ??0003                          ; CHECKSUM VECTOR
006C+8500                 DW ??0004                          ; ALLOCATION VECTOR
006E+FEFFFEFFFE           DW 0FFFEH,0FFFEH,0FFFEH ; DIRBCB, DTABCB, HASH ALLOC'D BY GENCPM
0074+00                   DB 0                       ; HASH BANK
0075+           ??0003    DS      16                 ; CHECKSUM VECTOR
0085+           ??0004    DS      31                 ; ALLOCATION VECTOR

                          cseg    ; DPB must be resident

                dpbsd     dpb 128,26,77,1024,64,2
0000+1A00                 DW      ??0005             ; 128 BYTE RECORDS PER TRACK
0002+0307                 DB      ??0006,??0007      ; BLOCK SHIFT AND MASK
0004+00                   DB      ??0008             ; EXTENT MASK
0005+F200                 DW      ??0009             ; MAXIMUM BLOCK NUMBER
0007+3F00                 DW      ??0010             ; MAXIMUM DIRECTORY ENTRY NUMBER
0009+C000                 DB      ??0011,??0012      ; ALLOC VECTOR FOR DIRECTORY
000B+1000                 DW      ??0013             ; CHECKSUM SIZE
000D+0200                 DW      2                  ; OFFSET FOR SYSTEM TRACKS
000F+0000                 DB      ??0014,??0015      ; PHYSICAL SECTOR SIZE SHIFT AND MASK

                          dseg    ; rest is banked
```

Listing I-4. (continued)

```

                        trans   skew 26,6,1
00A4+01                         DB      ?NXTSEC+1
00A5+07                         DB      ?NXTSEC+1
00A6+0D                         DB      ?NXTSEC+1
00A7+13                         DB      ?NXTSEC+1
00A8+19                         DB      ?NXTSEC+1
00A9+05                         DB      ?NXTSEC+1
00AA+0B                         DB      ?NXTSEC+1
00AB+11                         DB      ?NXTSEC+1
00AC+17                         DB      ?NXTSEC+1
00AD+03                         DB      ?NXTSEC+1
00AE+09                         DB      ?NXTSEC+1
00AF+0F                         DB      ?NXTSEC+1
00B0+15                         DB      ?NXTSEC+1
00B1+02                         DB      ?NXTSEC+1
00B2+08                         DB      ?NXTSEC+1
00B3+0E                         DB      ?NXTSEC+1
00B4+14                         DB      ?NXTSEC+1
00B5+1A                         DB      ?NXTSEC+1
00B6+06                         DB      ?NXTSEC+1
00B7+0C                         DB      ?NXTSEC+1
00B8+12                         DB      ?NXTSEC+1
00B9+18                         DB      ?NXTSEC+1
00BA+04                         DB      ?NXTSEC+1
00BB+0A                         DB      ?NXTSEC+1
00BC+10                         DB      ?NXTSEC+1
00BD+16                         DB      ?NXTSEC+1



                            ; Disk I/O routines for standardized BIOS interface

                        ; Initialization entry point.

                        ;               called for first time initialization.


                        fd$init0:
00BE 21CE00                     lxi h,init$table
                        fd$init$next:
00C1 7EB7C8                     mov a,m ! ora a ! rz
00C4 47234E23                   mov b,a ! inx h ! mov c,m ! inx h
                                outir
00C8+EDB3                       DB      0EDH,0B3H
00CA C3C100                     jmp fd$init$next

                        fd$init1:       ; all initialization done by drive 0
00CD C9                         ret

00CE 040A               init$table      db 4,p$zpio$1A
00D0 CFC217FF                   db      11001111b, 11000010b, 00010111b,11111111b
00D4 040B                       db 4,p$zpio$1B
00D6 CFDD17FF                   db      11001111b, 11011101b, 00010111b,11111111b
00DA 00                         db 0


                        fd$login:
                                        ; This entry is called when a logical drive is about to
                                        ; be logged into for the purpose of density determination.

                                        ; It may adjust the parameters contained in the disk
                                        ; parameter header pointed at by <DE>

00DB C9                         ret     ; we have nothing to do in
                                        ;       simple single density only environment.


                        ; disk READ and WRITE entry points.

