CP/M Plus™
(CP/M Version 3.0)
Operating System

System Guide

NOTICE TO USER

From time to time changes are made in the filenames and in the files actually included on the distribution disk. This manual should not be construed as a representation or warranty that such files or facilities exist on the distribution disk or as part of the materials and programs distributed. Most distribution disks include a "README.DOC" file. This file explains variations from the manual which do constitute modification of the manual and the items included therewith. Be sure to read this file before using the software.

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

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*     First Edition: January 1983     *
*     Second Edition: July 1983       *
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CP/M(R) 3, also marketed as CP/M Plus(R) , is a single-console operating system for 8-bit machines that use an Intel(R) 8080, 8085, or Zilog(R) Z80(R) 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 (hereafter cited as CP/M Plus 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 (hereafter cited as CP/M Plus 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 (hereafter cited as CP/M Plus Programmer's Guide), which describes the system calls use by the applications programmer to interface with the operating system. The Programmer' s Utilities Guide for the CP/M Family of Operating Systems (hereafter cited as Programmer's Utilities Guide) 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.

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S ection 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 ZBO 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 that 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: DTR, 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 modif i es 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 Proqrammer'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.

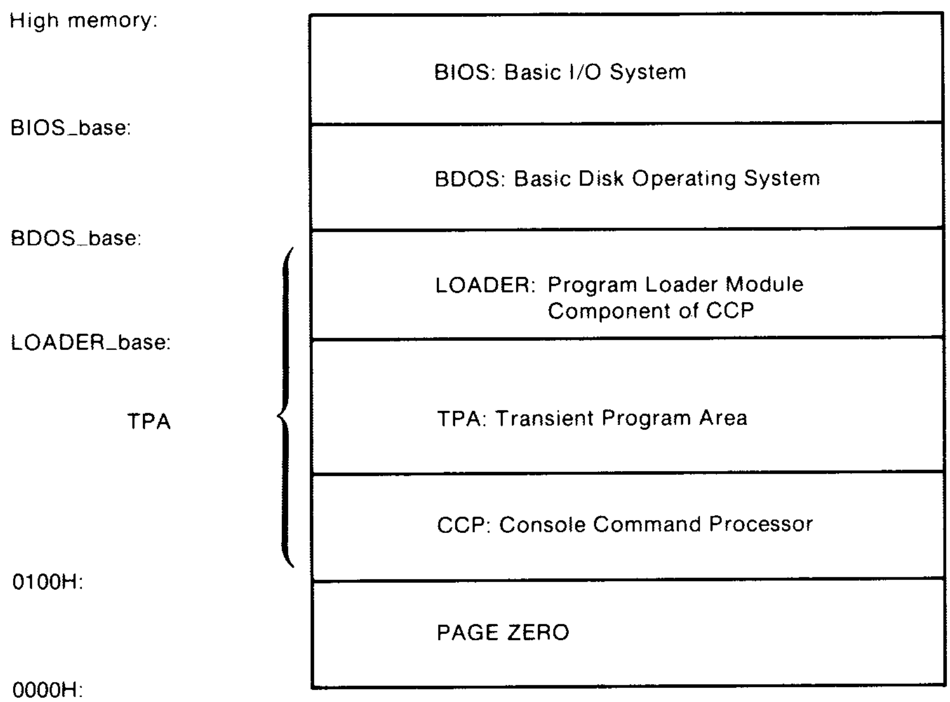


Figure 1-1. General Memory Organization of CP/M 3

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.

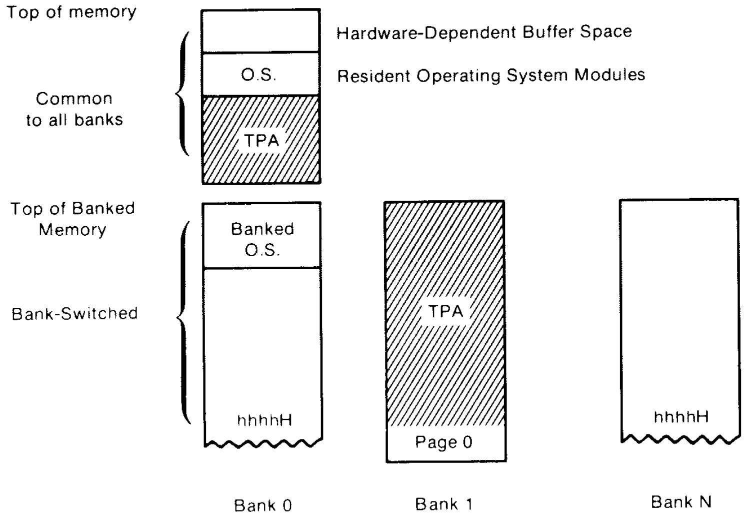
Digital Research supplies System Page Relocatable (. SPR) files for both a banked BDOS and a nonbanked BDOS. A sample banked BIOS is supplied for you to use as an example when creating a customized BIOS for your set of hardware components.

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 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.

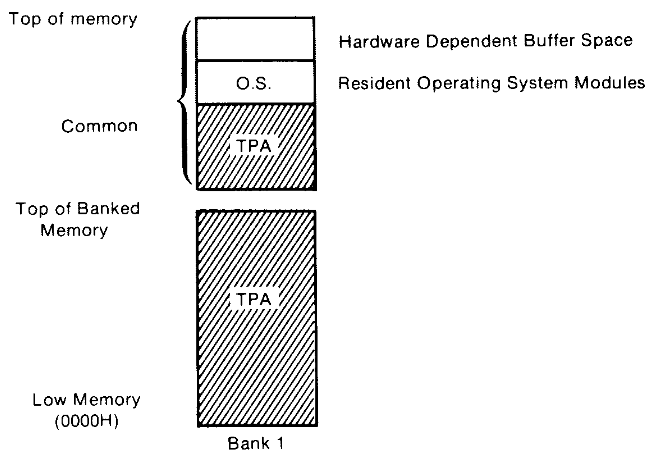


Figure 1-3. Memory Organization with Bank I Enabled
in Banked System

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:

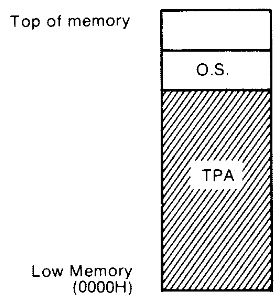


Figure 1-4. Memory Organization in Nonbanked CP/M 3 System

In the nonbanked version of CP/M 3, memory consists of a single contiguous region addressable from OOOOH up to a maximum of OFFFFH, 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	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.

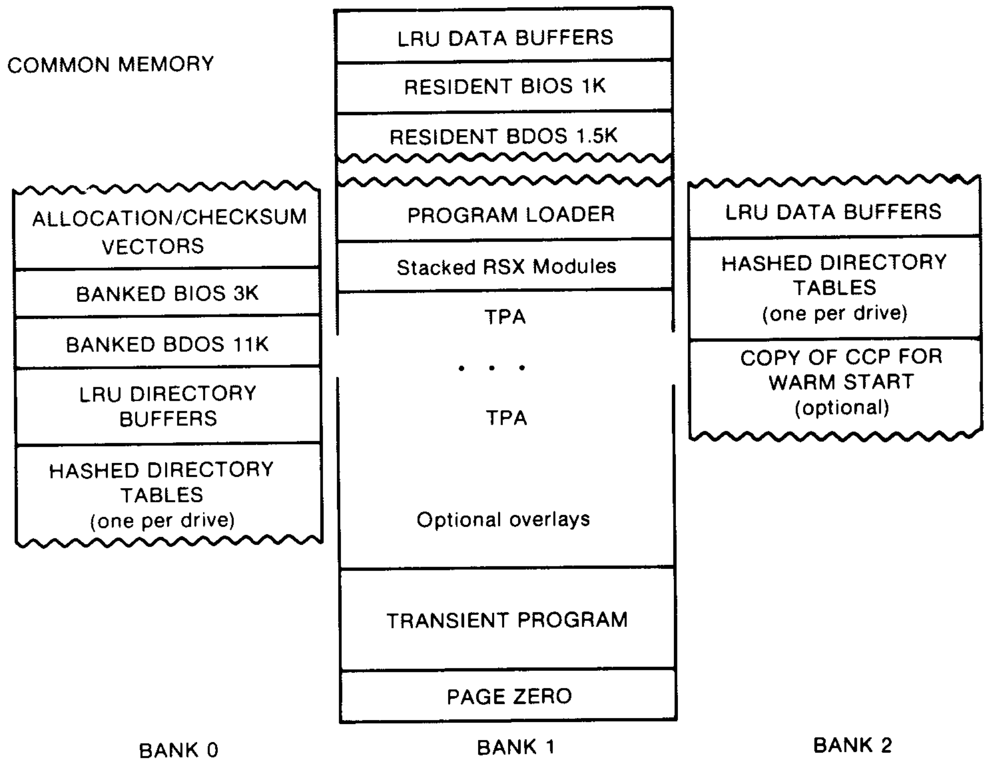


Figure 1-5. Memory Organization in Banked CP/M 3

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.

