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Concurrent CP/M-86™
Operating System
System Guide

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Operating System
System Guide

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

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TRADEMARKS

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Foreword

Concurrent CP/M-86™ is a single-user, multitasking, real-time operating system. It is designed for use with any disk-based microcomputer using an Intel® 8086, 8088, or compatible microprocessor with a real-time clock. Concurrent CP/M-86 is modular in design, and can be modified to suit the needs of a particular installation.

The information in this manual is arranged in the order needed for use by the system designer. Section 1 provides an overview of the Concurrent CP/M-86 system. Section 2 describes how to build a Concurrent CP/M-86 system using the GENSYS utility. Section 3 contains an overview of the Concurrent CP/M-86 Extended Input/Output System (XIOS). XIOS Character Devices are covered in Section 4, and Disk Devices in Section 5. Section 6 describes miscellaneous XIOS functions and routines.

A detailed description of the XIOS Timer Interrupt routine is found in Section 7. Section 8 deals with debugging the XIOS, and Chapter 9 discusses the bootstrap loader program necessary for loading the operating system from disk. Section 10 treats the utilities that the OEM must write in order to have a commercially distributable system, and Section 11 covers changes to end-user documentation which the OEM must make if certain modifications to Concurrent CP/M-86 are performed. Appendix A discusses removable media considerations, and Appendix B covers how to implement auto density support.

Many sections of this manual refer to the example XIOS. The source code for the example XIOS appears on the Concurrent CP/M-86 distribution disk in the file XIOS.A86; we strongly suggest assembling the source file following the instructions in Section 2, and referring often to the assembly listing while reading this manual. Example listings of the Concurrent CP/M-86 Loader BIOS and Boot Sector can also be found on the release disk.

Digital Research supports the user interface and software interface to Concurrent CP/M-86, as described in the Concurrent CP/M-86 Operating System User's Guide and the Concurrent CP/M-86 Operating System Programmer's Reference Guide, respectively. Digital Research does not support any additions or modifications made to Concurrent CP/M-86 by the OEM or distributor. The OEM or Concurrent CP/M-86 distributor must also support the hardware interface (XIOS) for a particular hardware environment.

The Concurrent CP/M-86 System Guide is intended for use by system designers who want to modify either the user or hardware interface to Concurrent CP/M-86. It assumes you have already implemented a CP/M-86® 1.0 Basic Input/Output System (BIOS), preferably on the target Concurrent CP/M-86 machine. It also assumes familiarity with these four manuals, which document and support Concurrent CP/M-86:

- The Concurrent CP/M-86 Operating System User's Guide documents the user's interface to Concurrent CP/M-86, explaining the various features used to execute applications programs and Digital Research utility programs.

- The Concurrent CP/M-86 Operating System Programmer's Reference Guide documents the applications programmer's interface to Concurrent CP/M-86, explaining the internal file structure and system entry points--information essential to create applications programs that run in the Concurrent CP/M-86 environment.

- The Concurrent CP/M-86 Operating System Programmer's Utilities Guide documents the Digital Research utility programs programmers use to write, debug, and verify applications programs written for the Concurrent CP/M-86 environment.

- The Concurrent CP/M-86 Operating System System Guide documents the internal, hardware-dependent structures of Concurrent CP/M-86.

Standard terminology is used throughout these manuals to refer to Concurrent CP/M-86 features. For example, the names of all XIOS function calls and their associated code routines begin with IO_. Concurrent CP/M-86 system functions available through the logically invariant software interface are called system calls. The names of all data structures internal to the operating system or XIOS are capitalized, for example XIOS Header and Disk Parameter Block. The Concurrent CP/M-86 system data segment is referred to as the SYSDAT area or simply SYSDAT. The fixed structure at the beginning of the SYSDAT area, documented in Section 1.10 of this manual, is called the SYSDAT DATA.

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Section 1
System Overview

Concurrent CP/M-86 is a single-user, multitasking, real-time operating system. It allows you to run multiple tasks simultaneously on two or more virtual consoles. Concurrent CP/M-86 supports extended features, such as intercommunication and sychronization of independently running processes. It is designed for implementation in a large variety of hardware environments and as such, you can easily customize it to fit a particular hardware environment and/or user's needs.

Concurrent CP/M-86 consists of three levels of interface: the user interface, the logically invariant software interface, and the actual hardware interface. The user interface, which Digital Research distributes, is the Resident System Process called the Terminal Message Process (TMP). It accepts commands from the user and either performs those commands that are built into the TMP, or passes the command to the operating system via the Command Line Interpreter (P_CLI). The Command Line Interpreter in the operating system kernel either invokes an RSP or loads a disk file in order to perform the command.

The logically invariant interface to the operating system consists of the system calls as described in the Concurrent CP/M-86 Operating System Programmer's Reference Guide. The logically invariant interface also interfaces transient and resident processes with the hardware interface.

The physical interface, or XIOS, communicates directly with the particular hardware environment. It is composed of a set of functions that are called by processes needing physical I/O. Sections 3 through 6 describe these functions. Figure 1-1 shows the relationships among the three interfaces.

Digital Research distributes Concurrent CP/M-86 with machine-readable source code for both the user and example hardware interfaces. You can write a custom user and/or hardware interface, and incorporate them by using the system generation utility, GENCCPM. The example XIOS is written for the IBM® Personal Computer with 128K to 544K RAM, keyboard, monochrome monitor, and two, single-sided, double-density, 5-1/4-inch disk drives. (Note that the bootstrap loader for the IBM PC assumes at least 160K of available RAM contiguous from address 0:0000H.) It is designed to be an example and not a commercially distributable system. Wherever a choice between clarity and efficiency was necessary, the example XIOS was written for clarity.

This section describes the modules comprising a typical Concurrent CP/M-86 operating system. It is important that you understand this material before you try to customize the operating system for a particular application.

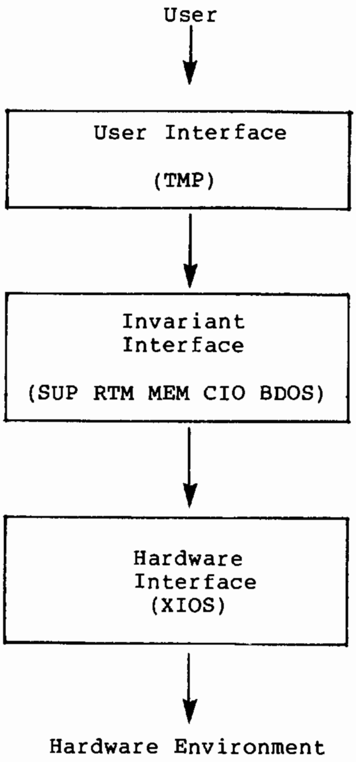


Figure 1-1. Concurrent CP/M-86 Interfacing

1.1 Concurrent CP/M-86 Organization

Concurrent CP/M-86 is composed of six basic code modules. The Real-time Monitor (RTM) handles process-related functions, including dispatching, creation, and termination, as well as the Input/Output system state logic. The Memory module (MEM) manages memory and handles the Memory Allocate (M_ALLOC) and Memory Free (M_FREE) system calls. The Character I/O module (CIO) handles all console and list device functions, and the Basic Disk Operating System (BDOS) manages the file system. These four modules communicate with the Supervisor (SUP) and the Extended Input/Output System (XIOS).

The SUP module manages the interaction between transient processes, such as user programs, and the system modules. All function calls go through a common table-driven interface in SUP. The SUP module also contains the Program Load (P_LOAD) and Command Line Interpreter (P_CLI) system calls.

The XIOS module handles the physical interface to a particular hardware environment. Any of the Concurrent CP/M-86 logical code modules can call the XIOS to perform specific hardware-dependent functions. The names used in this manual for the XIOS functions always begin with IO_ in order to easily distinguish them from Concurrent CP/M-86 operating system calls.

All operating system code modules, including the SUP and XIOS, share a data segment called the System Data Area (SYSDAT). The beginning of SYSDAT is the SYSDAT DATA, a well-defined structure containing public data used by all system code modules. Following this fixed portion are local data areas belonging to specific code modules. The XIOS area is the last of these code module areas. Following the XIOS Area are Table Areas, used for the Process Descriptors, Queue Descriptors, System Flag Tables, and other operating system tables. These tables vary in size depending on options chosen during system generation. See Section 2, "System Generation."

The Resident System Processes (RSPs) occupy the area in memory immediately following the SYSDAT module. The RSPs you select at system generation time become an integral part of the Concurrent CP/M-86 operating system. For more information on RSPs, see Section 1.11 of this manual, and the Concurrent CP/M-86 Operating System Programmer's Reference Guide.

Concurrent CP/M-86 loads all transient programs into the Transient Program Area (TPA). The TPA for a given implementation of Concurrent CP/M-86 is determined at system generation time.

1.2 Memory Layout

The Concurrent CP/M-86 operating system area can exist anywhere in memory except over the interrupt vector area. You define the exact location of Concurrent CP/M-86 during system generation. The GENCCPM program determines the memory locations of the system modules that make up Concurrent CP/M-86 based upon system generation parameters and the size of the modules.

The XIOS must reside within SYSDAT. You must write the XIOS as an 8080 model program, with both the code and data segment registers set to the beginning of SYSDAT.

Figure 1-2 shows the relationship of the Concurrent CP/M-86 system image to the CCPM.SYS disk file structure.

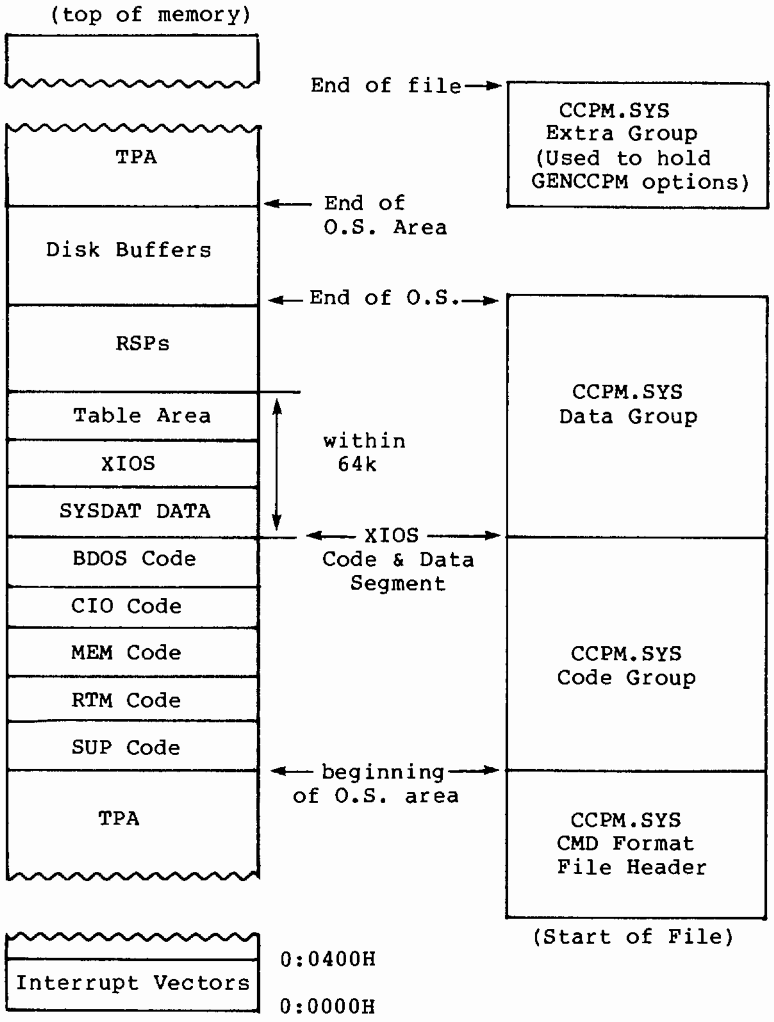


Figure 1-2. Concurrent CP/M-86 Memory Layout and File Structure

1.3 Supervisor

The Concurrent CP/M-86 Supervisor (SUP) manages the interface between system and transient processes and the invariant operating system. All system calls go through a common table-driven interface in SUP.

The SUP module also contains system calls that invoke other system calls, like P_LOAD (Program Load) and P_CLI (Command Line Interpreter).