                                        ; these entries are called with the following arguments:

                                                ; relative drive number in @rdrv (8 bits)
                                                ; absolute drive number in @adrv (8 bits)
                                                ; disk transfer address in @dma (16 bits)
                                                ; disk transfer bank    in @dbnk (8 bits)
                                                ; disk track address    in @trk (16 bits)
                                                ; disk sector address   in @sect (16 bits)
                                                ; pointer to XDPH in <DE>

```

Listing I-4. (continued)

```
                                        ; they transfer the appropriate data, perform retries
                                        ; if necessary, then return an error code in <A>

                        fd$read:
 00DC 211802                    lxi h,read$msg          ; point at " Read "
 00DF 3E880601                  mvi a,88h ! mvi b,01h   ; 1797 read + Z80DMA direction
 00E3 C3ED00                    jmp rw$common

                        fd$write:
 00E6 211F02                    lxi h,write$msg         ; point at " Write "
 00E9 3EA80605                  mvi a,0A8h ! mvi b,05h  ; 1797 write + Z80DMA direction
                            ;   jmp wr$common

                        rw$common:                      ; seek to correct track (if necessary),
                                                        ;       initialize DMA controller,
                                                        ;       and issue 1797 command.

 00ED 222702                    shld operation$name             ; save message for errors
 00F0 321102                    sta disk$command                ; save 1797 command
 00F3 7832A802                  mov a,b ! sta zdma$direction    ; save Z80DMA direction code
 00F7 2A0000229F                lhld @dma ! shld  zdma$dma      ; get and save DMA address
 00FD 3A00006F26                lda @rdrv ! mov l,a ! mvi h,0   ; get controller-relative disk drive
 0103 11160219                  lxi d,select$table ! dad d      ; point to select mask for drive
 0107 7E321202                  mov a,m ! sta select$mask       ; get select mask and save it
 010B D308                      out p$select                    ; select drive
                        more$retries:
 010D 0E0A                      mvi c,10                        ; allow 10 retries
                        retry$operation:
 010F C5                        push b                          ; save retry counter

 0110 3A12022113                lda select$mask ! lxi h,old$select ! cmp m
 0117 77                        mov m,a
 0118 C22D01                    jnz new$track                   ; if not same drive as last, seek

 011B 3A00002114                lda @trk ! lxi h,old$track ! cmp m
 0122 77                        mov m,a
 0123 C22D01                    jnz new$track                   ; if not same track, then seek

 0126 DB09E602C2                in p$fdmisc ! ani 2 ! jnz same$track    ; head still loaded, we are OK

                        new$track:      ; or drive or unloaded head means we should . . .
 012D CDA901                    call check$seek         ; . . read address and seek if wrong track

 0130 011B41                    lxi b,16667             ; 100 ms / (24 t states*250 ns)
                        spin$loop:                      ; wait for head/seek settling
 0133 0B                        dcx b
 0134 78B1                      mov a,b ! ora c
 0136 C23301                    jnz spin$loop

                        same$track:
 0139 3A0000D305                lda @trk ! out p$fdtrack        ; give 1797 track
 013E 3A0000D306                lda @sect ! out p$fdsector      ;       and sector

 0143 219A02                    lxi h,dma$block                 ; point to dma command block
 0146 010011                    lxi b,dmab$length*256 + p$zdma  ; command block length and port address
                                outir                           ; send commands to Z80 DMA
 0149+EDB3                      DB      0EDH,0B3H

 014B DB25                      in p$bankselect                 ; get old value of bank select port
 014D E63F47                    ani 3Fh ! mov b,a               ; mask off DMA bank and save
 0150 3A00000F0F                lda @dbnk ! rrc ! rrc           ; get DMA bank to 2 hi-order bits
 0155 E6C0B0                    ani 0C0h ! ora b                ; merge with other bank stuff
 0158 D325                      out p$bankselect                ; and select the correct DMA bank

 015A 3A1102                    lda disk$command        ; get 1797 command
 015D CDD501                    call exec$command       ; start it then wait for IREQ and read status
 0160 321502                    sta disk$status         ; save status for error messages

 0163 C1                        pop b                   ; recover retry counter
 0164 B7C8                      ora a ! rz              ; check status and return to BDOS if no error

 0166 E610                      ani 0001$0000b          ; see if record not found error
 0168 C4A901                    cnz check$seek          ; if a record not found, we might need to seek

 016B 0DC20F01                  dcr c ! jnz retry$operation

                           ; suppress error message if BDOS is returning errors to application...