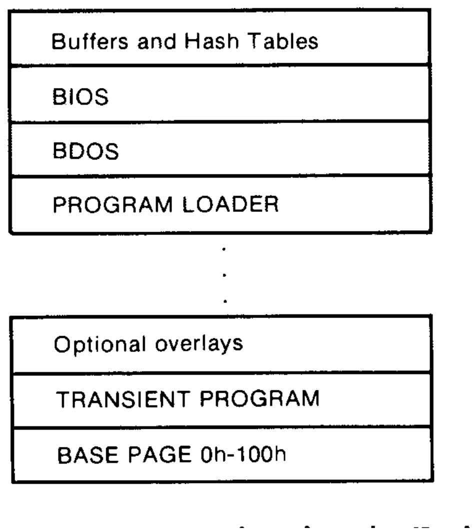


Figure 1-6. Memory organization in Nonbanked CP/M 3

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.

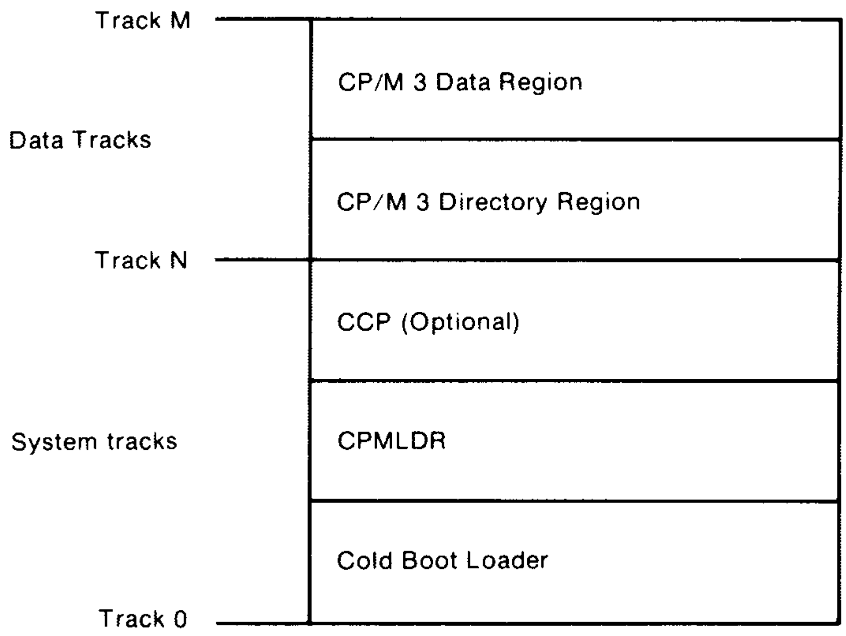


Figure 1-7. CP/M 3 System Disk Organization

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

o Intel 8080, Intel 8085, or zilog Z80 CPU or equivalent.

o 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.
o one to sixteen disk drives of up to 512 megabytes capacity each.
o Some form of ASCII console device, usually a CRT.
o 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

o Intel 8080, Intel 8085, or Zilog Z80 CPU or equivalent.
o A minimum of 32K and up to 64K contiguous memory addressable from location zero.
o One to sixteen disk drives of up to 512 megabytes capacity each.
o Some form of ASCII console device, usually a CRT.
o 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 specif ications 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 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 f ile, 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 BOCT system initialization routine in the BIOS.

For the f inal 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 IOOH 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 BDOS 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, and FLUSH subroutines. Implement SELMEM and SETBNK only in a banked environment. You can implement MULTIO, FLUSH, and TIME 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 can 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 BIOS Function 1: WBOOT on page 52.)

The BOOT and WBOOT routine must load the CCP into the TPA in Bank I 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;

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 lowercase, with no parity. An ASCII CRTL-Z (lAH) 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	T h e 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 to change the current device configurations, as described in the CP/M Plus 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

Call	Explanation
Nonbanked BDOS	
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	
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

Call	Explanation
	Nonbanked BDOS
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.
	Banked BDOS
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 buf fers 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

The 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 31 December 1977. 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 specif ic 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 f ield 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  equ   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. 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 OFFH then @VINFO contains the address of a valid FCB. If @RESEL is not equal to OFFH, 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 31 December 1977, 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 CP/M Plus Programmer's Guide 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+L to point to an alternate message routine. Your error message handler can refer to @FX, @VINFO (if @RESEL is equal to OFFH), @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

TheBIOS 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$000lb            ; device may do input
mb$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$0000b            ; XON/XOFF protocol
;    equates for baud rate byte
baud$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 scratche>ad 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.

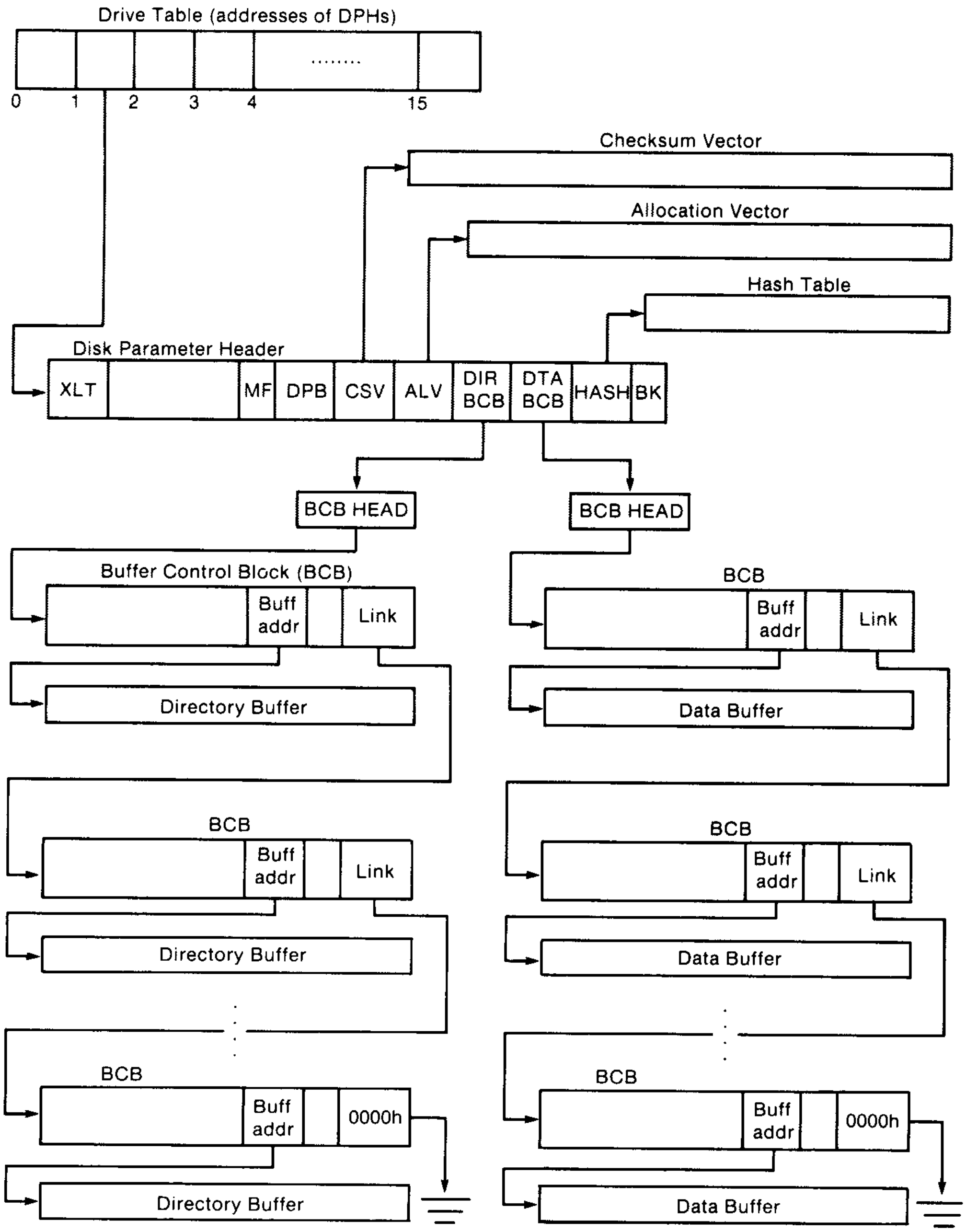


Figure 3-1. Disk Data Structures in a Banked System

3.3.1 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   dpho
             dw   dphl
             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 hysical sector translation table. If there is no sector translation and the logical and physical sector numbers are the same, set XLT to 0000H. Disk drives with identical sector skew factors can share the same translation 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 f ield 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)+l. (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) + 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 f ile 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 = OFFFEH) , 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 OFFFEH 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 OFFFEH 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 RASH to OFFFEH 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+l) 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.
ALO, ALl	Determine reserved directory blocks. See Figure 3-4 for more information.
CKS	The size of the directory check vector, @DRM/4)+l. 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. 0FF 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	6 3
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)-l.

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 EXK 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 OOFFH. The product BLS*(DSM+l) 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 ALI. The two fields AL0 and ALI can together be considered a string of 16 bits, as shown in Figure 3-4.

AL 0								AL 1							
00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15

Figure 3-4. ALO and ALI

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 ALI. 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 ALI 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 = OF0H 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)-l. See Table 3-7 for PHM values.