Table 1-1. Supervisor System Calls

System Call	Number	Hex
F_PARSE	152	98
P_CHAIN	47	2F
P_CLI	150	96
P_LOAD	59	3B
P_RPL	151	97
S_BDOSVER	12	0C
S_BIOS	50	32
S_OSVER	163	0A3
S_SYSDAT	154	9A
S_SERIAL	107	6B
T_SECONDS	155	9B

1.4 Real-time Monitor

The Real-time Monitor (RTM) is the multitasking kernel of Concurrent CP/M-86. It handles process dispatching, queue and flag management, device polling, and system timing tasks. It also manages the logical interrupt system of Concurrent CP/M-86. The primary function of the RTM is transferring the CPU resource from one process to another, a task accomplished by the RTM Dispatcher module. At every dispatch operation, the Dispatcher suspends the currently running process from execution and stores its state in the Process Descriptor (PD) and User Data Area (UDA) associated with that process. The Dispatcher then selects the highest-priority process in the ready state and restores it to execution, using the data in its PD and UDA. A process is in the ready state if it is waiting for the CPU resource only. The new process continues to execute until it needs an unavailable resource, a resource needed by another process becomes available, or an external event, such as an interrupt, occurs. At this time the RTM performs another dispatch operation, allowing another process to run.

The Concurrent CP/M-86 RTM Dispatcher also performs device polling. A process waits for a polled device through the RTM DEV_POLL system call.

When a process needs to wait for an interrupt, it issues a DEV_WAITFLAG system call on a logical interrupt device. When the appropriate interrupt actually occurs, the XIOS calls the DEV_SETFLAG system call, which wakes up the waiting process. The interrupt routine then performs a Far Jump to the RTM Dispatcher, which reschedules the interrupted process, as well as all other ready processes that are not yet on the Ready List. At this point, the Dispatcher places the process with the highest priority into execution. Processes that are handling interrupts should run at a better prior.ity than noninterrupt-dependent processes (the lower the priority number, the better the priority) in order to respond quickly to incoming interrupts.

The system clock generates interrupts, clock ticks, typically 60 times per second. This allows Concurrent CP/M-86 to effect time-slicing. Since the operating system waits for the tick flag, the XIOS Timer Interrupt routine must execute a Concurrent CP/M-86 DEV_SETFLAG system call at each tick (see Section 7, "XIOS TICK Interrupt Routine"), then perform a Far Jump to the SUP entry point. At this point, processes with equal priority are scheduled for the CPU resource in round-robin fashion unless a better-priority process is on the Ready List. If no process is ready to use the CPU, Concurrent CP/M-86 remains in the Dispatcher until an interrupt occurs, or a polling process is ready to run.

The RTM also handles queue management. System queues are composed of two parts: the Queue Descriptor, which contains the queue name and other parameters, and the Queue Buffer, which can contain a specified number of fixed-length messages. Processes read these messages from the queue on a first-in, first-out basis. A process can write to or read from a queue either conditionally or unconditionally. If a process attempts a conditional read from an empty queue, or a conditional write to a full one, the RTM returns an error code to the calling process. However, an unconditional read or write attempt in these situations causes the suspension of the process until the operation can be accomplished. An important use of this feature is to implement mutual exclusion of processes from serially reusable system resources, such as the disk hardware.

Other functions of the Real-time Monitor are covered in the Concurrent CP/M-86 Operating System Programmer's Reference Guide under their individual descriptions.

Table 1-2. Real-time Monitor System Calls

System Call	Number	Hex
DEV_SETFLAG	133	85
DEV_WAITFLAG	132	84
DEV_POLL	131	83
P_ABORT	157	9D
P_CREATE	144	90
P_DELAY	141	8D
P_DISPATCH	142	8E
P_PDADR	156	9C
P_PRIORITY	145	91
P_TERM	143	8F
P_TERMCPM	0	00
Q_CREAT	138	8A
Q_CWRITE	140	8C
Q_DELETE	136	88
Q_MAKE	134	86
Q_OPEN	135	87
Q_READ	137	89
Q_WRITE	139	8B

1.5 Memory Management Module

The Memory Management module (MEM) handles all memory functions. Concurrent CP/M-86 supports an extended model of memory management. Future releases of Concurrent CP/M-86 may support different versions of the Memory module depending on classes of memory management hardware that become available.

The MEM module describes memory partitions internally by Memory Descriptors (MDs). Concurrent CP/M-86 initially places all available partitions on the Memory Free List (MFL). Once MEM allocates a partition (or set of contiguous partitions), it takes that partition off the MFL and places it on the Memory Allocation List (MAL). The Memory Allocation List contains descriptions of contiguous areas of memory known as Memory Allocation Units (MAUs). MAUs always contain one or more partitions. The MEM module manages the space within an MAU in the following way: when a process requests extra memory, MEM first determines if the MAU has enough unused space. If it does, the extra memory requested comes from the process's own partition first.

A process can only allocate memory from a MAU in which it already owns memory, or from a new MAU created from the MFL. If one process shares memory with another, either can allocate memory from the MAU that contains the shared memory segment. The MEM module keeps a count of how many processes "own" a particular memory segment to ensure that it becomes available within the MAU only when no processes own it. When all of the memory within an MAU is free, the MEM module frees the MAU and returns its memory partitions to the MFL.

If the system for which Concurrent CP/M-86 is being implemented contains memory management hardware, the XIOS can protect a process's memory when it is not in context. When the process is entering the operating system, all memory in the system should be made Read-Write. When a process is exiting the operating system, the process's memory should be made Read-Write, the operating system memory (from CCPMSEG to ENDSEG) made Read-Only, and all other memory made nonexistent. Memory protection can be implemented within the XIOS by a routine that intercepts the INT 224 entry point for Concurrent CP/M-86 system calls, and interrupt routines that handle attempted memory protection violations.

Figure 1-3 shows how to find a process's memory.

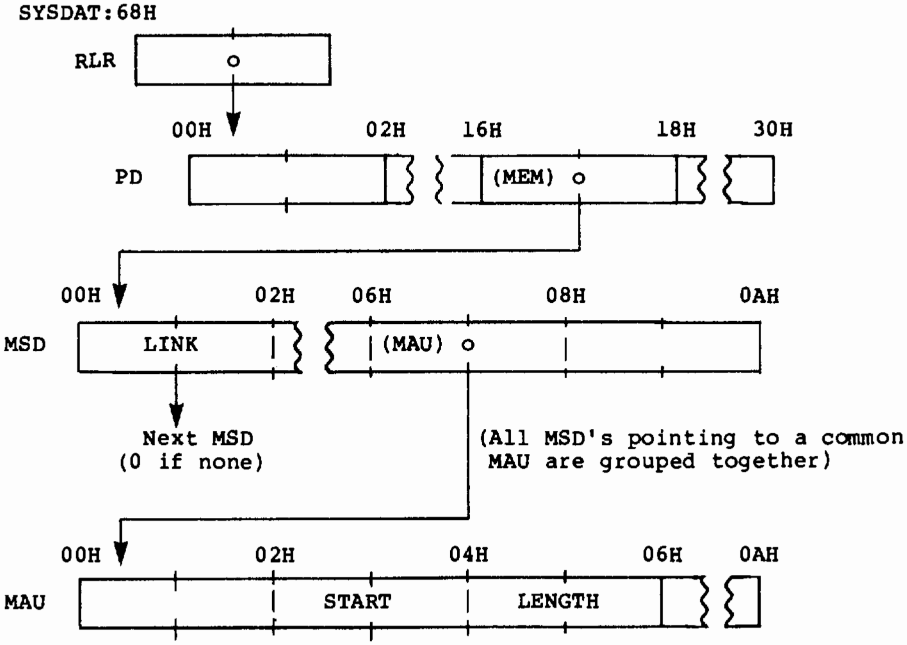


Figure 1-3. Finding a Process's Memory

Table 1-3. Definitions for Figure 1-3.

Data Field	Explanation
RLR	Ready List Root; points to currently running process.
MEM	MEM field of Process Descriptor.
PD	Process Descriptor; describes a process.
MSD	Memory Segment Descriptor; describes a single memory allocation. A process may have many of these in a linked list. The MSD list pointed to by the MEM field describes all the successful memory allocations made by the process. Also, many MSDs may point to the same MAU. All MSDs pointing to the same MAU are grouped together.
MAU	Memory Allocation Unit; describes a contiguous area of allocated memory. A MAU is built from one or more contiguous memory partitions. The START and LENGTH fields are the starting paragraph and number of paragraphs, respectively.

Table 1-4. Memory Management System Calls

System Call	Number	Hex
M_ALLOC	128, 129	80, 81
M_FREE	130	82
MC_ABS	54	36
MC_ALLFREE	58	3A
MC_ALLOC	55	37
MC_ALLOCABS	56	38
MC_FREE	57	39
MC_MAX	53	35

Note: the MC_ABS, MC_ALLOC, MC_ALLOCABS, MC_FREE, MC_ALLFREE, and MC_MAX system calls internally execute the M_ALLOC and M_FREE system calls. They are supported for compatibility with the CP/M-86 and MP/M-86™ operating systems.

1.6 Character I/O Manager

The Character Input/Output (CIO) module of Concurrent CP/M-86 handles all console and list device I/O, and interfaces to the XIOS, the PIN (Physical Input Process) and the VOUT (Virtual OUTput process). An overview of the CIO is presented in the Concurrent CP/M-86 Operating System Programmer's Reference Guide, and XIOS Character Devices are described in Section 4 of this manual. For details of the Console Control Block (CCB) and List Control Block (LCB) data structures, see Sections 4.1 and 4.3 respectively.

Table 1-5. Character I/O System Calls

System Call	Number	Hex
C_ASSIGN	149	95
C_ATTACH	146	92
C_CATTACH	162	0A2
C_DELIMIT	110	6E
C_DETACH	147	93
C_GET	153	99
C_MODE	109	6D
C_RAWIO	6	06
C_READ	1	01
C_READSTR	10	0A
C_SET	148	94
C_STAT	11	0B
C_WRITE	2	02
C_WRITEBLK	111	6F
C_WRITESTR	9	09
L_ATTACH	158	9E
L_CATTACH	161	0A1
L_DETACH	159	9F
L_GET	164	0A4
L_SET	160	0A0
L_WRITE	5	05
L_WRITEBLK	112	70

1.7 Basic Disk Operating System

The Basic Disk Operating System (BDOS) handles all file system functions. It is described in detail in the Concurrent CP/M-86 Operating System Programmer's Reference Guide. Table 1-6 lists the Concurrent CP/M-86 BDOS system calls.

Table 1-6. System Calls

System Call	Number	Hex
DRV_ACCESS	38	26
DRV_ALLOCVEC	27	1B
DRV_DPB	31	1F
DRV_FLUSH	48	30
DRV_GET	25	19
DRV_GETLABEL	101	65
DRV_LOGINVEC	24	18
DRV_RESET	37	25
DRV_ROVEC	29	1D
DRV_SET	14	0E
DRV_SETLABEL	100	64
DRV_SETRO	28	1E
DRV_SPACE	46	2E
F_ATTRIB	30	1E
F_CLOSE	16	10
F_DELETE	19	13
F_DMASEG	51	33
F_DMAGET	52	34
F_DMAOFF	26	1A
F_ERRMODE	45	2D
F_LOCK	42	2A
F_MAKE	22	16
F_MULTISEC	44	2C
F_OPEN	15	0F
F_PASSWD	106	6A
F_READ	20	14
F_READRAND	33	21
F_RANDREC	36	24
F_RENAME	23	17
F_SFIRST	17	11
F_SIZE	35	23
F_SNEXT	18	12
F_TIMEDATE	102	66
F_TRUNCATE	99	63
F_UNLOCK	43	2B
F_USERNUM	32	20
F_WRITE	21	15
F_WRITERAND	34	22
F_WRITEXFCB	103	67
F_WRITEZF	40	28
T_GET	105	69
T_SET	104	68

1.8 Extended I/O System

The Extended Input/Output System (XIOS) handles the physical interface to Concurrent CP/M-86. It is similar to the CP/M-86 BIOS module, but it is extended in several ways. By modifying the XIOS, you can run Concurrent CP/M-86 in a large variety of different hardware environments. The XIOS recognizes two basic types of I/O devices: character devices and disk drives. Character devices are devices that handle one character at a time, while disk devices handle random blocked I/O using data blocks sized from one physical disk sector to the number of physical sectors in 16K. Use of devices that vary from these two models must be implemented within the XIOS. In this way, they appear to be standard Concurrent CP/M-86 I/O devices to other operating system modules through the XIOS interface. Sections 4 through 6 contain detailed descriptions of the XIOS functions, and the source code for a sample implementation can be found in machine-readable format on the Concurrent CP/M-86 OEM release disk.