 016F 3A0000FEFF                lda @ermde ! cpi 0FFh ! jz hard$error
```

Listing I-4. (continued)

```
                        ; Had permanent error, print message like:

                                ; BIOS Err on d: T-nn, S-mm, <operation> <type>, Retry ?

0177 CD0000             call ?pderr             ; print message header

017A 2A2702CD00         lhld operation$name ! call ?pmsg            ; last function

                                ; then, messages for all indicated error bits

0180 3A1502             lda disk$status         ; get status byte from last error
0183 212902             lxi h,error$table       ; point at table of message addresses
                errml:
0186 5E235623           mov e,m ! inx h ! mov d,m ! inx h ; get next message address
018A 87F5               add a ! push psw        ; shift left and push residual bits with status
018C EBDC0000EB         xchg ! cc ?pmsg ! xchg  ; print message, saving table pointer
0191 F1C28601           pop psw ! jnz errml     ; if any more bits left, continue

0195 218A02CD00         lxi h,error$msg ! call ?pmsg    ; print "<BEL>, Retry (Y/N) ? "
019B CDF501             call u$conin$echo       ; get operator response
019E FE59CA0D01         cpi 'Y' ! jz more$retries ; Yes, then retry 10 more times
                hard$error:                     ; otherwise,
01A3 3E01C9             mvi a,1 ! ret           ;       return hard error to BDOS

                cancel:                         ; here to abort job
01A6 C30000             jmp ?wboot              ; leap directly to warmstart vector


                                ; subroutine to seek if on wrong track
                                ; called both to set up new track or drive

                check$seek:
01A9 C5                 push b                          ; save error counter
01AA CDE101             call read$id                    ; try to read ID, put track in <B>
01AD CABE01             jz id$ok                        ; if OK, we're OK
01B0 CDCE01             call step$out                   ; else step towards Trk 0
01B3 CDE101             call read$id                    ; and try again
01B6 CABE01             jz id$ok                        ; if OK, we're OK
01B9 CDD301             call restore                    ; else, restore the drive
01BC 0600               mvi b,0                         ; and make like we are at track 0
                id$ok:
01BE 78D305             mov a,b ! out p$fdtrack         ; send current track to track port
01C1 3A0000B8C1         lda @trk ! cmp b ! pop b ! rz   ; if its desired track, we are done
01C7 D307               out p$fddata                    ; else, desired track to data port
01C9 3E1A               mvi a,00011010b                 ; seek w/ 10 ms. steps
01CB C3D501             jmp exec$command



                step$out:
01CE 3E6A               mvi a,01101010b                 ; step out once at 10 ms.
01D0 C3D501             jmp exec$command

                restore:
01D3 3E0B               mvi a,00001011b                 ; restore at 15 ms
                     ;  jmp exec$command


                exec$command:           ; issue 1797 command, and wait for IREQ
                                        ;       return status
01D5 D304               out p$fdcmnd                    ; send 1797 command
                wait$IREQ:                              ; spin til IREQ
01D7 DB08E640CA         in p$fdint ! ani 40h ! jz wait$IREQ
01DE DB04               in p$fdstat                     ; get 1797 status and clear IREQ
01E0 C9                 ret

                read$id:
01E1 21AB02             lxi h,read$id$block     ; set up DMA controller
01E4 01000F             lxi b,length$id$dmab*256 + p$zdma ; for READ ADDRESS operation
                        outir
01E7+EDB3               DB      0EDH,0B3H
01E9 3EC4               mvi a,11000100b         ; issue 1797 read address command
01EB CDD501             call exec$command       ; wait for IREQ and read status
01EE E69D               ani 10011101b           ; mask status
01F0 21110046           lxi h,id$buffer ! mov b,m       ; get actual track number in <B>
01F4 C9                 ret                     ; and return with Z flag true for OK
```

Listing I-4. (continued)