Table 3-7. PSH and PHN 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 0FFH.
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 BCD 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 I (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 f ields 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 <ACSHDO,FDSDO,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 OFFFEH so that GENCPM automatically allocates the vectors.

The form of the DPH macro call is

label: DPH ?trans,?dpb,[?csize],[?asizel

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:

FDSDO: 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 Sunmary

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	HL=DPH addr
		E=Init Sel Flag	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=0H 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
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	HL & DE point to next
		DE=Source Adr	bytes following MOVE
		BC=Count	
26	TIME	C=Get/Set Flag	None
27	SELMEM	A=Mem Bank	None
28	SETBNK	A=Mem Bank	None
29	XMOVE	B=Dest Bank	None
		C=Source Bank	

Table 3-10. (continued)

No. I	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 SCS.

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 specif ied 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 utilized if specified by the DPHs Referenced by this DRVTBL.
HL=0FFFFH if no Drive Table; GENCPM does not set up buffers. Hashing is supported.
HL=0FFFEH if no Drive Table; GENCPM does not set up buffers. 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 lowercase, with no parity. ANASCII CTRL-Z (lAH) 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.

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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 (lAH) reports an end-of-file.

BIOS Function 15: LISTST

Return the Ready Status of the List Device

Entry Parameters: None

Returned Values: A=00H 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 OFFH 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=00H 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=00H 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=0000H 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 00H 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, unless I/O is required for automatic density sensing.

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 OFFH 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=00H 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=00H 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 A. 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 Z8O 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 OFFH 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 KMOVE 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-8 OTM 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, 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 Sumary 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 SCE.ASM module.

Digital Research supplies the BIOSKRNL.ASM module. This module is the fixed, invariant portion of the BIOS, aiid 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, 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 BIOSKR,-NL.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 @CRDf4A 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.ASK

utility I	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
?ST12RK	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 def-ined 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	010 0	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, def ines 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 shows the format of the Extended Disk Parameter Header.

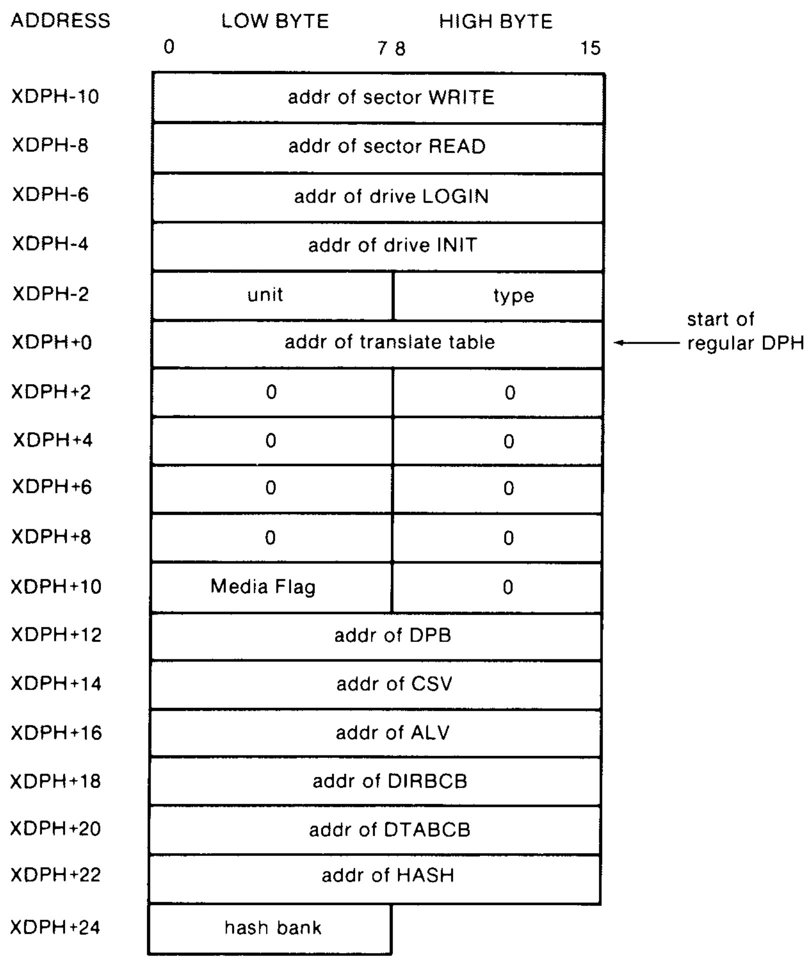

Figure 4-1. XDPH Format

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 f irst-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 occurst 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

The 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 Sector 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 Z8O LDIR instruction for intrabank moves.
?XMOVE	Set banks for one following ?MOVE
	?XMOVE is called with the destination bank in register B and the source 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. (Not implemented in the example.)
?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 GENCPK:

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

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

End of Section 4

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 f i le from the RESBDOS3. SPR f i le, 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. It also relocates references to the System Control Block, as described on page 27. 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 I ? I ?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.

Program Questions:

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 fil,

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. OFFH 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 (CO) ?

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,CO,02) ?
Base,size,bank (00,CO,03) ?

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

Question Variable: MEMSEGO# 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 OFFFEH 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 OFFFEH.

Number of directory buffers for drive d: (#l) ? 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: (#l) ? 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>
memseg0l    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 (CO) ?
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 (OD,B3,02)   ?
 Base,size,bank (00,CO,03)   ?
 CP/M 3 Sys     SBOOH 3500H Bank 00
 Memseg No. 00 OOOOH BBOOH Bank 00
 Memseg No. 01  ODOOH B300H   Bank 02
 Memseg No. 02  OOOOH COOOH   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 = 00BBH, 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: (410) ?
     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 BI00H 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 020OH:
   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 00B0H:

   Available space in 256 byte pages:
   TPA = 0005H

        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 CPf4LDR[LlOO]=CPNLDR,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 CPKLDR 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 I 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 CP14LDR.COM
CP/M 3 SID - Version 3.0
NEXT MSZE PC END
0E80 0EB0 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 th'e 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 an the drive if the drive's DPH MEDIA flag is set, disk integrity is enhanced.

End of Appendix A

Apendix 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 drivers 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 OOOOH 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 OFFH in register A and set the media flag in the System Control Block. 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 drivers 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

Modifing a CP/M 2 BIOS

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

- o 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.

- o 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. CPH3.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.
6-15	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 Relocatable BIOS for CP/M 3

All the listings in Appendixes E through I are assembled with , the cP/M Relocating Macro Assembler, and cross-referenced XREF , an assembly language cross-reference program used with . listings are output from the XREF program. The assembly 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 -l
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    =       1f        equ 10
0007    =       bell      equ 7
0011    =       ctlQ      equ 'Q'-'@'
0013    =       ctlS      equ 'S'-'@'

0100    =       ccp       equ 0100h     ; CCP gets loaded  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 7ci,?co,?cist,?cost         ; each take device in <B>
                        extrn ?cinlt                      ; (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

                        public @cbnk                      ; current bank
                        extrn ?xmove,?move                ; select move bank, and block move
                        extrn ?bank                       ; select CPU bank

                        ; clock         support

                        extrn ?time                       ; siqnal 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,7read,?write
                        public ?lists,?sctrn
                        public ?conos,?auxis,?auxos,?dvtbl,?devin,?drtbl
                        public 7mltio,?flush,?mov,7tim,?bnksl,7stbnk,?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   C30A00 ?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    ; met disks to logical home
```

```
001B   C33F00 ?sldsk:  jmp    seldek  ; select disk drive, return disk parm info
00lE   C37100 ?sttrk:  jmp    settrk  ; Set disk track
0021   C37700 ?stsec:  jmp    setsec  ; set disk sector
0024   C37000 ?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    listat  ; 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    auxibt  ; 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   C30600 ?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 DMA
0054   C38500 ?stbnk:  jmp    setbnk  ; select different bank for disk I/O DMA
0057   C30000 ?xmov:jmp       ?xmove; set source and destination banks for one 127
005a   C30000 jmp      0              ; reserved for system implementor
0050   C30000 jmp      0              ; reserved for future expansion
0060   C30000 jmp      0              ; reserved for future expansion



                       ; BOOT
                       ;          Initialentry point for SyStem startup.

                       dseg           ; this part can be banked

              boot:
0000   310200          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

000E   CD0000 call ?init               ; perform any additiunal 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 b          ; grab @drv entry
00IC   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,  ; get init pointer
0031    EBCDB6Dl        xchg ! call ipchl  ; call init routine
0035    El              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$l

                        cseg               ; following in resident memory

                boot$l:
0063    CD7800          call set$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    3E01CDSl00      mvi a,1 ! call ?bnksl
                ndif

007D    3EC3            mvi a,JMP
007F    3200003205      sta 0 ! sta 5         ; met up jumps in page zero
0085    2103002201      lxi h,?wboot ! shld I   ; BIOS warm start entry
0085    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


                             ; AUX0UT
                             ;          Auxiliary Output. Send character in <C>
                             :                     to all selected devices