1.9 Reentrance in the XIOS

Concurrent CP/M-86 allows multiple processes to use certain XIOS functions simultaneously. The system guarantees that only one process uses a particular physical device at any given time. However, some XIOS functions handle more than one physical device, and thus their interfaces must be reentrant. An example of this is the IO_CONOUT Function. The calling process passes the console number to this function. There can be several processes using the function, each writing a character to a different virtual console or character device. However, only one process is actually outputting a character to a given device at any time.

IO_STATLINE can be called more than once. The CLOCK process calls the IO_STATLINE function once per second, and the PIN process will also call it on screen switches, CTRL-S, CTRL-P, and CTRL-O. As shown in the example XIOS, the IO_STATLINE routine should return if a process calls it while another process is executing its code.

Since the XIOS file functions, IO_SELDSK, IO_READ, IO_WRITE, and IO_FLUSH are protected by the MXdisk mutual exclusion queue, only one process may access them at a time. None of these XIOS functions, therefore, need to be reentrant.

1.10 SYSDAT Segment

The System Data Area (SYSDAT) is the data segment for all modules of Concurrent CP/M-86. The SYSDAT segment is composed of three main areas, as shown in Figure 1-4. The first part is the fixed-format portion, containing global data used by all modules. This is the SYSDAT DATA. It contains system variables, including values set by GENCCPM and pointers to the various system tables. The Internal Data portion contains fields of data belonging to individual operating system modules. The XIOS begins at the end of this second area of SYSDAT. The third portion of SYSDAT is the System Table Area, which is generated and initialized by the GENCCPM system generation utility.

Figure 1-4 shows the relationships among the various parts of SYSDAT.

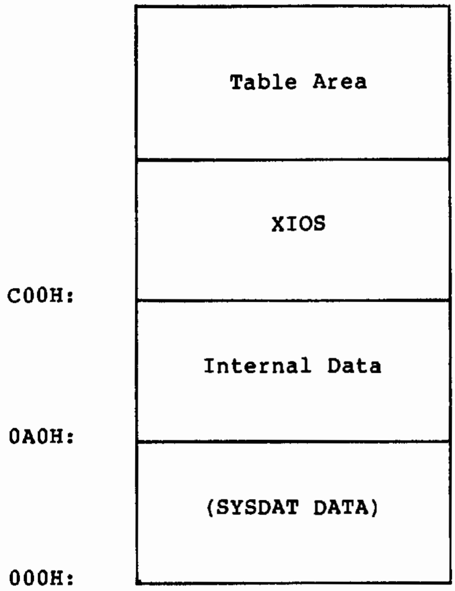


Figure 1-4. SYSDAT

Figure 1-5 gives the format of the SYSDAT DATA and describes its data fields.

00H	SUP ENTRY				RESERVED			
08H	RESERVED							
10H	RESERVED							
18H	RESERVED							
20H	RESERVED							
28H	XIOS ENTRY				XIOS INIT			
30H	RESERVED							
38H	DISPATCHER				PDISP			
40H	CCPMSEG		RSPSEG		ENDSEG		RESER -VED	NVCNS
48H	NLCB	NCCB	N_ FLAGS	SYS_ DISK	MMP		RESER -VED	DAY FILE
50H	TEMP DISK	TICKS /SEC	LUL		CCB		FLAGS	
58H	MDUL		MFL		PUL		QUL	
60H	QMAU							
68H	RLR		DLR		DRL		PLR	
70H	RESERVED		THRDRT		QLR		MAL	
78H	VERSION		VERNUM		CCPMVERNUM		TOD_DAY	
80H	TOD _HR	TOD _MIN	TOD _SEC	NCON DEV	NLST DEV	NCIO DEV	LCB	
88H	OPEN_FILE		LOCK_ MAX	OPEN_ MAX				

Figure 1-5. SYSDAT DATA

Table 1-7. SYSDAT DATA Data Fields

Data Field	Explanation
SUP ENTRY	Double-word address of the Supervisor entry point for intermodule communication. All internal system calls go through this entry point.
XIOS ENTRY	Double-word address of the Extended I/O System entry point for intermodule communication. All XIOS function calls go through this entry point.
XIOS INIT	Double-word address of the Extended I/O System Initialization entry point. System hardware initialization takes place by a call through this entry point.
DISPATCHER	Double-word address of the Dispatcher entry point that handles interrupt returns. Executing a JMPF instruction to this address is equivalent to executing an IRET (Interrupt Return) instruction. The Dispatcher routine causes a dispatch to occur and then executes an Interrupt Return. All registers are preserved and one level of stack is used. The address in this location can be used by XIOS interrupt handlers for termination instead of executing an IRET instruction. The TICK interrupt handler (I_TICK in the example XIOS) ends with a Jump Far (JMPF) to the address in this location. Usually, interrupt handlers that make DEV_SETFLAG calls end with a jump far to the address stored in the DISPATCHER field. Refer to the example XIOS interrupt routines and Sections 3.5 and 3.6 for more detailed information.
PDISP	Double-word address of the Dispatcher entry point that causes a dispatch to occur with all registers preserved. Once the dispatch is done, a RETF instruction is executed. Executing a JMPF PDISP is equivalent to executing a RETF instruction. This location should be used as an exit point whenever the XIOS releases a resource that might be wanted by a waiting process.

Table 1-7. (continued)

Data Field	Explanation
CCPMSEG	Starting paragraph of the operating system area. This is also the Code Segment of the Supervisor Module.
RSPSEG	Paragraph Address of the first RSP in a linked list of RSP Data Segments. The first word of the data segment points to the next RSP in the list. Once the system has been initialized, this field is zero. See the Concurrent CP/M-86 Operating System Programmer's Reference Guide section on debugging RSPs for more information.
ENDSEG	First paragraph beyond the end of the operating system area, including any buffers consisting of uninitialized RAM allocated to the operating system by GENCCPM. These include the Directory Hashing, Disk Data, and XIOS ALLOC buffers. These buffer areas, however, are not part of the CCPM.SYS file.
NVCNS	Number of virtual consoles, copied from the XIOS Header by GENCCPM.
NLCB	Number of List Control Blocks, copied from the XIOS Header by GENCCPM.
NCCB	Number of Character Control Blocks, copied from the XIOS Header by GENCCPM.
NFLAGS	Number of system flags as specified by GENCCPM.
SYSDISK	Default system disk. The CLI (Command Line Interpreter) looks on this disk if it cannot open the command file on the user's current default disk. Set by GENCCPM.
MMP	Maximum memory allowed per process. Set during GENCCPM.
DAY FILE	Day File option. If this field is OFFH, the operating system displays date and time information when an RSP or CMD file is invoked. Set by GENCCPM.

Table 1-7. (continued)

Data Field	Explanation
TEMP DISK	Default temporary disk. Programs that create temporary files should use this disk. Set by GENCCPM.
TICKS/SEC	The number of system ticks per second.
LUL	Locked Unused List. Link list root of unused Lock list items.
CCB	Address of the Character Control Block Table, copied from the XIOS Header by GENCCPM.
FLAGS	Address of the Flag Table.
MDUL	Memory Descriptor Unused List. Link list root of unused Memory Descriptors.
MFL	Memory Free List. Link list root of free memory partitions.
PUL	Process Unused List. Link list root of unused Process Descriptors.
QUL	Queue Unused List. Link list root of unused Queue Descriptors.
QMAU	Queue buffer Memory Allocation Unit.
RLR	Ready List Root. Linked list of PDs that are ready to run.
DLR	Delay List Root. Link list of PDs that are delaying for a specified number of system ticks.
DRL	Dispatcher Ready List. Temporary holding place for PDs that have just been made ready to run.
PLR	Poll List Root. Linked list of PDs that are polling on devices.
THRDRT	Thread List Root. Linked list of all current PDs on the system. The list is threaded though the THREAD field of the PD instead of the LINK field.

Table 1-7. (continued)

Data Field	Explanation
QLR	Queue List Root. Linked list of all System QDs.
MAL	Memory Allocation List; link list of active memory allocation units. A MAU is created from one or more memory partitions.
VERSION	Address, relative to CCPMSEG, of ASCII version string.
VERNUM	Concurrent CP/M-86 version number (returned by the S_BDOSVER system call).
CCPMVERNUM	Concurrent CP/M-86 version number (system call 163, S_OSVER).
TOD_DAY	Time of Day. Number of days since 1 Jan, 1978.
TOD_HR	Time of Day. Hour of the day.
TOD_MIN	Time of Day. Minute of the hour.
TOD_SEC	Time of Day. Second of the minute.
NCONDEV	Number of XIOS consoles, copied from the XIOS Header by GENCCPM.
NLSTDEV	Number of XIOS list devices, copied from the XIOS Header by GENCCPM.
NCIODEV	Total number of character devices (NCONDEV + NLSTDEV).
LCB	Offset of the List Control Block Table, copied from the XIOS Header by GENCCPM.
OPEN_FILE	Open File Drive Vector. Designates drives that have open files on them. Each bit of the word value represents a disk drive; the least significant bit represents Drive A, and so on through the most significant bit, Drive P. Bits which are set indicate drives containing open files.
LOCK_MAX	Maximum number of locked records per process. Set during GENCCPM.
OPEN_MAX	Maximum number of open disk files per process. Set during GENCCPM.

1.11 Resident System Processes

Resident System Processes (RSPs) are an integral part of the Concurrent CP/M-86 operating system. At system generation, the GENCCPM RSP menu lets you select which RSPs to include in the operating system. GENCCPM then places all selected RSPs in a contiguous area of RAM starting at the end of SYSDAT. The main advantage of an RSP is that it is permanently resident within the Operating System Area, and does not have to be loaded from disk whenever it is needed.

Concurrent CP/M-86 automatically allocates a Process Descriptor (PD) and User Data Area (UDA) for a transient program, but each RSP is responsible for the allocation and initialization of its own PD and UDA. Concurrent CP/M-86 uses the PD and QD structures declared within an RSP directly if they fall within 64K of the SYSDAT segment address. If outside 64K, the RSP's PD and QD are copied to a PD or QD allocated from the Process Unused List or the Queue Unused List. In either case the PD and QD of the RSP lie within 64K of the beginning of the SYSDAT Segment. This allows RSPs to occupy more area than remains in the 64K SYSDAT segment.

Further details on the creation and use of RSPs can be found in the Concurrent CP/M-86 Operating System Programmer's Reference Guide.

End of Section 1

Section 2
System Generation

The Concurrent CP/M-86 XIOS should be written as an 8080 model (mixed code and data) program and origined at location 0C00H using the ASM86 ORG assembler directive. Once you have written or modified the XIOS source for a particular hardware configuration, use the Digital Research assembler ASM-86™ to generate an XIOS.CON file for use with GENCCPM:

```
A>ASM86 XIOS               ; Assemble the XIOS

A>GENCMD XIOS 8080         ; Create XIOS.CMD from XIOS.H86

A>REN XIOS.CON=XIOS.CMD    ; Rename XIOS.CMD to XIOS.CON
```

Then invoke the GENCCPM program to produce a system image in the CCPM.SYS file by typing the command:

```
A>GENCCPM                  ; generate system image
```

2.1 GENCCPM Operation

You can generate a Concurrent CP/M-86 system by running the GENCCPM program under an existing CP/M-86 or Concurrent CP/M-86 system. GENCCPM builds the CCPM.SYS file, which is an image of the Concurrent CP/M-86 operating system. Then you can use DDT-86™ or SID-86™ to place the CCPM.SYS file in memory for debugging under CP/M-86.

GENCCPM allows the user to define certain hardware-dependent variables, the amount of memory to reserve for system data structures, the selection and inclusion of Resident System Processes in the CCPM.SYS file, and other system parameters. The first action GENCCPM performs is to check the current default drive for the files necessary to construct the operating system image:

● SUP.CON	Supervisor Code Module
● RTM.CON	Real Time Monitor Code Module
● MEM.CON	Memory Manager Code Module
● CIO.CON	Character Input/Output Code Module
● BDOS.CON	Basic Disk Operating System Code Module
● XIOS.CON	Extended Input/Output System Module
● SYSDAT.CON	SYSDAT DATA and Internal Data modules of SYSDAT segment
● VOUT.RSP	Virtual console OUTput process
● PIN.RSP	Physical keyboard INput process
● TMP.RSP	Terminal Message Process
● CLOCK.RSP	CLOCK process
● DIR.RSP	DIRectory process
● ABORT.RSP	ABORT process

Note: *.RSP = Resident System Process file. The VOUT, PIN, TMP, and CLOCK RSPs are required for Concurrent CP/M-86 to run. The RSPs listed are all distributed with Concurrent CP/M-86.