```
                        u$conin$echo:   ; get console input, echo it, and shift to upper case
0lF5 CD0000B7CA                 call ?const ! ora a ! jz u$cl   ; see if any char already struck
0lFC CD0000C3F5                 call ?conin ! jmp u$conin$echo  ; yes, eat it and try again
                        u$cl:
0202 CD0000F5                   call ?conin ! push psw
0206 4FCD0000                   mov c,a ! call ?cono
020A FlFE61D8                   pop psw ! cpi 'a' ! rc
020E D620                       sui 'a'-'A'             ; make upper case
0210 C9                         ret
0211            disk$command    ds      1       ; current wdl797 command
0212            select$mask     ds      1       ; current drive select code
0213            old$select      ds      1       ; last drive selected
0214            old$track       ds      1       ; last track seeked to
0215            disk$status     ds      1       ; last error status code for messages
0216 1020       select$table    db      0001$0000b,0010$0000b ; for now use drives C and D
                                ; error message components
0218 2C20526561read$msg         db      ', Read',0
021F 2C20577269write$msg        db      ', Write',0
0227 1802       operation$name  dw      read$msg
                                ; table of pointers to error message strings
                                ;       first entry is for bit 7 of 1797 status byte
0229 3902       error$table     dw      b7$msg
022B 4502                       dw      b6$msg
022D 4F02                       dw      b5$msg
022F 5702                       dw      b4$msg
0231 6A02                       dw      b3$msg
0233 7002                       dw      b2$msg
0235 7C02                       dw      bl$msg
0237 8302                       dw      b0$msg
0239 204E6F7420b7$msg           db      ' Not ready,',0
0245 2050726F74b6$msg           db      ' Protect,',0
024F 204661756Cb5$msg           db      ' Fault,',0
0257 205265636Fb4$msg           db      ' Record not found,',0
026A 204352432Cb3$msg           db      ' CRC,',0
0270 204C6F7374b2$msg           db      ' Lost data,',0
027C 2044524551bl$msg           db      ' DREQ,',0
0283 2042757379b0$msg           db      ' Busy,',0
028A 2052657472error$msg        db      ' Retry (Y/N) ? ',0
                                ; command string for Z80DMA device for normal operation
029A C3         dma$block       db      0C3h    ; reset DMA channel
029B 14                         db      14h     ; channel A is incrementing memory
029C 28                         db      28h     ; channel B is fixed port address
029D 8A                         db      8Ah     ; RDY is high, CE/ only, stop on EOB
029E 79                         db      79h     ; program all of ch. A, xfer B->A (temp)
029F            zdma$dma        ds      2       ; starting DMA address
02Al 7F00                       dw      128-1   ; 128 byte sectors in SD
02A3 85                         db      85h     ; xfer byte at a time, ch B is 8 bit address
02A4 07                         db      p$fddata ; ch B port address (1797 data port)
02A5 CF                         db      0CFh    ; load B as source register
02A6 05                         db      05h     ; xfer A->B
02A7 CF                         db      0CFh    ; load A as source register
02A8            zdma$direction  ds      1       ; either A->B or B->A
02A9 CF                         db      0CFh    ; load final source register
02AA 87                         db      87h     ; enable DMA channel
0011 =          dmab$length     equ     $-dma$block
02AB C3         read$id$block   db      0C3h    ; reset DMA channel
02AC 14                         db      14h     ; channel A is incrementing memory
02AD 28                         db      28h     ; channel B is fixed port address
02AE 8A                         db      8Ah     ; RDY is high, CE/ only, stop on EOB
02AF 7D                         db      7Dh     ; program all of ch. A, xfer A->B (temp)
02B0 1100                       dw      id$buffer ; starting DMA address
02B2 0500                       dw      6-1     ; Read ID always xfers 6 bytes
```

Listing I-4. (continued)