                        auxout:
      00E0   2A0000          lhld @aovec    ; fetch aux output bit vector
      00E3   C3K900          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$scan:
      00E9   0600            mvi b,           ; Start with device 0
                        co$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:
      00Fl   CD2C0IB7CA      call coster ! ora a ! jz not$out$ready
      00F8   CIC5            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   El              pop h            ; recover the rest of the vector
                        not$out$device:
      00FF   04              inr b            ; next device number
      0100   7CBS            mov a,h ! ora 1  ; 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:
0l0C  2A0000           lhld @aovec     ; get aux output bit vector
0I0F  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$scan:
0115  0600             mvi b,0            ; start with device 0
               cos$next:
0117  29               dad h              ; check next bit
0118  E5               push h             ; save the vector
0119  C5               push b             ; save the count
0llA  3EFF             mvi a,0FFh         ; assume device ready
011C  DC2C01           cc coster          ; check status for this device
0llF  C1               pop b              ; recover count
0120  El               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,b! ora 1     ; see if any more selected devices
0126  C21701           jnz cos$next
0129  F6FF             ori 0FFh           ; all selected were ready, return true
012B  C9               ret

             coster:                      ; check for output device ready. including optional
                                          ;  xon/xorf 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 ; 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$xonxoff
013A  El               pop     h          ; recover console number in <HL>
013B  CA0000           jz      ?cost      ; not a xon device, go get output status direct
013E  11280219         lxi     d,xofflist ! dad d ; make pointer to proper xon/xoff flag
0142  CD5D0l           call cisti         ; see if this keyboard has character
0145  7EC46F01         mov     a,m ! cnz cii      ; get flag or read key if mny
0149  FEIIC2500I       cpi     ctlq ! jnz not$q; if its a ctl-Q,
014E  3EFF             mvi     a,0FFh  ; set the flag ready
             not$g:
```

```
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,
0158    A6              ana     m           ; and mask with ctl-Q/ctl-S flag
01SC    C9              ret                 ; return this am the status

            cistl:                         ; get input status with <BC> and <HL> saved
01SD    CSES            push b ! push h
015F    CD0000          call ?cist
0162    ElCI            pop     h ! pop b
0164    87              ora     a
0165    C9              ret

            costl                          ; get output status, saving <BC> &  <HL>
0166    CSE5            push b ! push h
0168    CD0000          call ?cost
0168    E1Cl            pop     h ! pop b
016D    87              ora     a
016E    C9              ret

            cil:                           . get input, saving <BC> & <HL>
016F    CSES            push b ! push h
0171    CD0000          call ?ci
0174    ElC1            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 hit 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$scan:
0180    0600            mvi     b,0          ; start    with device 0
            cis$next:
0182    29              dad     h           ; check  next hit
0183    3E00            mvi     a,0          , assume device not ready
0185    DCSD0l          cc cistl            ; check status for this device
0188    B7C0            ora     a ! rnz      ; if any ready, return true
018A    04              inr     b           ; next device number
```

```
0188   7CB5          mov    a,h ! ora 1 ; see if any more selected devices
0180   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


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

                auxin:
0198   2A0000     lhld @aivec

                in$scan:
0198   E5            push h        ; save bit vector
019C   0600          mvi b,0
                ci$next:
0191   29            dad h         ; shift out next bit
019F   3100          mvi a,0       ; insure zero a  (nonexiatant device not ready) .
0lAl   DC5D0l        cc cisti      ; see if the device has a character
01A4   B7            ora a
0lA5   C2B201        jnz ci$rdy    ; this device has a character
01A8   05            dcr b         ; else, next device
01A9   7CB5          mov a,h ! ora 1 ; see if any more devices
0lAB   C29E01 jnz ci$next    ; go look at them
0IAE   El            pop h         ; recover bit vector
0lAF   C39B01        jmp in$scan    ; loop til we find a character

                ci$rdy:
0152   El            pop h         ; discard extra stack
0183   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    Dl                 pop d
     01C9    C1                 pop h
     0lCA    C9                 ret

                     ?pdec:                      ; print binary number 0-65535 from <HL>
     0ICB    01F30111F0         lxi b,tablel0! lxi d,-10000
                     next:
     01D1    3E2F               mvi a, '0'-l
                     pdecl:
     01D1    E53Cl9D2DE         push h! inr a! dad d! jnc stoploop
     0109    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    El                 pop h
     01E7    0ASF03             ldax b! mov e,a! inx b
     0llA    0A5703             ldax b! mov d,a! inx b
     01E0    7BB2C20101         mov a,e! ora d! jnz next
     01F2    C9                 ret

                     tabel10:
     01F3    l8FC9CFFF6         dw     -l000,-l00,-10,-l,0

                     ?pderr:
     01FD    210100CD87         lxi h,drive$msg ! call ?pmsg          ; error header
     0203    3AE000C641         lda @adrv ! adi 'A'  ! mov c,a ! call ?cono   ; drive code
     020C    211300C0B7         lxi h,track$msg ! call ?pmsg          . track header
     0212    2AEF00CDCB         lhld @trk ! call ?pdec                ; track number
     0218    211800C0B7         lxi h,sector$msg ! call ?pmsg         ; sector header
     0211    2AFI00CDCB         lhld @sect ! call ?pdec               ; sector number
     0224    C9                 ret


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

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


     0228    FFFFFFFFFFxofflist     db    -1,-1,-1,-l,-l,-1,-l,-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 h,@dtbl ! dad b         ; get pointer to dispatch table
0045    7E23666F        mov a,m !  inx h ! mov h,m ! mov l,a ; point at disk descriptor
004F    54C8            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    2lFEFF197E      lxi h,-2 ! dad d ! mov a,m ! sta @RDRV      ; get relative drive
0061    2IFAFFI9        lxi h,-6 ! dad d    ; find LOGIN addr
0065    7E23666F        mov a,m !  inx h ! mov h,m ! mov l,a ; get addr of LOGIN routine
0069    CDB60l          call ipchl          ; call LOGIN
006C    El              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 @TRE 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
007?    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
        0070    6960            mov l,c ! mov h,b
        007F    22F300          shld @dma

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

                        ; SETBNK
                        ;       Set DiBk Memory Bank.  Saves bank number
                        ;               in @DBNK for future disk dBtB
                        ;               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
        0088    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      ihId @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    llF8FFl9        lxi  d,-8 ! dad d               ; point to read routine ddress
        00A7    C3BDOO          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
    0084  7E23666F       mov a,B ! inx h ! mov h,m ! mov l,a     ; fetch able entry
    0088  E5             push h          ; save address of table
    0089  llF6FFl9       lxi d,-l0 ! 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
    00Cl  Dl             pop d           ; recover address of table
    00C2  1518           dcx d ! dcx d            ; point to relative drive
    00C4  IA32EE00       ldax d ! sta @rdrv               ; get relative drive code and post it
    00C8  1313           inx d ! inx d            ; point to DPN again
    00CA  E9             pchl            ; leap to driver


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

                     multio
    00CB  32F500C9       sta @cnt ! ret


                       ; FLUSH
                       ;       BIDS deblocking buffer flush.  Not implemented.

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



                       ; error message components
    00D1  oDoAo74249drive$msg       db      cr,lf,bell,'BIOS Error on ',0
    00E3  3A2o542Dootrack$msg       db      '  T-',0
    00E8  2C20S32D00sector$msg   db      ', S-',0


                        ; disk communication data items

  00ED                   @adrv ds                  1           ; currently melected dimk drive
  00EE                   @rdrv    ds               1           ; controller relative disk drive
  00EP                   @trk     ds               2           ; current track number
  00Fl                   @eect    ds               2           ; Current Sector number
  00F3                   @dma     ds               2           ; Current DMA address
  00F5        00         @cnt     db               0           ; record count for multisectortransfer
  00F6        00         @dbnk    db               0           ; bank for DMA operations