If GENCCPM does not find the preceding .CON files on the default drive, it prints an error message on the console:

```
Can't find these modules: <FILESPEC>...{<FILESPEC>}
```

where FILESPEC is the name of the missing file.

2.2 GENCCPM Main Menu

All of the GENCCPM Main Menu options have default values. When generating a system, GENCCPM assumes the value shown in square brackets, unless you specify another value. Any menu item that requires a yes or no response represents a Boolean value, and can be toggled simply by entering the variable. For example, entering VERBOSE in response to the GENCCPM prompt will change the state of the VERBOSE variable from the default state, [Y], to the opposite state.

In the GENCCPM Main Menu illustrated in Figure 2-1, all numeric values are in hexadecimal notation.

```
GENCCPM  vX.X [MM/DD/YY]
GENerate system image for Concurrent CP/M-86 2.0
Constructing new CCPM.SYS file


*** Concurrent CP/M-86 2.0 GENCCPM Main Menu ***

        help          GENCCPM Help
     verbose [Y]      More Verbose GENCCPM Messages
   destdrive [A:]     CCPM.SYS Output To (Destination) Drive
   deletesys [N]      Delete (instead of rename) old CCPM.SYS file

   sysparams          Display/Change System Parameters
      memory          Display/Change Memory Allocation Partitions
 diskbuffers          Display/Change Disk Buffer Allocation
     oslabel          Display/Change Operating System Label
        rsps          Display/Change RSP List

      gensys          I'm finished changing things, go
                      GENerate a SYStem

CHANGES?__
```

Figure 2-1. GENCCPM Main Menu

If you type HELP in response to the GENCCPM Main Menu prompt CHANGES?, as shown in this example:

```
   CHANGES? HELP <cr>
```

the program prints the following message on the Help Function Screen:

```
                  *** GENCCPM Help Function ***
                  =============================

   GENCCPM  lets you edit and  generate a system image
   from  operating system  modules on the default disk
   drive.   A  detailed explanation  of  each  GENCCPM
   parameter  may be found in  the  Concurrent CP/M-86
   System Guide, Section 2.

   GENCCPM  assumes the  default  values shown  within
   square brackets.   All numbers are in  Hexadecimal.
   To change a parameter,  enter  the  parameter  name
   followed by  "="  and the  new  value.   Type  <cr>
   (carriage return) to enter the assignment.  You can
   make multiple assignments if you separate them by a
   space.  No spaces are allowed within an assignment.
   Example:

   CHANGES?  verbose=N sysdrive=A: openmax=1A <cr>

   Parameter  names  may  be  shortened to the minimum
   combination of  letters  unique  to  the  currently
   displayed menu.  Example:

   CHANGES?  v=N des=A: del=Y <cr>

   Press RETURN to continue...__
```

Figure 2-2. GENCCPM Help Function Screen 1

```
Sub-menus (the  last  6  options)  are accessed  by
typing the sub-menu name followed by <cr>.  You may
enter multiple sub-menus,  in which  case each sub-
menu will be displayed in order.  Example:

CHANGES? help sysparams rsps oslabel <cr>

Enter <cr> alone to exit a menu, or a parameter name,
"=" and the new value to assign a parameter.  Multiple
assignments may be entered,  as  in  response  to the
Main Menu prompt.

Press RETURN to continue.__
```

Figure 2-3. GENCCPM Help Function Screen 2

Table 2-1 describes the remaining GENCCPM Main Menu options.

Table 2-1. GENCCPM Main Menu Options

Option	Explanation
VERBOSE	The GENCCPM program messages are normally verbose. However, experienced operators might want to limit them in the interest of efficiency. Setting VERBOSE to N (no) limits the length of GENCCPM messages to the absolute minimum.
DESTDRIVE	The drive upon which the generated CCPM.SYS file is to reside. If no destination drive is specified, GENCCPM assumes the currently logged drive as the default.
DELETESYS	Delete, instead of rename, old CCPM.SYS file. Normally, GENCCPM renames the previous system file to CCPM.OLD before building the new system image. By specifying DELETESYS=Y, you cause GENCCPM to delete the old file instead. This is useful when disk space is limited.
SYSPARAMS	Typing SYSPARAMS <cr> displays the GENCCPM System Parameter Menu. See Figure 2-4 and accompanying text.

Table 2-1. (continued)

Option	Explanation
MEMORY	Typing MEMORY <cr> displays the GENCCPM Memory Partition Menu. See Figure 2-5 and accompanying text.
DISKBUFFERS	Typing DISKBUFFERS <cr> displays the GENCCPM Disk Buffer Allocation Menu. See Figure 2-7 and accompanying text.
OSLABEL	Typing OSLABEL <cr> displays the GENCCPM Operating System Label Menu. See Figure 2-8 and accompanying text.
RSPS	Typing RSPS <cr> displays the GENCCPM RSP List Menu. See Figure 2-6 and accompanying text.
GENSYS	Typing GENSYS <cr> initiates the GENeration of the SYStem file. When using an input file to specify system parameters, and the GENSYS command is not the last line in the input file, GENCCPM goes into interactive mode and prompts you for any additional changes. See Section 2.9, "GENCCPM Input Files," for more information.

Note: to create the CCPM.SYS file you must type in the GENSYS command, or include it in the GENCCPM input file.

2.3 System Parameters Menu

The GENCMD System Parameters Menu is shown in Figure 2-3. You access this menu by typing SYSPARAMS in response to the Main Menu.

Note: all GENCCPM parameter values are in hexadecimal.

```
            *** Display/Change System Parameters Menu ***

   sysdrive [B:]   System Drive
   tmpdrive [B:]   Temporary File Drive
 cmdlogging [N]    Command Day/File Logging at Console
 compatmode [Y]    CP/M FCB Compatibility Mode
     memmax [4000] Maximum Memory per Process (paragraphs)
    openmax [20]   Open Files per Process Maximum
    lockmax [20]   Locked Records per Process Maximum

    osstart [1008] Starting Paragraph of Operating System
 nopenfiles [  40] Number of Open File and Locked Record Entries
    npdescs [14]   Number of Process Descriptors
      nqcbs [20]   Number of Queue Control Blocks
   qbufsize [ 400] Queue Buffer Total Size in bytes

CHANGES?__
```

Figure 2-4. GENCCPM System Parameters Menu

Table 2-2. System Parameters Menu Options

Option	Explanation
SYSDRIVE	The system drive where Concurrent CP/M-86 looks for a transient program when it is not found on the current default drive. All the commonly used transient processes can thus be placed on one disk under User Number 0 and are not needed on every drive and user number. See the <u>Concurrent CP/M-86 Operating System User's Guide</u> for information on how the operating system performs file searches.
TMPDRIVE	The drive entered here is used as the drive for temporary disk files. This entry can be accessed in the System Data Segment by application programs as the drive on which to create temporary files. The temporary drive should be the fastest drive in the system, for example, the Memory Disk, if implemented.

Table 2-2. (continued)

Option	Explanation
CMDLOGGING	Entering the response [Y] causes the generated Concurrent CP/M-86 Command Line Interpreter (CLI) to display the current time and how the command will be executed.
COMPATMODE	CP/M..FCB Compatibility Mode [Y]. When the default value [Y] is set, the operating system recognizes the compatibility attributes. Setting this parameter to [N] makes the generated system ignore the compatibility attributes. See the Concurrent CP/M-86 Operating System Programmer's Reference Guide, Section 2.12, "Compatibility Attributes," for more information on this feature.
MEMMAX	Maximum Paragraphs Per Process [4000]. A process may make Concurrent CP/M-86 memory allocations. This parameter puts an upper limit on how much memory any one process can obtain. The default shown here is 256K (40000H) bytes.
OPENMAX	Maximum Open Files per Process [20]. This parameter specifies the maximum number of files that a single process, usually one program, can open at any given time. This number can range from 0 to 255 (0FFH) and must be less than or equal to the total open files and locked records for the system. See the explanation of the NOPENFILES parameter below.
LOCKMAX	Maximum Locked Records per Process [20]. This parameter specifies the maximum number of records that a single process, usually one program, can lock at any given time. This number can range from 0 to 255 (0FFH) and must be less than or equal to the total open files and locked records for the system. See the explanation of the NOPENFILES parameter in the SYSPARAMS Menu.

Table 2-2. (continued)

Option	Explanation
OSSTART	Starting Paragraph of the operating system [1008]. The starting paragraph is where the CCPMLDR is to put the operating system. Code execution starts here, with the CS register set to this value and the IP register set to 0. The Data Segment Register is set to the SYSDAT segment address. When first bringing up and debugging Concurrent CP/M-86 under CP/M-86, the answer to this question should be 8 plus where DDT-86 running under CP/M-86 reads in the file using the R command. The DDT86 R command also can be used to read the CCPM.SYS file to a specific memory location. After debugging the system, you might want to relocate it to an address more appropriate to your hardware configuration. This location naturally depends on where the Boot Sector and Loader are placed, and how much RAM is used by ROM monitor or memory-mapped I/O devices.
NOPENFILES	Total Open Files in System [40]. This parameter specifies the total size of the System Lock List, which includes the total number of open disk files plus the total number of locked records for all the processes executing under Concurrent CP/M-86 at any given time. This number must be greater than or equal to the maximum open files per process (the OPENMAX parameter above) and the maximum locked records per process (the LOCKMAX parameter above). It is possible either to allow each process to use up the total System Lock List space, or to allow each process to only open a fraction of the system total. The first technique implies a situation where one process can forcibly block others because it has consumed all the available Lock list items.

Table 2-2. (continued)

Option	Explanation
NPDESCS	Number Of Process Descriptors [14]. For each memory partition, at least one transient program can be loaded and run. If transient programs create child processes, or if RSPs extend past 64K from the beginning of SYSDAT, extra Process Descriptors are needed. When first bringing up and debugging Concurrent CP/M-86, the default for this parameter suffices. After the debug phase, during system tuning, you can use the Concurrent CP/M-86 SYSTAT Utility to monitor the number of processes and queues in use by the system at any time.
NQCBS	Number Of Queue Control Blocks [20]. The number of Queue Control Blocks should be the maximum number of queues that may be created by transient programs or RSPs outside of 64k from SYSDAT. The default value suffices during initial system debugging.
QBUFSIZE	Size Of Queue Buffer Area in Bytes [400]. The Queue Buffer Area is space reserved for Queue Buffers. The size of the buffer area required for a particular queue is the message length times the number of messages. The Queue Buffer Area should be the anticipated maximum that transient programs will need. Again, the default value will be adequate for initial system debugging. Note that the Queue Buffer Area can be large enough (up to 0FFFFH) to extend past the SYSDAT 64K boundary.

2.4 Memory Allocation Menu

The Memory Allocation Partitions Menu, shown in Figure 2-5, is an interactive menu. When the menu is first displayed, it lists the current memory partitions. If none have been specified, the list field is blank. Following the list is the menu of options available. You may choose either to ADD to the list of partitions, or to DELETE one or more partitions. Partition assignments must be made by specifying either ADD or DELETE, followed by an equal sign, the starting address and last address of the memory region to be partitioned, and the size, in paragraphs, of each partition. All values must be in hexadecimal notation and separated by commas. An asterisk can be used to delete all memory partitions. The Start and Last values are paragraph addresses; multiply them by 16 (10H) to obtain absolute addresses. Similarly, partition sizes are in paragraphs; multiply by 16 (10H) to obtain size in bytes.