```
 424   02B4 85                        db       85h      ; byte xfer, ch B is 8 bit address
 425   02B5 07                        db       p$fddata ; ch B port address (1797 data port)
 426   02B6 CF                        db       0CFh     ; load dest (currently source) register
 427   02B7 01                        db       01h      ; xfer B->A
 428   02B8 CF                        db       0CFh     ; load source register
 429   02B9 87                        db       87h      ; enable DMA channel
 430   000F =         length$id$dmab  equ      $-read$id$block
 431
 432                          cseg     ; easier to put ID buffer in common
 433
 434   0011           id$buffer       ds       6        ; buffer to hold ID field
 435                          ; track
 436                          ; side
 437                          ; sector
 438                          ; length
 439                          ; CRC 1
 440                          ; CRC 2
 441
 442   0017                   end
BOMSG          0283   381   390#
B1MSG          027C   380   389#
B2MSG          0270   379   388#
B3MSG          026A   378   387#
B4MSG          0257   377   386#
B5MSG          024F   376   385#
B6MSG          0245   375   384#
B7MSG          0239   374   383#
BC             0000
BELL           0007    52#
CANCEL         01A6   289#
CHECKSEEK      01A9   226   257   296#
CR             000D    50#
DE             0002
DISKCOMMAND    0211   203   249   354#
DISKSTATUS     0215   251   275   359#
DMABLENGTH     0011   239   413#
DMABLOCK       029A   238   398#  413
DPBSD          0000    62    66    79    83    93#
ERRM1          0186   277#  281
ERRORMSG       028A   283   392#
ERRORTABLE     0229   276   374#
EXECCOMMAND    01D5   250   310   316   323#  337
FDINIT0        00BE    60   143#
FDINIT1        00CD    77   152#
FDINITNEXT     00C1   145#  150
FDLOGIN        00DB    59    76   162#
FDREAD         00DC    58    75   188#
FDSD0          000A    14    62#
FDSD1          005C    14    79#
FDWRITE        00E6    57    74   193#
HARDERROR      01A3   263   286#
HL             0004
IDBUFFER       0011   339   422   434#
IDOK           01BE   299   302   305#
INITTABLE      00CE   144   155#
IX             0004
IY             0004
LENGTHIDDMAB   000F   333   430#
LF             000A    51#
MORERETRIES    010D   210#  285
NEWTRACK       012D   217   221   225#
OLDSELECT      0213   215   356#
OLDTRACK       0214   219   357#
OPERATIONNAME  0227   202   271   369#
PBANKSELECT    0025   243   247
PBAUDCON1      000C
```

Listing I-4. (continued)

PBAUDCON2	0030					
PBAUDCON34	0031					
PBAUDLPT1	000E					
PBAUDLPT2	0032					
PBOOT	0014					
PCENTDATA	0011					
PCENTSTAT	0010					
PCON2DATA	002C					
PCON2STAT	002D					
PCON3DATA	002E					
PCON3STAT	002F					
PCON4DATA	002A					
PCON4STAT	002B					
PCONFIGURATION	0024					
PCRTDATA	001C					
PCRTSTAT	001D					
PFDCMND	0004	325				
PFDDATA	0007	308	406	425		
PFDINT	0008	327				
PFDMISC	0009	223				
PFDSECTOR	0006	236				
PFDSTAT	0004	328				
PFDTRACK	0005	235	306			
PINDEX	000F					
PLPT2DATA	0028					
PLPT2STAT	0029					
PLPTDATA	001E					
PLPTSTAT	001F					
PRTC	0033					
PSELECT	0008	209				
PWD1797	0004					
PZCTC1	000C					
PZCTC2	0030					
PZDART	001C					
PZDMA	0000	239	333			
PZPIO1	0008					
PZPIO1A	000A	155				
PZPIO1B	000B	157				
PZPIO2	0010					
PZPIO2A	0012					
PZPIO2B	0013					
PZPIO3	0024					
PZPIO3A	0026					
PZPIO3B	0027					
PZSIO1	0028					
PZSIO2	002C					
READID	01E1	298	301	331#		
READIDBLOCK	02AB	332	417#	430		
READMSG	0218	189	366#	369		
RESTORE	01D3	303	318#			
RETRYOPERATION	010F	212#	259			
RWCOMMON	00ED	191	198#			
SAMETRACK	0139	223	234#			
SELECTMASK	0212	208	215	355#		
SELECTTABLE	0216	207	361#			
SPINLOOP	0133	229#	232			
STEPOUT	01CE	300	314#			
TRANS	00A4	62	63	79	80	106#
UC1	0202	344	346#			
UCONINECHO	01F5	284	343#	345		
WAITIREQ	01D7	326#	327			
WRITEMSG	021F	194	367#			
ZDMADIRECTION	02A8	204	410#			
ZDMADMA	029F	205	403#			
?CONIN	0000	32	345	347		
?CONO	0000	32	348			
?CONST	0000	33	344			
?PDEC	0000	30				
?PDERR	0000	31	269			
?PMSG	0000	29	271	280	283	
?WBOOT	0000	28	290			
@ADRV	0000	18				

Listing I-4. (continued)