                                  cseg             ; common memory

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


```

653 023C				end		
AUXIN	0198	99	397#			
AUXIST		017D	113	367#		
AUXOST		0l0C	114	277#		
AUXOUT		00E0	98	230#		
BANKED		FFFF	8#	186		
BAUDll0		0003				
BAUD12000		0008				
BAUD134		0004				
BAUDl50		0005				
BAUDl800		00009				
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	1981	
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	3381			
COSTER		012C	250	297	3081	
CR		000D	25#	632		
CTLQ		0011	281	320		
CTLS		0013	291	323		
DEVTBL		00D2	115	2041		
DINITLOOP		0017	1491	163		
DINITNEXT		0036	152	1611		
DRIVEMSG		00]D1	463	6321		
FALSE		0000	6#			
FLUSH		00CF	120	6261		
GETDRV		00D6	118	211#		
HOME		006E	101	5201		
INSCAN		019B	390	4001	413	
IPCHL		*01B6	159	4231	511	

ISTSCAN	0180	359	3701			
LF	000A	26#	632			
LIST	00E6	97	2391			
LISTST	0112	109	2879			
MBINOUT	0003					
MBINPUT	0001					
MBOUTPUT	0002					
MBSERIAL	0008					
MBSOFTBAUD	0004					
MBXONXOFF	0010	314				
MULTIO	00CB	119	6191			
NEXT	0lD1	443#	456			
NEXTDIGIT	01E6	452#				
NOTFIRSTSELECT	006D	506	513#			
NOTOUTDEVICE	00FF	246	255#			
NOTOUTREADY	00Fl	249#	250			
NOTQ	0150	320	322#			
HOTS	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	SBS#			
RWCOMMON	00BD	591	606#			
SECTORMSG	00E8	46?	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	0lDE	446	448#			
TABLEl0	01F3	442	459#			
TRACKMSG	00E3	465	633#			
TRUE	FFFF	S#	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	l24#	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	941			

?COST	0000	49	316	340			
?DEVIN	003F	82	116#				
?DRTBL	0042	82	118#				
?DVTBL	003C	82	115#				
?FLUSH	0048	83	1201				
?HOME	0018	80	l0ll				
?INIT	0000	44	145				
?LDCCP	0000	45]	170				
?LIST	000F	79	97#				
?LISTS	002D	81	109#				
?MLTIO	0045	83	119#				
?MOV	004B	83	1221				
?MOVE	0000	62	122				
?PDEC	0ICB	71	4411	466	468		
?PDERR	0IFD	72	4621				
?PMSG	01B7	71	4271	463	465]	467	
?READ	0027	80	106#				
?RLCCP	0000	45	180				
?SCTRN	0030	81	1101				
?SLDSK	001B	80	1021				
?STBNK	0054	83	125#				
?STDMA	0024	80	1051				
?STSEC	0021	80	1041				
?STTRK	00lE	80	1031				
?TIM	004E	83	1231				
?TIME	0000	67	123				
?WBOOT	0003	79	921	192			
?WRITE	002A	80	1071				
?XMOV	0057	83	1261				
?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	6441			
@COVEC	0000	38	222	268			
@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			
@MXT'PA	0000	39	193				
@RDRV	00EE	56	155	508	610	640#	
@SECT	00F1	56	468	540	642#		
@TRK	00EF	56	466	530	641#		

End of Appendix E

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

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

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

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


FE00 =      srb*base equ    0FE00H           ,  Baseof 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$base+26h ; Auxi1iary Input Redirection
                                           ; Vector (word,  r/w)
FE2B  =     @AOVEC     equ    scb$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 ; FC0 Flag (byte,  r/o)
FE43  =     @FX   equ  scb$base+43h  . BDOS Function )br Error
                                           ; Mess age   (byte,  r/o)
FE44  =     @USRCD     equ    scb$base+44h ; current User Code (byte, r/o)
FE4A  =     @MLTIO     equ    scb$base+4Ah ; Current Multi-Sector Count
                                           ;  (byte. r/w)
FE4B  =     @ERMOE     equ    scb$base+4Bh ; BDOS Error Mode (byte. r/o)
FE51  =     @BROSK     equ    scb$base+5lh ; BDOS Error Disk (byte.r/o)
FE54  =     @MED!A     equ    scb$base+54h ; Set by BIOS to indicate
                                           ;  open door (byte. r/w)
FE57  =     @BFLOS     equ    scb$base+57h ;  BDOS Message Size Flag (byte.
r/o)
FE58  =     @iDATE     equ    scb$base+58h ; Date in Days Since I Jan 78
                                           ;  (word,  r/w)
```

```
FE5A  =    @HOUR    equ   scb$base+5Ah ;  Hour in BCD (byte. r/w)
FE5B  =    @MIN     equ   scb$base+58h ; Minute in BCD (byte. r/w)
FE5c  =    @SEC     equ   scb$base+5Ch ; Second in BCID (byte. r/w)
FE5F  =    @ERJMP   equ   scb$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
```

Appendix G
Equates for Mode Byte Bit Fields

```
                ; equates for mode byte bit fields
mb$input        equ 0000$000lb  ; device may do input
mb$output       equ 0000$00l0b  ; device may do output
mb$in$out       equ mb$input+mb$output
mb$soft$baud    equ 0000$0l00b      ; software selectable baud rates
mb$serial       equ 0000$l000b      ; device may use protocol
mb$xon$xoff     equ 000l$0000b      ; XON/XOFF protocol enabled
baud$none       equ   0      ; no baud rate associated with device
baud$50         equ   1      ; S0 baud
baud$75         equ   2      ; 75 baud
baud$ll0        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      ; 1900 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 Node Byte Fields: NODEBAUD.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,dphl,...>           - 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+l
           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; dirbeb, dtabcb, hash alloc'd by GENCPM
                db 0    ; hash bank
        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,?exu,?dsm,?drm,?al0,?all,?cks,?psh,?psm
        local ?n
;; physical sector mask and physical sector shift
        ?psh    set 0
        ?n      set ?psize/l28
        ?psm    Set ?n-l
                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
                exits
                endif
        ?bsh    set ?bsh + 1
        endm
?blm    set ?bls/128-l
?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-l
?all    set 0
?n      set     (?ndirs*32+?b1s-l)/?bls
        rept ?n
        ?all    set (?all shr    1) or 8000h
        endm
?al0    set high ?all
?all    set low ?a11
?drm    set ?ndirs-l
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,?al1       ; alloc vector for directory
   dw   ?cks            ; checksum size
   dw   ?0ff            ; offset for system tracks
   db   ?psh,?psm       ; physical sector size shift and mask
endm
```

```
;
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  ;;vsrisble 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-l
                        if ?nelts = 0
                        ?nxtbas  set ?nxtbas+l
                        ?nxtsec  set ?nxtbas
                        ?nelts     set ?neltst
                        endif
                endm
        endm
```

End of Appendix H

Appendix I
ACS 8000-15 BIOS Modules

1.1 Boot Loader Module for CP/M 3

The BOOT.ASM module performs system initialization other than and disk I/O. BOOT loads the CCP for cold starts and it for warm starts. Note that the device drivers in the Research sample BIOS initialize devices for a polled, and an interrupt-driven, environment.

```
                    title   'Boot loadar 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 2100802200     lxi h,08000h ! shld @civec ! shld @covec ; assign console to CRT:
        0009 2100402200     lxi h,04000h ! shld @lovec                ; assign printer to LPT:
        000F 2100202200     lxi h,02000h ! shld @aivec ! shld @aovec  ; assign AUX to CRTl:
        0018 21EF00CD2S     lxi h,init$table ! call out$blocks      ; set up misc hardware
        00IE 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 llCC00CD73      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,0l00h ! call setdma       ; Start of TPA
001A l18000CD7D      lxi d,128 ! call setmulti       ; allow up to 16k bytes
0020 IlCC00CD82      lxi d,ccp$fcb ! call read       ; load the thing
                                                     ; now,
                                                     ;   copy CCP to bank 0 for reloading
0026 2100010180      lxi     h;0l00h ! lxi b,0C80h   ; clone 3.125K, just in case
002C 3A0000F5        lda     @cbnk ! push psw        ; save current bank
                ld$1:
0030 3E01CD0000      mvi     a,tpa$bank ! call ?bnks ; select TPA
0035 7EF5            mov     a,m ! push psw          ; get a byte
0037 3E02CD0000      mvi     a,2 ! call ?bnksl       ; select extra bank
003C Fl77            pop     psw ! mov m,s ; save the byte
003E 230B            inx     h ! dcx b               ; bump pointer, drop count
0040 78B1            mov     a,b ! ora c             ; test for done
0042 C23000          jnz     ld$1
0045 FlCD0000        pop     psw ! call ?bnksl       ; restore original bank
0049 C9              ret

                no$CCP:                              ; here 1f we couldn't find the file
004A 2lAB00CD00      lxi     h,ccp$msg ! call ?pms ; report this. . .
0050 CD0000          call ?conin                     ; get a response
0053 C30000          jmp     ?ldccp                  ; and try again

                ?rlccp:
0056 2100010180      lxi     h,0l00h ! lxi b,0C80h   ; clone 3.125K
                rl$l:
005C 3B02CD0000      mvi     a,2 ! call ?bnksl       ; select extra bank
0061 7EF5            mov     a,m ! push psw          ; get a byte
0063 3E01CD0000      mvi     a,tpa$bank ! call ?bnksl ; select TPA
0068 Fl77            pop     psw ! mov m,a ; save the byte
```

```
006A 230B           inx    h ! dcx b              ; bump pointer, drop count
006C 78B1           mov    a,b ! ora c            ; test for done
006E C25C00         jnz    rl$1
0071 C9             ret

                    ; No external clock.
               ?time:
0072 C9             ret

          ; CP/M BDOS Function Interfaces

               open:
0073 0E0FC30500     mvi    c,l5 ! jmp bdos; open file control block

               setdma:
0078 0EIAC30500     mvi    c,26 ! jmp bdos        ; set data transfer address

               setmulti:
0070 0E2CC30500     mvi    c,44 ! jmp bdos        ; set record count

               read:
0082 0E14C30500     mvi    c,20 ! jmp bdos        ; read records


0087  0D0A0D0A43signon$msg db    13,l0,13,10,'CP/M Version 1.0, sample
                                     BIOS',13,l0,0

00AB  0D0A42494Fccp$msg  db    13,l0,'BIOS Err on A: No CCP.COM file',0


00CC  0143435020ccp$fcb  db    1,'CCP    ','COM',0,0,0,0
00DC                     ds    16
00EC 000000   fcb$nr           db    0,0,0

00BF  0326CFFF07init$table db   3,p$zpio$3a,0CFh,0FFh,07h  ; set up config port
00F4 0327CF0007            db   3,p$zpio$3b,0CFh,000h,07h ;set up bank port
00F9 012500               db   1,p$bank$select,0       ; select bank 0
00FC 00                   db   0                   ; end of init$table

00FD                      end

BANKED         FFFF   6#    18
BC             0000
BDOS           0005  16#    97    100  103  106
CCPFCB         00CC   50    52     56  114#
CCPMSG         00AB   73    lll#
```