In the example below, all default memory partitions are first deleted (DELETE=*). Then two kinds of memory partitions are added to the list: 16K (4000h) partitions from address 2400:0 to 4000:0, and 32K (8000h) partitions from 4000:0 to 6000:0.

```
        Addresses          Partitions
#     Start     Last      Size      Qty
1.     400h     6000h     400h      17h

*** GENCCPM Memory Allocation Partitions Menu ***
=================================================
     add        ADD memory partition(s)
   delete       DELETE memory partition(s)

CHANGES? delete=* add=2400,4000,400 add=4000,6000,800

        Addresses          Partitions
#     Start     Last      Size      Qty
1.    2400h     4000h     400h      7h
2.    4000h     6000h     800h      4h


*** GENCCPM Memory Allocation Partitions Menu ***
=================================================
     add        ADD memory partition(s)
   delete       DELETE memory partition(s)

CHANGES? <cr>
```

Figure 2-5. GENCCPM Memory Allocation Sample Session

Memory partitions are highly dependent on the particular hardware environment. Therefore, you should carefully examine the defaults that are given, and change them if they are inappropriate. The memory partitions cannot overlap, nor can they overlap the operating system area. GENCCPM checks and trims memory partitions that overlap the operating system but does not check for partitions that refer to nonexistent system memory. GENCCPM does not size existing memory because the hardware on which it is running might be different from the target Concurrent CP/M-86 machine (this may be done by the XIOS at initialization time). Error messages are displayed in case of overlapping or incorrectly sized partitions, but GENCCPM does not automatically trim overlapping memory partitions. GENCCPM does not allow you to exit the Main Menu or the Memory Allocation Menu if the memory partition list is not valid.

The nature of your application dictates how you should specify the partition boundaries in your system. The system never divides a single partition among unrelated programs. If any given memory request requires a memory segment that is larger than the available partitions, the system concatenates adjoining partitions to form a single contiguous area of memory. The MEM module algorithm that determines the best fit for a given memory allocation request takes into account the number of partitions that will be used and the amount of unused space that will be left in the memory region. This allows you to evaluate the tradeoffs between memory allocation boundary conditions causing internal versus external memory fragmentation, as described below.

External memory fragmentation occurs when memory is allocated in small amounts. This can lead to a situation where there is plenty of memory but no contiguous area large enough to load a large program. Internal fragmentation occurs when memory is divided into large partitions, and loading a small program leaves large amounts of unused memory in the partition. In this case, a large program can always load if a partition is available, but the unused areas within the large partitions cannot be used to load small programs if all partitions are allocated.

When running GENCCPM you can specify a few large partitions, many small partitions, or any combination of the two. If a particular environment requires running many small programs frequently and large programs only occasionally, memory should be divided into small partitions. This simulates dynamic memory management as the partitions become smaller. Large programs are able to load as long as memory has not become too fragmented. If the environment consists of running mostly large programs or if the programs are run serially, the large-partition model should be used. The choice is not trivial and may require some experimentation before a satisfactory compromise is attained. Typical solutions divide memory into 4K to 16K partitions.

2.5 GENCCPM RSP List Menu

The GENCCPM RSP (Resident System Process) List Menu is shown in Figure 2-6. The example session illustrates excluding ABORT.RSP and MY.RSP from the list of RSPs to be included in the system.

```
*** GENCCPM RSP List Menu ***
=============================
RSPs to be included are:

        PIN.RSP         DIR.RSP         ABORT.RSP        TMP.RSP
        VOUT.RSP        CLOCK.RSP       MY.RSP

Display/Change RSP List
    include          Include RSPs
    exclude          Exclude RSPs

CHANGES?__exclude=abort.rsp,my.rsp

RSPs to be included are:

        PIN.RSP         DIR.RSP         VOUT.RSP        CLOCK.RSP
        TMP.RSP

CHANGES?__<cr>
```

Figure 2-6. GENCCPM RSP List Menu Sample Session

The GENCCPM RSP List Menu first reads the directory of the current default disk and lists all .RSP files present. Responding to the GENCCPM prompt CHANGES? with either an include or exclude command edits the list of RSPs to be made part of the operating system at system generation time. The wildcard (*:) file specification can be used with the include command to automatically include all .RSP files on the disk.

Note: the PIN, VOUT, and CLOCK RSPs must be included for Concurrent CP/M-86 to run.

2.6 GENCCPM OSLABEL Menu

If you type OSLABEL in response to the main menu prompt, as shown in this example:

```
CHANGES? OSLABEL
```

the following screen menu appears on your screen:

```
Display/Change Operating System Label
Current message is:
<null>

Add lines to message.  Terminate by entering only RETURN:
```

Figure 2-7. GENCCPM Operating System Label Menu

You can type any message at this point. This message is printed on each virtual console when the system boots up. Note that if the message contains a $, GENCCPM accepts it, but it causes the operating system to terminate the message when it is being printed. This is because the operating system uses the C_WRITESTR function to print the message, and $ is the default message terminator.

The XIOS may also print its own sign-on message during the INIT routine. In this case, the XIOS message appears before the message specified in the GENCCPM OSLABEL Menu.

2.7 GENCCPM Disk Buffering Menu

Typing DISKBUFFERS in response to the main menu prompt displays the GENCCPM Disk Buffering Menu. Figure 2-8 shows a sample session:

```
          *** Disk Buffering Information ***
      Dir  Max/Proc   Data Max/Proc   Hash   Specified
Drv   Bufs Dir Bufs   Bufs Dat Bufs   -ing   Buf Bytes
===   ==== ========   ==== ========   ====   =========
A:     ??     0        ??     0        yes     ??
B:     ??     0        ??     0        yes     ??
C:     ??     0        ??     0        yes     ??
D:     ??     0        ??     0        yes     ??
E:     ??     0        ??     0        yes     ??
M:     ??     0       fixed           fixed    ??
          Total bytes allocated to buffers: 0
Drive (<cr> to exit) ? a:
Number of directory buffers, or drive to share with? 8
Maximum directory buffers per process [8] ? 4
Number of data buffers, or drive to share with? 4
Maximum data buffers per process [4]? 2
Hashing [yes] ? <cr>

          *** Disk Buffering Information ***
      Dir  Max/Proc   Data Max/Proc   Hash   Specified
Drv   Bufs Dir Bufs   Bufs Dat Bufs   -ing   Buf Bytes
===   ==== ========   ==== ========   ====   =========
A:      8     4         4     2        yes     2000
B:     ??     0        ??     0        yes     ??
C:     ??     0        ??     0        yes     ??
D:     ??     0        ??     0        yes     ??
E:     ??     0        ??     0        yes     ??
M:     ??     0       fixed           fixed    ??
Total bytes allocated to buffers: 2000
Drive (<cr> to exit) ? *:
Number of directory buffers, or drive to share with? a:
Number of data buffers, or drive to share with? a:
Hashing [yes] ? <cr>

          *** Disk Buffering Information ***
      Dir  Max/Proc   Data Max/Proc   Hash   Specified
Drv   Bufs Dir Bufs   Bufs Dat Bufs   -ing   Buf Bytes
===   ==== ========   ==== ========   ====   =========
A:      8     4         4     2        yes     2000
B:     shares A:       shares A:       yes      800
C:     shares A:       shares A:       yes      200
D:     shares A:       shares A:       yes      180
E:     shares A:       shares A:       yes      100
M:     shares A:       fixed          fixed       0
Total bytes allocated to buffers: 2C80

Drive (<cr> to exit) ? <cr>
```

Figure 2-8. GENCCPM Disk Buffering Sample Session

In the sample session shown in Figure 2-8, GENCCPM is reading the DPH addresses from the XIOS Header, and calculating the buffer parameters based upon the data in the DPHs and the answers to its questions. GENCCPM only asks questions for the relevant fields in the DPH which you have marked with 0FFFFh values. See Section 5.4, "Disk Parameter Header," for a detailed explanation of DPH fields and GENCCPM table generation. An asterisk can be used to specify all drives, in which case GENCCPM applies your answers to the following questions to all unconfigured drives.

Note that GENCCPM prints out how many bytes of memory must be allocated to implement your disk buffering requests. You should be aware that disk buffering decisions can significantly impact the performance and efficiency of the system being generated. If minimizing the amount of memory occupied by the system is an important consideration, you can use the Disk Buffering Menu to specify a minimal disk buffer space. We have found, however, that the amount of Directory Hashing space allocated has the most impact on system performance, followed by the amount of Directory Buffer space allocated. As with the trade-offs in memory partition allocation discussed above, deciding on the proper ratio of operating system space to performance requires some experimentation.

GENCCPM checks to see that the relevant fields in the DPHs are no longer set to 0FFFFH. GENCCPM does not allow you to exit from the Main Menu until these fields have been set using the Disk Buffering Menu.

2.8 GENCCPM GENSYS Option

Finally, specifying the GENSYS option in answer to the main menu prompt causes GENCCPM to generate the system image on the specified destination disk drive. During the actual system generation, the following messages print out on the screen:

```
Generating new SYS file
Generating tables
Appending RSPs to system file
Doing Fixups
SYS image load map:
        Code starts at GGGGh
        Data starts at HHHHh
       Tables start at IIIIh
         RSPs start at JJJJh
 XIOS Buffers start at KKKKh
          End of OS at LLLLh
                                           -------
Trimming memory partitions.  New List:         ^
                                              |
        Addresses          Partitions         |
      (in Paragraphs)    Size      How     (only if
#     Start     Last    (Paras.)   Many     necessary)
1.    AAAAh     BBBBh    XXXXh      Yh        |
2.    MMMMh     NNNNh    QQQQh      Vh        |
                                              v
                                           -------

Wrapping up

A>
```

Figure 2-9. GENCCPM System Generation Messages

2.9 GENCCPM Input Files

GENCCPM allows you to input all system generation commands from an input file. It also facilitates redirection of the console output to a disk file if desired. You initiate these GENCCPM features by invoking it with command of the form:

```
GENCCPM <filein >fileout
```

where filein is the name of the GENCCPM input file. Note that no spaces may intervene between the greater-than or less-than sign and the file specification. If this condition is not met, GENCCPM responds with the message:

```
REDIRECTION ERROR
```

The format of the input file is similar to a SUBMIT file; each command is entered on a separate line, followed by a carriage return, exactly in the order required during a manually operated GENCCPM session. The last command can be followed by a carriage return and the command:

A>**GENSYS**

to end the command sequence and generate the system. If the GENSYS command is not present, GENCCPM queries the console for changes.

The following example illustrates the use of the GENCCPM input file. Assuming that the input file file specification is GENCCPM.IN, use the following command to invoke GENCCPM:

A>**GENCCPM <GENCCPM.IN**

Figure 2-10 shows a typical GENCCPM command file:

```
VERBOSE=N DESTDRIVE=D:
SYSPARAMS
OSSTART=4000 NPDESCS=20 QBUFSIZE=4FF TMPDRIVE=A: CMDLOGGING=Y
<cr>
MEMORY
DELETE=* ADD=2400,4000,400 ADD=4000,6000,800
<cr>
DISKBUFFERS
A:
8
4
4
2
hashing
*:        ; for all remaining drive questions
A:        ; share directory buffers with A:
A:        ; share data buffers with A:
hashing   ; hashing on all drives
<cr>
OSLABEL
Concurrent CP/M-86  Version 1.21  04/15/83
Hardware Configuration:
         A: 10 MB Hard Disk
         B: 5 MB Hard Disk
         C: Single-density Floppy
         D: Double-density Floppy
         M: Memory Disk
<cr>
GENSYS <cr> <------- Only if you do not want to be able
                       to specify additional changes
```

Figure 2-10. Typical GENCCPM Command File

After reading in the command file and optionally accepting any additional changes you want to make, GENCCPM builds a system image in the CCPM.SYS file in the manner described in Section 2.1.

End of Section 2

Section 3
XIOS Overview

Concurrent CP/M-86 version 2.0, as implemented with the example XIOS discussed in Section 3.1, is configured for operation with the IBM Personal Computer with two 5 1/4-inch, double-density, single-sided, floppy disk drives and at least 128K of RAM. All hardware dependencies are concentrated in subroutines collectively referred to as the Extended Input/Output System, or XIOS. You can modify these subroutines to tailor the system to almost any 8086 or 8088 disk-based operating environment. This section provides an overview of the XIOS, and variables and tables referenced within the XIOS.

The following material assumes that you are familiar with the CP/M-86 BIOS. To fully use this material, refer frequently to the example XIOS found in source code form on the Concurrent CP/M-86 distribution disk.

Note: programs that depend upon the interface to the XIOS must check the version number of the operating system before trying direct access to the XIOS. Future versions of Concurrent CP/M-86 can have different XIOS interfaces, including changes to XIOS function numbers and/or parameters passed to XIOS routines.