```
@DBNK           0000    20   245
@DMA            0000    19   205
@ERMDE          0000    24   263
@RDRV           0000    18   206
@SECT           0000    19   236
@TRK            0000    19   219   235   307
```

Listing I-4. (continued)

I.5 Bank and Move Module for CP/M 3 Linked BIOS

The MOVE.ASM module performs memory-to-memory moves and bank selects.

```
                                title 'bank & move module for CP/M3 linked BIOS'

                                cseg

                                public ?move,?xmove,?bank
                                extrn @cbnk

                                maclib z80
                                maclib ports

                        ?xmove:         ; ALTOS can't perform interbank moves
      0000 C9                   ret

                        ?move:
      0001 EB                   xchg            ; we are passed source in DE and dest in HL
                                ldir            ; use Z80 block move instruction
      0002+EDB0                 DB      0EDH,0B0H
      0004 EB                   xchg            ; need next addresses in same regs
      0005 C9                   ret

                                                                ; by exiting through bank select
                        ?bank:
      0006 C5                   push b                          ; save register b for temp
      0007 171717E618           ral ! ral ! ral ! ani 18h       ; isolate bank in proper bit position
      000C 47                   mov b,a                         ; save in reg B
      000D DB25                 in p$bankselect                 ; get old memory control byte
      000F E6E7B0               ani 0E7h ! ora b                ; mask out old and merge in new
      0012 D325                 out p$bankselect                ; put new memory control byte
      0014 C1                   pop b                           ; restore register b
      0015 C9                   ret

                                                        ;       128 bytes at a time

      0016                      end
BC                0000
DE                0002
HL                0004
IX                0004
IY                0004
PBANKSELECT       0025    26    28
PBAUDCON1         000C
PBAUDCON2         0030
PBAUDCON34        0031
PBAUDLPT1         000E
PBAUDLPT2         0032
PBOOT             0014
PCENTDATA         0011
PCENTSTAT         0010
PCON2DATA         002C
PCON2STAT         002D
PCON3DATA         002E
PCON3STAT         002F
PCON4DATA         002A
PCON4STAT         002B
PCONFIGURATION    0024
PCRTDATA          001C
```

Listing I-5. Bank and Move Module for CP/M 3 Linked BIOS

```
PCRTSTAT        001D
PFDCMND         0004
PFDDATA         0007
PFDINT          0008
PFDMISC         0009
PFDSECTOR       0006
PFDSTAT         0004
PFDTRACK        0005
PINDEX          000F
PLPT2DATA       0028
PLPT2STAT       0029
PLPTDATA        001E
PLPTSTAT        001F
PRTC            0033
PSELECT         0008
PWD1797         0004
PZCTC1          000C
PZCTC2          0030
PZDART          001C
PZDMA           0000
PZPIO1          0008
PZPIO1A         000A
PZPIO1B         000B
PZPIO2          0010
PZPIO2A         0012
PZPIO2B         0013
PZPIO3          0024
PZPIO3A         0026
PZPIO3B         0027
PZSIO1          0028
PZSIO2          002C
?BANK           0006     5     22#
?MOVE           0001     5     14#
?XMOVE          0000     5     11#
@CBNK           0000     6
```

Listing I-5. (continued)

I.6 I/O Port Addresses for Z80 Chip-based System: PORTS.LIB

This listing is the PORTS.LIB file on your distribution diskette. It contains the port addresses for the Z80 chip-based system with a Western Digital 1797 Floppy Disk Controller.