BE	0002			
FALSE	0000	4#		
FCBNR	00BC	51	ll6#	
EL	0004			
INITTABLE	00EF	30		119#
IX	0004			
IY	0004			
1,01	0030	61#	68	
NOCCP	004A	53	72#	
OPEN	0073	52	96#	
OUTBLOCKS0025	30	34#	39	
PBANKSELECT	0025	120		
PBAUDCON1	000C			
PBAUDCON2	0030			
PBAUDCON34	0031			
PBAUDLPT1	000E			
PBAUDLPT2	0032			
PBOOT	0014			
PCENTDATA	0011			
PCENTSTAT	0010			
PCON2DATA	002C			
PCON2STAT	002D			
PCON3DATA	002E			
PCON3STAT	0021			
PCON4DATA	002A			
PCON4STAT	002B			
PCONFIGURATION	0024			
PCRTDAT'A	00IC			
PCRTSTAT	001D			
PFDCMND	0004			
PFDDATA	0007			
PFDINT	0008			
PFDMISC	0009			
PFDSBCTOR	000E			
PFDSTAT	0004			
PFDTRACK	0005			
PINDEX	0001			
PLPT2DATA	0028			
PLPT2STAT	0029			
PLP'TDATA	001E			
PLPTSTAT	0011			
PRTC	0033			
PSELECT	0008			
PWD1797	0004			
PZCTCl	000C			
PZCTC2	0030			

PZDART	00IC						
PZDNA	0000						
PZPIO1	0008						
PZPIOIA	000A						
PZPIO1B	000B						
PZPIO2	0010						
PZPIO2A	0012						
PZPIO2B	0013						
PZPIO3	0024						
PZPIO3A	002E	118					
PZPIO3B	0027	119					
PZSIO1	0028						
PZSIO2	002C						
RIAD	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	484	75			
?PMSG	0000	9	31	73			
?RLCCP	0056	8	78#				
?TINE	0072	8	914				
@AIVEC	0000	10	29				
@AOVEC	0000	10	29				
@CBNK	0000	11	60				
@CIVEC	0000	10	27				
@COVEC	0000	10	27				
@LOVEC	0000	10	28				

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

The CHARIO.ASM module performs all character device , input, output, and status polling. CHARIO contains 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:

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

                          ;        9600 is the maximum baud rate that is likely
                          ;             to work,
                          ;        haud 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$devlces ! jz cent$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
000F 11E900196E   lxi d,@ctbl+7 ! dad d ! mov 1;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 3FC4         mvi a,0C4h                  ;    else, use *64 mode
                  hi$speed:
0010 323501       sta sio$reg$4
0020 2600111B01   mvi h,0 ! lxi d,speed$table ! dad d     ; point to counter entry
0026 7E322F01     mov a,m ! sta speed    ; get and save ctc count
002A El           pop h                       ; recover
0028 11DC0019     lxi d,data$ports ! dad d  ; point at SIO port address
```

```
0034 IIFAFF19          lxi d,baud$ports-data$ports ! dad d     ; offset to baud rate port
0038 7E322C01          mov a,B ! sta ctc$port          ; get and save
003C 212801            lxi h,serlal$init$tbl
003F C34500            jmp stream$out

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

                stream$out:
004S 7FB7C8            mov a,m ! ora a ! rz
0048 47234F23          mov b,a ! inx h ! mov c;m ! inx h
                       outir
004C+EDB3   DB         0EDH,0B3H
004E C34500            jmp stream$out


                ?ci:           ; character input

0051 78FE06D263        mov a,b ! cpi 6 ! jnc null$input ; can't read from centronics
                cil:
0057 C06600CA57        call ?cist ! jz cii      ; wait for character ready
0050 00                dcr c ! inp a                  ; get data
00SE+ED78              DB      0EDH,A*8+40H
0060 E67F              ani 7Fh                        ; mask parity
0062 C9                ret

                null$lnput:
0063   3E1A            mvi a,lAh        ; return a ctl-Z for no device
0065   C9              ret

                ?ciat:          ; character input Status

0066   78FE06D27D      mov a,b ! cpi 6 ! jnc null$status ; can't read from centronics
006C   682600          mov l,b ! mvi h,0        ; make device number 16 bits
006F   llDC00l9        lxi d,data$ports ! dad ; 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 l                    ; isolate RxRdy
0079   C8              rz        ; return with zero
007A   F6FF            ori 0FFh
007C   C9              ret

                null$status:
0070   AFC9            xra a ! ret
```

```
                      ?co:                          ; character output
  007F  78FE06CA9E mov a,b ! cpi 6 ! jz centronics$out
  0085  029000         jnc null$Output
  0088  79F5           mov a,c ! push psw    ; save character from <C>
  008A  C5             push b                ; save device number
                      co$spin:
  008B  CDB300CA8  call ?cost ! jz co$spin  ; wait for TxEmpty
  0091  E16C2600       pop h ! mov l,h ! mvi h,0        ; get device number in <HL>
  0095  11DC0019       lxI d,data$ports ! dad d         ; make address of port address
  0099  4E             mov c,m         ; get port address
  009A  Fl             pop psw ! outp a       ; send data
009B+ED79              DB      0EDH,A*8+41H
                      null$output:
  0090  C9             ret
                      centronics$out:
  009E  DBl0E620C2  in p$centstat ! ani 20h ! jnz csntronics$out
  00A5  79D311         mov a,c ! out p$centdata        ; give printer data
  00A8  DBI0F60lD3  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  027000         jnc null$status
  00BC  682600         mov 1,b ! mvi h,0
  00BF  11DC0019       lxi d,data$ports ! dad d
  00C3  4E0C           mov c,m ! inr c
                       inp a    ; get input status
00CS+ED78              DB      0EDH,A*8+40H
  00C7  E604C8         ani 4 ! rz         ; test transmitter empty
  00CA  F6FFC9         ori 0FFh ! ret  ; return true if ready
                      cent$stat:
  00CD  DBl02F         in p$centstat ! cas
  0000  E620C8         ani 20h ! rz
  0003  F6FFC9         ori 0FFh ! ret
                      baud$ports:             ; CTC ports by physical device number
  0006  0C0E3031       db     p$baud$conl , p$baud$lptl , p$baud$con2, p$baud$con 34
  000A  3132           db     p$baud$con34,p$baud$lpt2
                      data$ports:             ; serial base ports by physical device number
  00DC  lClE2C2E       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
00FI  QE               db baud$9600
00F2  4352543120  db 'CRTl  '     ; device 2, CRT port 1
00F8  0F               db mb$in$out+mb$serlal+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  CE               db baud$9600
0102  4352543320  db 'CRT3  '     ; device 4, CRT port 3
0108  0F               db 'mb$in$out+mb$serial+mb$softbaud
0L09  0E               db baud$9600
0l0A  5641582020  db 'VAX   '     ; device 5, LPT port 1 used for VAX interface
0110  0F               db mb$in$out+mb$serial+mb$softbaud
0111  0E               db baud$9600
0112  43454E2020  db 'CEN   '     ; device 6, Centronics rerallel printer
0118  02               db mb$output
0119  00               db baud$none
0llA 00           db 0              ; table terminator


011B 00FFFFFFE9Speed$table db 0,255,255,255,233,208,104,208,104,69,52,35,
                                          26,17,13,7

                  serial$init$tbl
012B  02               db      2         ; two bytes to CTC
012C              ctc$port       ds      I         ; port addresS of CTC
012D  47               db      47h       ; CTC mode byte
012E              Speed  ds      1         ; baud multiplier
012F  07               db      7         ; 7 bytes to SIO
0130              Sio$port       ds      1         ; port address of SIO
0131  180311104   db      18h,3,0Elh,4
0135              sio$reg$4      ds      1
0136 05EA              db      5,0EAh
0138 00                db      0         ; terminator

0139 02130F07  pio$init$tbl  db      2,p$zpio$2b,0Fh,07h
0130 0312CFF807        db      3,p$zpio$2a,0CFh,0F8h,07h
0142  00               db 0
```

180	0143	end					
BAUDII0	0003						
BAUD1200	0008						
BAUD134	0004						
BAUD150	0005						
BAUD1800	0009						
BAUO19200	000F						
BAUD2400	000A						
BAUD300	0006						
BAUD3600	000B						
BAUD4800	000C						
BAUD50	0001						
BAUD600	0007	34					
BAUD7200	0000						
BAUD75	0002						
BAUD9600	000E	140	143	146	149	152	155
BAUDNONE	0000	158					
BAUDPORTS	0006	44	129#				
BC	0000						
CENTINIT	0042	28	49#				
CENTRONICSOUT	00911	91	105#	106			
CENTSTAT	00C0	113	124#				
CII	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	000B	139	142	145	148	151	154
MBSOFTBAUD	0004	139	142	145	148	151	154
MBXONXOFF	0010	142					
NULLINPUT	0063	62	70#				
NULLOUTPUT	0090	92	102#				
NULLSTATUS	0070	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				
pCON2STAT	002D					
PCON3DATA	002E	134				
pCON3STAT	002F					
PCON4DATA	002A	135				
PCON4STAT	002B					
PCONFIGURATION	0024					
PCRT'DATA	001C	134				
PCRTSTAT	001D					
PFDCMBD	0004					
PFDDATA	0007					
PFDINT	0008					
PFDMISC	0009					
PFDSECTOR	0006					
PFDSTAT	0004					
PFDTRACK	0005					
PINDEX	000F					
PIOINITTBL	0139	50	176#			
PLPT2DATA	0028	135				
PLPT2ST'AT	0029					
PLPTDATA	001E	134				
PLPTSTAT	001F					
PRTC	0033					
PSELECT	0008					
PWD1797	0004					
PZCTCl	000C					
PZCTC2	0030					
PZDART	001C					
PZDMA	0000					
PZPIO1	0008					
PZPIOlA	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	0083	16	96	112#
@CTBL	00E2	17	33	138#

1.3 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
                        extin fdsd0,fdsdl

                        cseg

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

      0020              end
FDSDO                   0000    2       6
FDSDl         0000    2       6
@DTBL                   0000    1       6#
```