The XIOS must fit within the 64K System Data Segment along with the SYSDAT and Table Area. Concurrent CP/M-86 accesses the XIOS through the two entry points INIT and ENTRY at offset 0C00H and 0C03H, respectively, in the System Data Segment. The INIT entry point is for system hardware initialization only. The ENTRY entry point is for all other XIOS functions. Since all operating system routines use a Call Far instruction to access the XIOS through these two entry points, the XIOS function routines must end with a Return Far instruction. Subsequent sections describe the XIOS entry points and other fixed data fields.

3.1 XIOS Header

The XIOS Header contains variables that GENCCPM uses when constructing the CCPM.SYS file and that the operating system uses when executing. Figure 3-1 illustrates the XIOS header.

<table>
<tr><td>C00H</td><td colspan="3">JMP INIT</td><td colspan="3">JMP ENTRY</td><td colspan="2">SYSDAT</td></tr>
<tr><td>C08H</td><td colspan="4">SUPERVISOR</td><td>TICK</td><td>TICKS
_SEC</td><td>DOOR</td><td>RESERVED</td></tr>
<tr><td>C10H</td><td>RESERVED</td><td>NVCNS</td><td>NCCB</td><td>NLCB</td><td colspan="2">CCB</td><td colspan="2">LCB</td></tr>
<tr><td>C18H</td><td colspan="2">DPH(A)</td><td colspan="2">DPH(B)</td><td colspan="2">DPH(C)</td><td colspan="2">DPH(D)</td></tr>
<tr><td>C20H</td><td colspan="2">DPH(E)</td><td colspan="2">DPH(F)</td><td colspan="2">DPH(G)</td><td colspan="2">DPH(H)</td></tr>
<tr><td>C28H</td><td colspan="2">DPH(I)</td><td colspan="2">DPH(J)</td><td colspan="2">DPH(K)</td><td colspan="2">DPH(L)</td></tr>
<tr><td>C30H</td><td colspan="2">DPH(M)</td><td colspan="2">DPH(N)</td><td colspan="2">DPH(O)</td><td colspan="2">DPH(P)</td></tr>
<tr><td>C38H</td><td colspan="2">ALLOC</td><td colspan="6"></td></tr>
</table>

Figure 3-1. XIOS Header

Table 3-1. XIOS Header Data Fields

Data Field	Explanation
JMP INIT	XIOS Initialization Point. At system boot, the Supervisor module executes a CALL FAR instruction to this location in the XIOS (XIOS Code Segment: 0C00H). This call transfers control to the XIOS INIT routine, which initializes the XIOS and hardware, then executes a RETURN FAR instruction. **The JMP INIT instruction must be present in the XIOS.A86 file.** For details of the INIT routine see Section 3.2, "INIT Entry Point."
JMP ENTRY	XIOS Entry Point. All access to the XIOS functions goes through the XIOS Entry Point. The operating system executes a far call (CALLF) to this location in the XIOS (XIOS Code Segment: 0C03H) whenever I/O is needed. This instruction transfers control to the XIOS ENTRY routine which calls the appropriate function within the XIOS. Once the function is complete, the ENTRY routine executes a return far (RETF) to the operating system. The RETF instruction must be present in the XIOS.A86 file. For details of the ENTRY routine, see Section 3.3, "XIOS ENTRY."

Table 3-1. (continued)

Data Field	Explanation

SYSDAT	The segment address of SYSDAT. It is in the Code Segment of the XIOS to allow access to data in SYSDAT while in interrupt routines and other areas of code where the Data Segment is unknown. For example, the following routine accesses the current process's Process Descriptor:
	
	DSEG
	        ORG 68H ; point to RLR field
	                              ; of SYSDAT
	RLR RW 1 ; does not generate
	                              ; a hex value
	        CSEG ; of XIOS
	
	        PUSH DS ; Save XIOS Data
	                              ; Segment
	        MOV DS,CS:SYSDAT ; Move the SYSDAT
	                              ; segment address
	                              ; into DS
	        MOV BX,RLR ; Move the current
	             . ; process's PD
	             . ; Address into BX
	             . ; and perform
	             . ; operation. (See
	             . ; Fig 1-5 for expla-
	                              ; nation of RLR)
	        POP DS ; Restore the XIOS
	                              ; Data Segment
	
	This variable is initialized by GENCCPM.

SUPERVISOR	FAR Address (double-word pointer) of the Supervisor Module entry point. Whenever the XIOS makes a system call, it must access the operating system through this entry point. GENCCPM initializes this field. Section 3.7, "XIOS System Calls", describes XIOS register usage and restrictions.

Table 3-1. (continued)

Data Field	Explanation
TICK	Set Tick Flag Boolean. The Timer Interrupt routine uses this variable to determine whether the DEV_SETFLAG system call should be called to set the TICK_FLAG. Initialize this variable to zero (00H) in the XIOS.CON file. Concurrent CP/M-86 sets this field to 0FFH whenever a process is delaying. The field is reset to zero (00H) when all processes finish delaying. See the Concurrent CP/M-86 Operating System Programmer's Reference Guide for details on the DEV_SETFLAG and P_DELAY system calls. See Section 7 of this manual, "XIOS TICK Interrupt Routine," for more information on the XIOS usage of TICK.
TICKS_SEC	Number of Ticks per Second. This field must be initialized in the XIOS.CON file to be the number of ticks that make up one second as implemented by this XIOS. GENCCPM copies this field into the SYSDAT DATA. Application programmers can use TICKS_SEC to determine how many ticks to delay in order to delay one second. See Section 7, "XIOS TICK Interrupt Routine," for more information.
DOOR	Global Door Open Interrupt Flag. This field must be set to 0FFH by the drive door open interrupt handler routine if the XIOS detects that any drive door has been opened. The BDOS checks this field before every disk operation to verify that the media is unchanged. If a door has been opened, the XIOS must also set the Media Flag in the DPH associated with the drive.
NVCNS	Number of Virtual Consoles. Initialize this field to the number of virtual consoles supported by the XIOS in the XIOS.CON file. GENCCPM creates a TMP and a VOUT process for each virtual console. GENCCPM copies NVCNS into the NVCNS field of the SYSDAT DATA.

Table 3-1. (continued)

Data Field	Explanation
NCCB	Number of Logical Consoles. Initialize this XIOS.CON file field to the number of virtual consoles plus the number of character I/O devices supported by the XIOS. Character I/O devices are devices accessed through the console system calls of Concurrent CP/M-86 (functions whose mnemonic begins with C_) but whose console numbers are beyond the range of the virtual consoles. Application programs access the character I/O devices by setting their default console number to the character I/O device's console number and using the regular console system calls of Concurrent CP/M-86. See the C_SET system call as described in the Concurrent CP/M-86 Operating System Programmer's Reference Guide. GENCCPM copies this field into the NCCB field of the SYSDAT DATA.
NLCB	Number of List Control Blocks. Initialize this field in the XIOS.CON file to equal the number of list devices supported by the XIOS. A list device is an output-only device, typically a printer. GENCCPM copies this field into the NLCB field of the SYSDAT DATA.
CCB	Offset of the Console Control Block Table. Initialize this field in the XIOS.CON file to be the address of the CCB Table in the XIOS. A CCB Entry in the Table must exist for each of the consoles indicated in NCCB. Each entry in the CCB Table must be initialized as described in Section 4.1, "Console Control Block". GENCCPM copies this field into the CCB field of the SYSDAT DATA.
LCB	Offset of the List Control Block. This field is initialized in the XIOS.CON file to be the address of the LCB Table in the XIOS. There must be an LCB Entry for each of the list devices indicated in NLST. Each entry must be initialized as described in Section 4.3, "List Device Functions." GENCCPM copies this field into the LCB field of the SYSDAT DATA.

Table 3-1. (continued)

Data Field	Explanation
DPH(A)-DPH(P)	Offset of initial Disk Parameter Header (DPH) for drives A through P, respectively. If the value of this field is 0000H, the drive is not supported by the XIOS. GENCCPM uses the DPH Table to initialize specific fields in the DPHs when it automatically creates BCBs and buffers. If the relevant DPH fields are not initialized to 0FFFFH, GENCCPM assumes the BCBs and buffers are defined by data already initialized in the XIOS.
ALLOC	This value is initialized in the XIOS to the size, in paragraphs, of an uninitialized RAM buffer area to be reserved for the XIOS by GENCCPM. When GENCCPM creates the CCPM.SYS image, it sets this field in the CCPM.SYS file to the starting paragraph of the XIOS uninitialized buffer area. This value may then be used by the XIOS for based or indexed addressing into the buffer area. Typically, the XIOS uses this buffer area for the virtual console screen maps, programmable function key buffers, and nondisk-related I/O buffering. GENCCPM allocates this uninitialized RAM immediately following the system image and any system disk data or directory hashing buffers. Because the XIOS buffer area is not included in the CCPM.SYS file, it can be of any desired size without affecting system load time performance. If the ALLOC field is initialized to zero in the XIOS.CON file, GENCCPM allocates no buffer RAM and leaves ALLOC set to zero in the system image.

Listing 3-1 illustrates the XIOS Header definition:

```
;****************************************************
;*
;*      XIOS Header Definition
;*
;****************************************************

        CSEG
        org     0C00h

        jmp init        ;system initialization
        jmp entry       ;xios entry point

sysdat          dw      0       ;Sysdat Segment
supervisor      rw      2

        DSEG
        org     0C0Ch

tick            db      false           ;tick enable flag
ticks_sec       db      60              ;# of ticks per second
door            db      0               ;global drive door open
                                        ;       interrupt flag
rsvd            db      0,0             ;reserved for operating
                                        ;system use

nvcns           db      4               ;number of virtual consoles
nccb            db      4               ;total number of ccbs
nlst            db      1               ;number of list devices

ccb             dw      offset ccb0     ;offset of the first ccb
lcb             dw      offset lcb0     ;offset of first lcb

                        ;disk parameter header offset table

dph_tbl         dw      offset dph0     ;drive A:
                dw      offset dph1     ;B:
                dw      0,0,0           ;C:,D:,E:
                dw      0,0,0           ;F:,G:,H:
                dw      0,0,0           ;I:,J:,K:
                dw      0               ;L:
                dw      offset dph2     ;M:
                dw      0,0,0           ;N:,O:,P:
alloc           dw      0

;---------------------------------------------------------------
```

Listing 3-1. XIOS Header Definition

3.2 INIT Entry Point

The XIOS initialization routine entry point, INIT, is at offset 0C00H from the beginning of the XIOS code module. The INIT process calls the XIOS Initialization routine during system initialization. The sequence of events from the time CCPM.SYS is loaded into memory until the RSPs are created is important for understanding and debugging the XIOS.

The loader loads CCPM.SYS into memory at the absolute Code Segment location contained in the CCPM.SYS file Header, and initializes the CS and DS registers to the Supervisor code segment and the SYSDAT, respectively. At this point, the loader executes a JMPF to offset 0 of the CCPM.SYS code and begins the initialization code of the Concurrent CP/M-86 SUP module as described below. When loading CCPM.SYS under DDT-86 or SID-86, use the R command and set the code and data segments manually before beginning execution. You cannot use the E command because it initializes the data segment base page to incorrect values. See Section 8, "Debugging the XIOS."

1) The first step of initialization in the SUP is to set up the INIT process. The INIT process performs the rest of system initialization at a priority equal to 1.

2) The INIT process calls the initialization routines of each of the other modules with a Far Call instruction. The first instruction of each code module is assumed to be a JMP instruction to its initialization routine. The XIOS initialization routine is the last of these modules called. Once this call is made, the XIOS initialization code is never used again. Thus, it can be located in a directory buffer or other uninitialized data area.

3) As shown in the example XIOS listing, the initialization routine must initialize all hardware and interrupt vectors. Interrupt 224 is saved by the SUP module and restored upon return from the XIOS. Because DDT-86 uses interrupts 1, 3, and 225, do not initialize them when debugging the XIOS with DDT-86 running under CP/M-86. On each context switch, interrupt vectors 0, 1, 3, 4, 224, and 225 are saved and restored as part of a process's environment.

4) The XIOS initialization routine can optionally print a message to the console before it executes a Far Return (RETF) instruction upon completion. Note that each TMP prints out the string addressed by the VERSION variable in the SYSDAT DATA. This string can be changed using the OSLABEL Menu in GENCCPM.

5) Upon return from the XIOS, the SUP Initialization routine, running under the INIT process, creates some queues and starts up the RSPs. Once this is done, the INIT process terminates.