```
;       I/O Port addresses for Z80 chip set based system with wd1797 FDC

        ; chip bases

p$zdma          equ 0
p$wd1797        equ 4
p$zpio1         equ 8
p$zctc1         equ 12
p$zpio2         equ 16
p$boot          equ 20  ; OUT disables boot EPROM
p$zdart         equ 28  ; console 1 and printer 1
p$zpio3         equ 36
p$zsio1         equ 40
p$zsio2         equ 44
p$zctc2         equ 48

        ; diskette controller chip ports

p$fdcmnd        equ p$wd1797+0
p$fdstat        equ p$wd1797+0
p$fdtrack       equ p$wd1797+1
p$fdsector      equ p$wd1797+2
p$fddata        equ p$wd1797+3

        ; parallel I/O 1
```

Listing I-6. I/O Port Addresses for Z80 Chip-based System

```
p$select        equ p$zpio1+0
p$fdint         equ p$zpio1+0
p$fdmisc        equ p$zpio1+1
p$zpio1a        equ p$zpio1+2
p$zpio1b        equ p$zpio1+3
        ; counter timer chip 1

p$baudcon1      equ p$zctc1+0
p$baudlpt1      equ p$zctc1+2
p$index         equ p$zctc1+3


        ; parallel I/O 2, Centronics printer interface

p$cent$stat     equ p$zpio2+0
p$cent$data     equ p$zpio2+1
p$zpio2a        equ p$zpio2+2
p$zpio2b        equ p$zpio2+3


        ; dual asynch rcvr/xmtr, console and serial printer ports
p$crt$data      equ p$zdart+0
p$crt$stat      equ p$zdart+1
p$lpt$data      equ p$zdart+2
p$lpt$stat      equ p$zdart+3


        ; Third Parallel I/O device

p$configuration equ p$zpio3+0
p$bankselect    equ p$zpio3+1
p$zpio3a        equ p$zpio3+2
p$zpio3b        equ p$zpio3+3


        ; Serial I/O device 1, printer 2 and console 4

p$lpt2data      equ p$zsio1+0
p$lpt2stat      equ p$zsio1+1
p$con4data      equ p$zsio1+2
p$con4stat      equ p$zsio1+3


        ; Serial I/O device 2, console 2 and 3

p$con2data      equ p$zsio2+0
p$con2stat      equ p$zsio2+1
p$con3data      equ p$zsio2+2
p$con3stat      equ p$zsio2+3


        ; second Counter Timer Circuit

p$baudcon2      equ p$zctc2+0
p$baudcon34     equ p$zctc2+1
p$baudlpt2      equ p$zctc2+2
p$rtc           equ p$zctc2+3
```

Listing I-6. (continued)

I.7 Sample Submit File for ASC 8000-15 System

Digital Research used this SUBMIT file to build the sample BIOS.