Listing I-3. Drive Table

1.4 Z80 DMA single-density Disk Handler

The FDl797SD module initializes the disk controllers for thedisks described in the Disk Parameter Headers and Disk Parameter Blocks contained in this module. FDl797SD 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

          dseg

        ; Disk drive dispatc))ing tables for linked BIOS

          public  fdsd0,fdsdl

        ; 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

        extrn    ?wboot  ; warm         hoot vector
        extrn    ?pmsg   ; printmessage @<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

                saclib   ports

        ; CP/M 3 Disk derinition macros

                maclib  cpm3

        ; Z80 macro library instruction definitions

                maclib  z80

        ; common control characters

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


            ; Extended                          Disk Parameter Headers (XPDNS)

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$login
0058 CD00         dw     fd$initl
00SA 0100         db     1,0     ; relative drive one
            fdsdl 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+ 770003      DS     16             ; CHECKSUM VECT0R
0085+ 770004      DS     31             ; ALLOCATION VECTOR

                  cseg    ; DPB must be resident

            dpbsd dpb 128,26,77,1024,64,2
0000+1A00         DW     ??0005 ; 128 BYTE REC0RDS PER TRACK
0002+0307         DB     ??0006,??000  ; BLOCK SHIFT' AND MASK
0004+00           DB     ??0008 ; EXTENT MASK
000S+F200         DW     ??0009 ; MAXIMUM BLOCK NUMBER
0007+3F00         DW     ??0010 ; MAXIMUM DIRECTORY ENTRY NUMBER
0009+C000         DB     ??0011,??0012 ; ALLOC VECTOR FOR DIRECTORY
0008+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

```

```
                 trans    skew 26,6,1
00A4+0l                   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+1l                   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
00BI+02                   DB    ?NXTSEC+1
00B2+09                   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$init0
00BE 2ICE00               lxi h,init$table
                 fd$init$next:
00CI 7EB7CB               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$initl:       ; all initialization done by drive 0
     00CD C9                    ret

     00CE 040A          init$table db   4,p$zpio$1A
     00D0 CFC217FF              db      ll00llllb, 11000010b, 000l0lllb,lllllllb
     00D4 040B                  db      4,p$zpio$lB
     00D6 CFDDl7FF              db      ll00llllb, ll0lll0lb, 000l0lllb,lllllllb
     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>

                                ; 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,0l h ; 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           ; fall through

```

```
                    rw$common:                      ; seek to correct track (if necessary),
                                                    ; initialize DMA controller,
                                                    ; and issue 1797 command.
0QED 222702         shld operation$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$dma  ; get and save DMA address
00FD 3A00006F26     lda @rdrv ! mov 1,a ! mvi h, 0 ; get controller-relative disk drive
0103 11160219       lxi d,select$table ! dad d        ; point to select mask for drive
0107 7E321202       mov a,m ! sta select$mask         ; get select mask and save it
0108 D308           outp$Select     ; select drive
                    more$retries:
0l0D 0E0A           mvi c,l0        ; allow 10 retries
                    retry$operation:
0l0F 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 ! csp m
0122 77             mov m,a
0123 C22001         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 CDA90l         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 3A00000305     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
```

```
0148 DB2S          in p$bankse)ect        ; get old value of bank select port
014D E63F47        ani 3Fh ! mov b,a      ; mask off DMA bank and save
0150 3A00000F0F    lda @dbnk ! rrc ! rrc  ; get DMA bank to 2 hi-order bits
0155 E6C0B0        ani 0C0h ! ora b       ; merge with other bank stuff
0158 D325          out p$bankselect       ; and select the correct DMA bank
0l5A 3A1102        lda disk$command        ; get 1797 command
015D CDDS0l        call exec$co"""and      ; 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 000l$0000b       ; see if record not found error
0168 C4A901        cnz check$seek       ; if a record not found, we might need to
                                          seek
0168 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
                  ; 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 CDF50I         call u$conin$echo       ; get operator response
019E FE59CA0D0l    cpi 'Y' ! jz more$retries ; Yes, then retry 10 more times
                  hard$error:                   ; otherwise,
01A3 3E01C9         mvi a,1 ! ret          ;  return hard error to BD0S
```

```
                          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$seek:
01A9 C5                        push b  ; save error counter
0lAA CDEl01                   call read$id        ; try to read ID, put track in <B>
0lAD CABE01                    jz id$ok           ; if OK, we're DE
0lB0 CDCE0l                   call step$out       ; else step towards Trk 0
01B3 CDEl0l                   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
                           id$ok:
0lBE 78D305                   mov a,b ! Out p$fdtrack        ; send current track to track port
0lCl 3A0000B8Cl               lda @trk ! cmp b ! pop b ! rz  ; lf its desired track, we are done
01C7 D307                     out p$fddata    ; else, desired track to data port
01C9 3E1A                     mvi a,000ll0l0b           ; seek wi 10 ms. steps
0lCB C3D501                   jmp exec$command



                          step$out:
0lCE 3E6A                     mvi a,0ll0l0l0b; step out once at 10 ms.
0100 C3DS0l                   jmp exec$command

                          restore:
01D3 3E0B                     mvi a,0000l0llb           ; restore at 15 ms
                          ;   jmp exec$command


                          exec$command:                     ; issue 1797 command, and wait for IREQ
                                                            ;       return Status
0105 0304                     out p$fdcmnd               ; send 1797 command
                          wait$IREQ:                        ; spin til IREQ
0107 DB08E640CA               in p$fdint ! ani 40h ! jz wait$IREQ
0lDE 0804                     in p$fdstat                ; get 1797 Status and clear IREQ
0IE0 C9                        ret

                          read$id:
0IEl 21AB02                   lxi h,read$id$block     ; set up DMA controller
```

```
0lE4 0100F          lxi b,length$id$dmab*256 + p$zdma ; for READ ADDRESS
                                                       operation
                    outir
01E7+EDB3           DB     0EDH,0B3H
01E9 3EC4           mvi a,ll000l00b            ; issue  1797 read address command
0lEB CDD50l         call exec$command          ; wait for IREQ and read status
0IEE E69D           ani 10011101b              ; mask status
0lF0 21110046       lxi h;id$buffer ! mov b,m  ; get actual track number in <B>
01F4 C9             ret                        ; and return with z flag true for OK
               u$conin$echo:        ; get console input, echo it, and shift to upper case
0lF5 CD000087CA     call ?const ! ora a ! jz u$cl      ; see if any char already struck
01FC CD0000C3FS     call ?conin ! jmp u$conin$echo  ; yes, eat it and try again
               u$cl:
0202 CD0000FS       call ?conin ! push psw
0206 4FCD0000       mov c,a ! call ?cono
020A  FlFE6lD8      pop psw ! cpi 'a' ! rc
020E D620           sui 'a'-'A'                ; make upper case
0210   C9           ret
0211          disk$command ds      1      ; current wd1797 command
0212          select$mask  ds      1      ; current drive select code
0213          old$select   ds      1      ; laat drive selected
0214          old$track    ds      1      ; last track seeked to
0215          diik$status  ds      1      ; last error status code for messages
0216   1020   select$table db      000l$0000b,00l0$0000b ; for now use drives C and
                                                              D
                     ; error message components
0218   2C20s26s6lread$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
0220   4F02                  dw    b5$msg
```

```
022F  5702                        dw    b4$msg
0231  6A02                        dw    b3$msg
0233  7002                        dw    b2$msq
0235  7C02                        dw    bl$msg
0237  8302                        dw    b0$msg

0239  204E6F7420b7$msg            db    ' Not ready,',0
0245  2050726F74b6$msq            db    ' protect,',0
024F  20466l756Cb5$msg            db    ' Fault,',0
0257  205265636Fb4$msg            db    ' Record not found,',0
026A  204352432Cb3$msg            db    ' CRC,',0
0270  204C6F7374b2$msg            db    ' Lost   dsta,',0
027C  2044524551b1$msg            db    ' DREQ,',0
0283  2042757379b0$msg            db    ' Busy,',0