The XIOS INIT routine should initialize all unused interrupts to vector to an interrupt trap routine that prevents spurious interrupts from vectoring to an unknown location. The example XIOS handles uninitialized interrupts by printing the name of the process that caused the interrupt followed by an uninitialized interrupt error message. Then the interrupting process is unconditionally terminated.

Concurrent CP/M-86 saves Interrupt Vector 224 prior to system initialization and restores it following execution of the XIOS INIT routine. However, it does not store or alter the Non-Maskable Interrupt (NMI) vector, INT 2. Setting NMI is also the responsibility of the XIOS. The example XIOS first initializes all the Interrupt Vectors to the uninitialized interrupt trap, then initializes specifically used interrupts.

Note: when debugging the XIOS with DDT-86 running under CP/M-86, do not initialize Interrupt Vectors 1, 3, and 225. The example XIOS has a debug flag that is tested by the INIT routine for this purpose.

3.3 XIOS ENTRY

All accesses to the XIOS after initialization go through the ENTRY routine. The entry point for this routine is at offset 0C03H from the beginning of the XIOS code module. The operating system accesses the ENTRY routine with a Far Call to the location offset 0C03H bytes from the beginning of the SYSDAT Segment. When the XIOS function is complete, the ENTRY routine returns by executing a Far Return instruction, as in the example XIOS. On entry, the AL register contains the function number of the routine being accessed, and registers CX and DX contain arguments passed to that routine. The XIOS must maintain all segment registers through the call. This means that the CS, DS, ES, SS, and SP registers are maintained by the functions being called.

Table 3-2. **XIOS Register Usage**

Registers on Entry
AL = function number
CX = first parameter
DX = second parameter
DS = SYSDAT segment
ES = User Data Area
AH, BX, SI, DI, BP, DX, CX are undefined
Registers on Return
AX = return or XIOS error code
BX = AX
DS = SYSDAT segment
ES = User Data Area
SI, DI, BP, DX, CX are undefined

All XIOS functions, with the exception of disk functions, use the register conventions shown above.

The segment registers (DS and ES) must be preserved through the ENTRY routine. However, when calling the SUP from within the XIOS, the ES Register must equal the UDA of the running process and DS must equal the System Data Segment. Thus, if the XIOS is going to perform a string move or other code using the ES Register, it must preserve ES using the stack as in the following example:

```
push es
mov es,segment_address
 ...
rep movsw
 ...
pop es
```

In the example XIOS, the XIOS function routines are accessed through a function table with the function number being the actual table entry. Table 3-3 lists the XIOS function numbers and the corresponding XIOS routines; detailed explanations of the functions appear in the referenced sections of this document. Listing 3-2 is an example XIOS ENTRY Jump Table.

Table 3-3. XIOS Functions

Function Number	XIOS Routine
Console Functions -- Section 4.2 を参照	
Function 0 Function 1 Function 2 Function 7	IO_CONST CONSOLE STATUS コンソールステータスチェック IO_CONIN CONSOLE INPUT コンソール入力 IO_CONOUT CONSOLE OUTPUT コンソール出力 IO_SWITCH SWITCH SCREEN 画面切替
List Device Functions -- Section 4.3	
Function 3 Function 4	IO_LSTST LIST STATUS リストステータスチェック IO_LSTOUT LIST OUTPUT リスト出力
Other Character Devices -- Section 4.4	
Function 5 Function 6	IO_AUXIN AUXILIARY INPUT IO_AUXOUT AUXILIARY OUTPUT
Disk Functions -- Section 5.1	
Function 9 Function 10 Function 11 Function 12	IO_SELDSK SELECT DISK IO_READ READ DISK IO_WRITE WRITE DISK IO_FLUSH FLUSH BUFFERS
Poll Device Function -- Section 6.1	
Function 13	IO_POLL POLL DEVICE
Status Line Function -- Section 6.2	
Function 8	IO_STATLINE DISPLAY STATUS LINE

Listing 3-2 illustrates the XIOS Jump Table.

```
;---------------------------------------------------------
;                  XIOS FUNCTION TABLE
;---------------------------------------------------------

functab dw      io_const         ; 0 - console status
        dw      io_conin         ; 1 - console input
        dw      io_conout        ; 2 - console output
        dw      io_listst        ; 3 - list status
        dw      io_list          ; 4 - list output
        dw      io_auxin         ; 5 - aux in
        dw      io_auxout        ; 6 - aux out
        dw      io_switch        ; 7 - switch screen
        dw      io_statline      ; 8 - display status line
        dw      io_seldsk        ; 9 - select disk
        dw      io_read          ;10 - read sector
        dw      io_write         ;11 - write sector
        dw      io_flushbuf      ;12 - flush buffer
        dw      io_polldev       ;13 - poll device

;-------------------------------------------------------------
```

Listing 3-2. XIOS Function Table

3.4 Converting the CP/M-86 BIOS

The implementation of Concurrent CP/M-86 described below assumes that you have written and fully debugged a CP/M-86 BIOS on the target Concurrent CP/M-86 machine. This is desirable for the following reasons:

- The implementation of CP/M-86 on the target Concurrent CP/M-86 machine greatly simplifies debugging the XIOS using DDT-86 or SID-86.

- A CP/M-86 or a running Concurrent CP/M-86 system is required for the initial generation of the Concurrent CP/M-86 system when using GENCCPM.

- You can use the CP/M-86 BIOS as a basis for construction of the target Concurrent CP/M-86 XIOS.

To transform the CP/M-86 BIOS to the Concurrent CP/M-86 XIOS, you must make the following principal changes. Details of the changes given in the following list may be found in the referenced sections of this manual, and in the example XIOS found on the Concurrent CP/M-86 distribution disk. Often it is easier to start with the example Concurrent CP/M-86 XIOS and replace the hardware-dependent code with the corresponding drivers from the existing

CP/M-86 BIOS. However, there are several important changes, also outlined below, that you must make to the CP/M-86 drivers before they work in the Concurrent CP/M-86 XIOS.

1) Change the BIOS Jump Table to use only the two XIOS entry points, INIT and ENTRY. Concurrent CP/M-86 assumes these entry points to be unconditional jump instructions to the corresponding routines. The INIT routine takes the place of the CP/M-86 cold start entry point and is only invoked once, at system initialization time. The ENTRY routine is the single entry point indexing into all XIOS functions and replaces the BIOS Jump Table. Concurrent CP/M-86 accesses the ENTRY routine with the XIOS function number in the AL register. The example XIOS then uses the value in the AL register as an index into a function table to obtain the address of the corresponding function routine.

2) Add a SUP module interface routine to enable the XIOS to execute Concurrent CP/M-86 system calls. The XIOS is within the operating system area and already uses the User Data Area stack; therefore, the XIOS cannot make system calls in the conventional manner. See Section 3.7, "XIOS System Calls."

3) Modify the console routines to reflect the IO_CONST, IO_CONIN, IO_CONOUT, IO_LSTST, and IO_LISTOUT specifications. Note that the register conventions for Concurrent CP/M-86 are different from CP/M-86 and MP/M-86.

4) Rewrite the CP/M-86 disk routines to conform to the IO_SELSCT, IO_READ, IO_WRITE, and IO_FLUSH specifications.

5) Change all polled devices to use the Concurrent CP/M-86 DEV_POLL system call. See Sections 6.1, "IO_POLL Function"; 3.5, "Polled Devices"; and Section 6 of the Concurrent CP/M-86 Operating System Programmer's Reference Guide.

6) Change all interrupt-driven device drivers to use the Concurrent CP/M-86 DEV_WAITFLAG and DEV_SETFLAG system calls. See Sections 3.6, "Interrupt Devices"; 7, "Timer Interrupt"; and Section 6 of the Concurrent CP/M-86 Operating System Programmer's Reference Guide.

7) Change the structure of the Disk Parameter Header (DPH) and Disk Parameter Block (DPB) data structures referenced by the XIOS disk driver routines. See Sections 5.4, "Disk Parameter Header" and 5.5, "Disk Parameter Block."

8) Remove the Blocking/Deblocking algorithms from the XIOS disk drivers. The Concurrent CP/M-86 BDOS now handles the blocking/deblocking function. The XIOS still handles sector translation.

9) Change the disk routines to reference the Input/Output Parameter Block (IOPB) on the stack. See Section 5.2, "IOPB Data Structure." Modify the disk driver routine to handle multisector reads and writes.

10) Rewrite the console and list driver code to handle virtual consoles. Details of the virtual console system are given in Section 4, "Character Devices."

11) Implement the TICK interrupt routine (see I_TICK in the example XIOS). This routine is used for process dispatching, maintaining the P_DELAY system call, and waking up the CLOCK process RSP. See Section 7, "XIOS TICK Interrupt Routine."

3.5 Polled Devices

Polled I/O device drivers in the CP/M-86 BIOS typically execute a small compute-bound instruction loop waiting for a ready status from the I/O device. This causes the driver routine to spend a significant portion of CPU execution time looping. To allow other processes use of the CPU resource during hardware wait periods, the Concurrent CP/M-86 XIOS must use a system call, DEV_POLL, to place the polling process on the Poll List. After the DEV_POLL call, the dispatcher suspends the process and calls the XIOS IO_POLL function every dispatch until IO_POLL indicates the hardware is ready. The dispatcher then restores the polling process to execution and the process returns from the DEV_POLL call. Since the process calling the DEV_POLL function does not remain in ready state, the CPU resource becomes available to other processes until the I/O hardware is ready.

To do polling, a process executing an XIOS function calls the Concurrent CP/M-86 DEV_POLL system call with a poll device number. The dispatcher then calls the XIOS IO_POLL function with the same poll device number. The example XIOS uses the poll device number to index into a table of poll routine entry points, calls the appropriate poll function and returns the I/O device status to the dispatcher.

3.6 Interrupt Devices

As in the case of polled I/O devices, an XIOS driver handling an interrupt-driven I/O device should not execute a wait loop or halt instruction while waiting for an interrupt to occur.

The Concurrent CP/M-86 XIOS handles interrupt-driven devices by using DEV_WAITFLAG and DEV_SETFLAG system calls. A process that needs to wait for an interrupt to occur makes a DEV_WAITFLAG system call with a flag number. The system suspends this process until the desired XIOS interrupt handler routine makes a DEV_SETFLAG system call with the same flag number. The waiting process then continues execution. The interrupt handler follows the steps outlined below, executing a far jump (JMPF) to the Dispatcher entry point. The interrupt handler can also perform an IRET instruction when it is done. However, jumping directly to the Dispatcher gives a little faster response to the process waiting on the flag, and is logically equivalent to the IRET instruction.

If interrupts are enabled within an interrupt routine, a TICK interrupt can cause the interrupt handler to be dispatched. This dispatch could make interrupt response time unacceptable. To avoid this situation, do not re-enable interrupts within the interrupt handlers or only jump to the dispatcher when not in another interrupt handler routine.

Interrupt handlers under Concurrent CP/M-86 differ from those in an 8080 environment due to machine architecture differences. Study the TICK interrupt handler in the example XIOS carefully. During initial debugging, it is not recommended that interrupts be implemented until after the system works in a polled environment. An XIOS interrupt handler routine must perform the following basic steps:

1) Do a stack switch to a local stack. The interrupted process might not have enough stack space for a context save.

2) Save the register environment of the interrupted process, or at least the registers that will be used by the interrupt routine. Usually the registers are saved on the local stack established in step (1) above.

3) Satisfy the interrupting condition. This can include resetting the hardware and performing a DEV_SETFLAG system call to notify a process that the interrupt for which it was waiting has occurred.

4) Restore the register environment of the interrupted process.

5) Switch back to the original stack.

6) Either a Jump Far (JMPF) to the dispatcher or an Interrupt Return (IRET) instruction must be executed to return from the interrupt routine. Note the above discussion on which return method to use for different situations. Usually, when interrupts are not re-enabled within the interrupt handler, a Jump Far (JMPF) to the dispatcher is executed on each system tick and after a DEV_SETFLAG call is made. Otherwise, if interrupts are re-enabled an IRET instruction is executed.

Note: DEV_SETFLAG is the only Concurrent CP/M-86 system call an interrupt routine may call. This is because the DEV_SETFLAG call is the only system call the operating system assumes has no process context associated with it. DEV_SETFLAG must enter the operating system through the SUP entry point at SYSDAT:0000H and cannot use INT 224.