```
;Submit file to build sample BIOS for ACS 8000-15 single-density system
;
rmac bioskrnl
rmac boot
rmac move
rmac chario
rmac drvtbl
rmac fdl797sd
rmac scb
link bnkbios3[b,q]=bioskrnl,boot,move,chario,drvtbl,fdl797sd,scb
gencpm
```

Listing I-7. Sample Submit File for ASC 8000-15 System

End of Appendix I

Appendix J
Public Entry Points for CP/M 3 Sample BIOS Modules

Module Name	Public Entry Point	Function	Input Parameter	Return Value
BIOSKRNL				
	?PMSG	Print Message	HL points to msg	none
	?PDEC	Print Decimal	HL=number	none
	?PDERR	Print BIOS Disk Err Msg Header	none	none
CHARIO				
	?CINIT	Char Dev Init	C=Phys Dev # Dev Parms in @CTBL	none
	?CIST	Char Inp Dev St	B=Phys Dev #	A=00 if no input A=0FFH if input char available
	?COST	Char Out Dev St	B=Phys Dev #	A=00 if output busy A=0FFH if output ready
	?CI	Char Dev Input	B=Phys Dev #	A=next available input char
	?CO	Char Dev Output	B=Phys Dev # C=Input Char	
MOVE				
	?MOVE	Memory to Memory Move	BC=byte count DE=start source adr HL=start dest adr	DE,HL point to next bytes after move
	?XMOVE	Set Banks for Extended Move	B=Source Bank C=Dest Bank	BC,DE,HL are unchanged
	?BANK	Select Bank	A=Bank Number	All unchanged
BOOT				
	?INIT	System Init	none	none
	?LDCCP	Load CCP	none	none
	?RLCCP	Reload CCP	none	none
	?TIME	Get/Set Time	C=000H if get C=0FFH if set	none

Listing J-1. Public Entry Points for CP/M 3 Sample BIOS Modules

End of Appendix J

Appendix K
Public Data Items in CP/M 3 Sample BIOS Modules

Table K-1. Public Data Items

Module Name	Public Data	Description
BIOSKRNL		
	@ADRV	Absolute Logical Drive Code
	@RDRV	Relative logical drive code (UNIT)
	@TRK	Track Number
	@SECT	Sector Address
	@DMA	DMA Address
	@DBNK	Bank for Disk I/O
	@CNT	Multi-sector Count
	@CBNK	Current CPU Bank
CHARIO		
	@CTBL	Character Device Table
DRVTBL		
	@DTBL	Drive Table

End of Appendix K

Appendix L
CP/M 3 BIOS Function Summary

Table L-1. BIOS Function Jump Table Summary

No.	Function	Input	Output
0	BOOT	None	None
1	WBOOT	None	None
2	CONST	None	A=0FFH if ready A=00H if not ready
3	CONIN	None	A=Con Char
4	CONOUT	C=Con Char	None
5	LIST	C=Char	None
6	AUXOUT	C=Char	None
7	AUXIN	None	A=Char
8	HOME	None	None
9	SELDSK	C=Drive 0-15 E=Init Sel Flag	HL=DPH addr HL=000H if invalid dr.
10	SETTRK	BC=Track No	None
11	SETSEC	BC=Sector No	None
12	SETDMA	BC=.DMA	None
13	READ	None	A=00H if no Err A=01H if Non-recov Err A=0FFH if media changed
14	WRITE	C=Deblk Codes	A=00H if no Err A=01H if Phys Err A=02H if Dsk is R/O A=0FFH if media changed
15	LISTST	None	A=00H if not ready A=0FFH if ready
16	SECTRN	BC=Log Sect No DE=Trans Tbl Adr	HL=Phys Sect No
17	CONOST	None	A=00H if not ready A=0FFH if ready
18	AUXIST	None	A=00H if not ready A=0FFH if ready
19	AUXOST	None	A=00H if not ready A=0FFH if ready
20	DEVTBL	None	HL=Chrtbl addr
21	DEVINI	C=Dev No 0-15	None
22	DRVTBL	None	HL=Drv Tbl addr HL=0FFFFH HL=0FFFEH HL=0FFFDH
23	MULTIO	C=Mult Sec Cnt	None
24	FLUSH	None	A=000H if no err A=001H if phys err A=002H if disk R/O
25	MOVE	HL=Dest Adr DE=Source Adr	HL & DE point to next bytes following MOVE

Table L-1. (continued)

No.	Function	Input	Output
26	TIME	C=Get/Set Flag	None
27	SELMEM	A=Mem Bank	None
28	SETBNK	A=Mem Bank	None
29	XMOVE	B=Dest Bank C=Source Bank BC=Count	None
30	USERF	Reserved for System Implementor	
31	RESERV1	Reserved for Future Use	
32	RESERV2	Reserved for Future Use	

End of Appendix L

Index

C

D

Reader Comment Form

We welcome your comments and suggestions. They help us provide you with better product documentation.

Date ____________ Manual Title ______________________________ Edition __________

1. What sections of this manual are especially helpful?

____

____

____

____

2. What suggestions do you have for improving this manual? What information is missing or incomplete? Where are examples needed?

____

____

____

____

3. Did you find errors in this manual? (Specify section and page number.)

____

____

____

____

NO POSTAGE
NECESSARY
IF MAILED IN THE
UNITED STATES

BUSINESS REPLY MAIL

FIRST CLASS / PERMIT NO. 182 / PACIFIC GROVE, CA

POSTAGE WILL BE PAID BY ADDRESSEE

DIGITAL RESEARCH™
P.O. Box 579
Pacific Grove, California
93950

Attn: Publication Production