028A  2052657472error$msg               db    ' Retry (Y/N) ? ',0



                        ; command string for Z80DMA device for normal operation

029A  C3      dma$block           db    0C3h   ; reset DMA channel
0298  14                          db    14h    ; channel A is incrementing memory
029C  28                          db    28h    ; channel B is fixed port address
029D  8A                          db    8Ah    ; RDY is high, CE/ only, stop on E0B
029E  79                          db    79h    ; program all of ch. A, xfer B->A (temp)
029F          zdma$dma            ds    2      ; starting DMA address
02A1  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$fddata ; ch B port address (1797 data port)
02A5  CF                          db    0CFh   ; load B as source register
02A6  05                          db    05h    ; ;'fer A->B
02A7  CF                          db    0CFh   ; load A as source register
02A8          zdma$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
```

```
423   0282  0500                    dw    6-1       ; Read ID always xfers 6 bytes
424   02B4  85                      db    85h       ; byte xfer, ch B is 8 bit address
425   02B5  07                      db    p$fddata ; ch B port address (1797 data port)
426   02B6  CF                      db    0CFh      ; load dest (currently source) register
427   02B7  01                      db    0lh       ; xfer B->A
428   02B8  CF                      db    0CFh      ; load source register
429   0259  87                      db    87h       ; enable DMA channel
430   000F  =     length$id$dmab          equu      $-read$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
B0MSG             0283  381   390#
BlMSG             027C  380   389#
B2MSG             0270  379   388#
B3MSG             026A  378   3871
B4MSG             0257  377   386#
B5MSG             024F  376   3851
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
DISKC0MMAMD       0211  203   249   354#
DISKSTATUS        0215  251   275   359#
DMABLENGTH        0011  239   4131
DMABLOCK          029A  238   398#  413
DPBSD             0000  62    66    79    83    93#
ERRMl             0186  277#  281
ERRORMSG          028A  283   392#
ERRORTABLE        0229  276   374#
EXECCOMMAND       0lD5  250   310   316   323#  337
FDINITD           00BE  60    143#
FDINIT1           00CD  77    152#
FDIMITNEXT        00C1  145#  150
```

FDLOGIN	00DB	59	76	1621
FDREAD	00DC	58	75	188#
FDSD0	000A	14	621	
FDSDl	005C	14	791	
FDWRITE	00E6	57	74	193#
HARDERROR	01A3	263	286#	
HL	0004			
IDBUFFER	0011	339	422	4341
IDOK	0lBE	299	302	3051
INITTABLE	00CE	144	1551	
IX	0004			
IY	0004			
LEMGTMIDDMAB	000F	333	430#	
LF	000A	511		
MORERETRIES	0l0D	2101	285	
NEWTRACK	012D	217	221	225#
OLDSELECT	0213	215	356#	
OLDTRACK	0214	219	3571	
OPERATIOMMAME	0227	202	271	3691
PBANkSELECT	0025	243	247	
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			
PCRTSTAT	001D			
PFDCMND	0004	325		
PFDDATA	0007	308	406	425
PFDINT	0008	327		
PFDMISC	0009	223		
PFDSECTOR	0006	236		
PFDSTAT	0004	329		
PFDTRACK	0005	235	306	
PINDEX	000?			
PLPT2DATA	0028			

PLPT2STAT	0029					
PLPTDATA	001E					
PLPTSTAT	001F					
PRTC	0033					
PSELECT	0008	209				
PWD1797	0004					
PZCTCl	000C					
PZCTC2	0030					
PZDART	001C					
PZDMA	0000	239	333			
PZPIO1	0008					
PzPIOlA	000A	155				
PZPIO1B	000B	157				
PZPIO2	0010					
PzPIO2A	0012					
PZPIO2B	0013					
PZPIO3	0024					
PZPI03A	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	0l0F	212#	259			
RWCOMMON	C0ED	191	198#			
SAMETRACK	0139	223	234#			
SELECTMASK	0212	208	215	355#		
SELECTTABLE	0216	207	361#			
SPINLOOP	0133	229#	232			
STEPOUT	0lCE	300	314#			
TRANS	00A4	62	63	79	80	106#
UCI	0202	344	346#			
UCONINECHO	0lF5	284	343#	345		
WAITIREQ	0107	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			
@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

I.5 Bank and Move Module for CP/M 3 Linked BIOS

The MOVE.ASM module performs memory-to-memory moves and bankselects .

```
                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                  xchq                   ; 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 lBh ; isolate bank in proper bit position
000C 47                 mov b,a                 ; save in reg B
0000 DB25                in p$bankselect        ; get old memory control byte
000F E6E7B0             ani 0E7h ( ora b        ; mask out old and merge in new
0012 0325               out p$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		
PORTDATA	001C		
PCRTSTAT	001D		
PFDCMND	0004		
PFDDATA	0007		
PFDINT	000B		
PFDMISC	0009		
PFDSECTOR	0006		
PFDSTAT	0004		
PFDTRACK	0005		
PINDEX	000F		
PLPT2DATA	0028		
PLPT2STAT	0029		
PLPTDATA	001E		
PLPTSTAT	001F		
PRTC	0033		
PSELECT	000B		
PWD1797	0004		
PZCTCl	000C		
PZCTC2	0030		
PZDART	001C		
PZDMA	0000		
PZPIO1	0008		
PZPIOlA	000A		
PZPIO1B	000B		
PZPIO2	0010		
PZPIO2A	0012		
PZPIO2B	0013		
PZPIO3	0024		
PZPI03A	0026		
PZPIO3B	0027		
PZSIO1	002B		
PZSIO2	002C		
?BANK	0006	5	22#

```
?MOVE          0001  5     14#
?XMOVE         0000  5     11#
@CBNK          0000  6
```

1.6 I/o Port Addresses for Z80 Chip-based System: PORTS.LIB

This listing is the PORTS.LIB file on your distributiondiskette. It contains the port addresses for the Z80 chip-basedsystem 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$zpio1        equ    8
p$zctcl        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$fdcmnd       equ    p$wdl797+0
p$fdstat       equ    p$wdl797+0
p$fdtrack      equ    p$wd1797+l
p$fdsector     equ    p$wd1797+2
p$fddata       equ    p$wd1797+3

               ; parallel I/O 1

p$select       equ p$zpiol+0
p$fdint        equ p$zpiol+0
p$fdmisc       equ p$zpiol+l
p$zpiola       equ p$zpiol+2
p$zpiolb       equ p$zpiol+3

               ; counter timer chip 1

p$baudconl     equ p$zctcl+0
p$baudlptl     equ p$zctcl+2
```

```
p$index            equ p$zctcl+3

                ; parallel I/O 2, Centronics printer interface

p$cent$stat     equ p$zpio2+0
p$cent$data     equ p$zpio2+l
p$zpio2a        equ p$zpio2+2
p$zpio2b        equ p$zpio2+3

                ; dual asynch rcvr/xstr, 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/0 device

p$configuration equ p$zpio3+0
p$bankselect    equ p$zplo3+l
p$zpio3a        equ p$zpio3+2
p$zpio3b        equ p$zpio3+3

                ; Serial I/0 device l, printer 2 and console 4

p$lpt2data      equ p$zsiol+0
p$lpt2stat      equ p$zsiol+l
p$con4data      equ p$zsiol+2
p$con4stat      equ p$zsio1+3

                ; Serial I/0 device 2, console 2 and 3

p$con2data      equ p$zsio2+0
p$con2stat      equ p$zsio2+l
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+l
p$baudlpt2      equ p$zctc2+2
p$rtc           equ p$zctc2+3
```

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		
PZCTCl	000C		
PZCTC2	0030		
PZDART	001C		
PZDMA	0000		
PZPIO1	0008		
PZPIO1A	000A		
PZPIO1B	000B		
PZPIO2	0010		
PZPIO2A	0012		
PZPIO2B	0013		
PZPI03	0024		
PZPI03A	0026		
PZPIO3B	0027		
PZSIO1	002B		
PZSIO2	002C		
?BANK	0006	5	22#
?MOVE	0001	5	14#
?XMOVE	0000	5	11#
@CBNK	0000	6	

1.7 Sauple 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 buot
rmac move
rmac chario
rmac drvtbl
rmac fdl797sd
rmac scb
link bnkbios3[b,q]=bioskrnl,boot,move,chario,drvtbl,fd17975d,scb
gencpm
```

Listing 1-7. Sample Submit File for ASC 8000-15 System

End of Appendix I

Appendix
Public Entry Points for CP/M 3 Sample BIOS Modules

Module Name	Public Entry Point	Function	Input Parameter	Return Value
BIOSERNL				
	?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 Dev Parms in @CTBL	C=Phys Dev #	none
	?CIST	Char Inp Dev St	B=Phys 0ev #	A=00 if no input A=0FFH if input char available
	?COST	Char Out 0ev 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=Dest Bank C=Source 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-l. 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	HL=DPH addr
		E=Init Sel Flag	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	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

23	MULTIO	C=Mult Sec Cnt	None
24	FLUSH	None	A=000H if no err A=00IH if phys err A=002H if disk R/O
25	MOVE	HL=Dest Adr DE=Source Adr BC=Count	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	None
30	USERF	Reserved for System Implementor	
31	RESERV1	Reserved for Future Use	
32	RESERV2	Reserved for Future Use	

End of Appendix L

Index