3.7 XIOS System Calls

Routines in the XIOS cannot make system calls in the conventional manner of executing a INT 224 instruction. The conventional entry point to the SUP does a stack switch to the User Data Area (UDA) of the current process. The XIOS is considered within the operating system, and a process entering the XIOS is already using the UDA stack. Therefore, a separate entry point is used for internal system calls.

Location 0003H of the SUP code segment is the entry point for internal system calls. Register usage for system calls through this entry point is the similar to the conventional entry point. They are as follows:

```
Entry:    CX = System call number
          DX = Parameter
          DS = Segment address if DX is an offset to a
               structure
          ES = User Data Area
Return:   AX = BX = Return
          CX = Error Code
          ES = Segment value if system call returns
               an offset and segment.  Otherwise
               ES is unaltered and equals the UDA
               upon return.
          DX, SI, DI, BP are not preserved.
```

The only differences between the internal and user entry points are the CX and ES registers on entry. For the internal call, CH must always be 0. ES must always point to the User Data Area of the current process. The UDA segment address can be obtained through the following code:

```
org 68H

rlr       rw     1      ; ready list root
                        ; in SYSDAT

org (XIOS code segment)

mov si,rlr
mov es,10h[si]
```

Note: on entry to the XIOS, ES is equal to the UDA segment address. The ES Register must equal the UDA on return from any XIOS function called by the XIOS ENTRY routine. Interrupt routines must restore ES and any other altered registers to their value upon entry to the routine, before performing an IRET instruction or a JMPF to the dispatcher.

End of Section 3

Section 4
Character Devices

Concurrent CP/M-86 treats all serial I/O devices as consoles. Serial I/O devices divide into two categories: virtual consoles and extra I/O devices. Associated with each serial I/O device is a Console Control Block (CCB). The serial I/O devices and CCBs are numbered relative to zero. Each process contains, in its Process Descriptor, the number of its default console. The default console can be either a virtual console or an extra serial I/O device.

Generally a Concurrent CP/M-86 system has only one physical console: a keyboard and a CRT monitor. However, up to 254 serial I/O devices can be implemented, depending on the specific application.

Since the XIOS must maintain a buffer containing the screen contents and cursor position for each virtual console implemented (over 4K bytes per virtual console in the example XIOS), the practical considerations of memory space dictate keeping the number of virtual consoles reasonably small. The example XIOS has four virtual consoles.

By convention, the first NVCNS serial I/O devices are the virtual consoles. The NVCNS parameter is located in the XIOS Header. Consoles beyond the last virtual console represent other serial I/O devices. When a process makes a console I/O call with a console number higher than the last virtual console, it references the Console Control Block for the called device number. Therefore a CCB for each serial I/O device is absolutely necessary.

As mentioned above, List Devices under Concurrent CP/M-86 are output-only. The XIOS must reserve and initialize a List Control Block for each list output device. When a process makes a list device XIOS call, it references the appropriate LCB.

4.1 Console Control Block

A Console Control Block Table must be defined in the XIOS. There must be one CCB for each virtual console and Character I/O device supported by the XIOS, as indicated by the NCCB variable in the XIOS Header. The table must begin at the address indicated by the CCB variable in the XIOS Header.

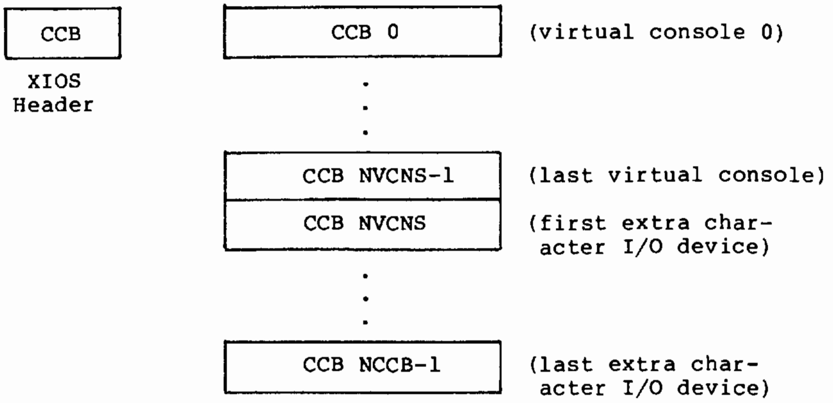


Figure 4-1. The CCB Table

The number of CCBs used for virtual consoles equals the NVCNS field in the XIOS Header. Any additional CCB entries are used for other character devices to be supported by the XIOS. The CCB entries are numbered starting with zero to match their logical console device numbers. Therefore, the last CCB in the CCB Table is the (NCCB-1)th CCB.

Each CCB corresponding to a virtual console has several fields which must be initialized, either when the XIOS is assembled or by the XIOS INIT routine. These fields allow the OEM to choose the configuration of the virtual consoles. For CCBs outside the virtual console range corresponding to extra I/O devices, these fields must all be initialized to zero (00H). Also, initialize to zero (OOH) all fields marked RESERVED in Figure 4-2.

00	OWNER		RESERVED					
08h	MIMIC	RESERVED					STATE	
10h	MAXBUFSIZE		RESERVED					
18h	RESERVED							
20h	RESERVED							

Figure 4-2. Console Control Block Format

Table 4-1. Console Control Block Data Fields

Data Field	Explanation
OWNER	Address of the Process Descriptor of the process that currently owns the virtual console or character I/O device. This field is used by the XIOS Status Line Function (IO_STATLINE) to find the name of the current owner. See Section 6.2, Display Status Line, for more information. Initialize this field display to zero (0000H). If the value in this field is zero when Concurrent CP/M-86 is running, no process owns the device.
MIMIC	This field indicates which list device receives the characters typed on the virtual console when the CTRL-P command is in effect. MIMIC must be initialized to 0FFH. Note that this list device is not necessarily the same as the default list device indicated in the Process Descriptor whose address is in the OWNER field of the CCB. Consider the following interaction at the console: A>**printer** The TMP's PD has a 0 in its LIST field. Printer Number = 0 A>^**P** Printer echo to list device 0. A>**printer 2** The TMP's PD has a 2 in its LIST field. Printer Number = 2 A>**pip lst:=letter.prn** LETTER.PRN is sent to list device 2 Printer echo is still going to list device 0, echoing the last two commands. The example status line routine distinguishes between the default list device and the CTRL-P list device by displaying Printer=2 for the default list device, and ^P=0 for the above illustration.

Table 4-1. (continued)

Data Field	Explanation
STATE	The least significant bit of this field indicates the background mode of the virtual console. The XIOS Status Line Function routine uses this information to display the background mode for the current foreground console. This bit has the following values: 0 background is dynamic 1 background is buffered The STATE field can be initialized to 0 or 1 on each virtual console to specify the background mode at system startup. The Concurrent CP/M-86 VCMODE utility allows the user to change the background mode.
MAXBUFSIZE	The MAXBUFSIZE field indicates the maximum size of the buffer file used to store characters when a background virtual console is in buffered mode. When a virtual console is placed in background mode by the user, a temporary file is created on the temporary drive, containing console output sent to the virtual console. These files are named VOUTx.$$$, where x equals the number of the associated virtual console. The MAXBUFSIZE field is the maximum size to which this file can grow. If this maximum is reached, the drive is Read-Only, or there is no more free space on the drive, subsequent console output causes the background process attached to the virtual console to be suspended. The MAXBUFSIZE parameter is in Kilobytes and must be initialized in the XIOS CCB entries. The Concurrent CP/M-86 VCMODE utility allows the user to change this value. The legal range for MAXBUFSIZE is 1 to 8191 decimal (1FFFH).

4.2 Console I/O Functions

A major difference between the Concurrent CP/M-86 XIOS and the CP/M-86 BIOS drivers is how they wait for an event to occur. In CP/M-86, a routine typically goes into a hard loop to wait for a change in status of a device, or executes a Halt (HLT) instruction to wait for an interrupt. In Concurrent CP/M-86, this will not work. It can be of some use, however, during the very early stages of debugging the XIOS.

Basically, two ways to wait for a hardware event are in the XIOS. For noninterrupt-driven devices, use the DEV_POLL method. For interrupt-driven devices, use the DEV_SETFLAG/DEV_FLAGWAIT method. These are both ways in which a process can give up the CPU resource while waiting for an external event, while allowing other processes to run concurrently. For detailed explanations of the DEV_POLL, DEV_FLAGWAIT and DEV_SETFLAG system calls, see Section 6 of the Concurrent CP/M-86 Operating System Programmer's Reference Guide.

IO_CONST CONSOLE INPUT STATUS

Return the Input Status of the specified
Serial I/O Device.

```
Entry Parameters:
    Register  AL:  00H (0)
              DL:  Serial I/O Device Number

Returned   Value:
    Register  AL:  0FFH if character ready
                   0    if no character ready
              BL:  Same as AL
              ES, DS, SS, SP  preserved
```

The IO_CONST routine returns the input status of the specified character I/O device. This function is only called by the operating system for console numbers greater than NVCNS-1, in other words, only for devices which are not virtual consoles. If the status returned is 0FFH, then one or more characters are available for input from the specified device.

IO_CONIN CONSOLE INPUT

Return a character from the console keyboard or a serial I/O device.

```
Entry Parameters:
    Register  AL:  01H (1)
              DL:  Serial I/O Device Number

Returned   Value:  (if the device # is a
                     virtual console):
    Register  AH:  00H if returning
                     character data
              AL:  character

              AH:  0FFH if returning a
                     switch screen request
              AL:  virtual console requested

(If the device # is not a virtual console):
              AH:  always 0
              AL:  character

              BX:  same as AX in all cases
               ES, DS, SS, SP  preserved
```

Because Concurrent CP/M-86 supports the full 8-bit ASCII character set, the parity bit must be masked off from input devices which use it. However, it should not be masked off if valid 8-bit characters are being input.

The OEM chooses the key or combination of keys that represent the virtual consoles by the implementation of IO_CONIN. The example XIOS reserves the combination of CTRL (the control key) and the number pad keys 0, 1, 2, and 3 to represent virtual consoles 0 through 3.

IO_CONOUT CONSOLE OUTPUT

Display and/or output a character to the specified device.

Entry Parameters:		
Register	AL:	02H (2)
	CL:	Character to send
	DL:	Device # to send to
Returned	Value:	NONE
		ES, DS, SS, SP preserved

The XIOS handles foreground and background virtual consoles differently. When outputting to the foreground virtual console, the character is placed directly in the video map. Depending on whether the screen management hardware is capable of reporting the cursor position, the XIOS might have to track the cursor position as well.

If the virtual console to receive the character is in the background, the XIOS updates the video RAM area reserved for the background virtual console. This area is a block of RAM the same size as the hardware video RAM, and updated in the same manner.

In the example XIOS, which supports four virtual consoles, a data structure called a Screen Structure is reserved for each screen. These structures store the current cursor position, default attributes, row, column, and the paragraph address of the video RAM for its associated virtual console. These structures can be expanded to support additional hardware requirements, such as color CRTs.

The XIOS IO_CONOUT routine must expand any escape sequences defined by the OEM. The Screen Structures in the example XIOS are used to track escape sequence expansion.

When a process calls this function with a device number higher than the last virtual console number, the character should be sent directly to the hardware device.

IO_SWITCH SWITCH SCREEN

Place the current virtual console into the background and the specified virtual console into the foreground.

Entry Parameters:
Register AL: 07H (7)
DL: Virtual Console # to switch to

Return Values: NONE

ES, DS, SS, SP preserved

When IO_SWITCH is called, the XIOS copies the video display RAM to the local RAM area reserved for the current screen. Then it copies the local RAM area reserved for the requested screen into the video display RAM. It must move the cursor on the physical screen to the proper position for the new foreground console. The XIOS must update the local variable representing the current foreground virtual console.

The example XIOS stores the cursor position for background virtual consoles in the Screen Structure associated with each console.

Concurrent CP/M-86 calls IO_SWITCH only when there is no process currently in the XIOS performing console output to either the foreground virtual console being switched out, or the background virtual console being switched into the foreground. Therefore, the XIOS never has to update a screen while simultaneously switching it from foreground to background, or vice versa.

4.3 List Device Functions

A List Control Block (LCB), similar to the CCB, must be defined in the XIOS for each list output device supported. The number of LCBs must equal the NLCB variable in the XIOS Header. The LCB Table begins with LCB zero, and ends with LCB NLCB-1, according to their logical list device names.

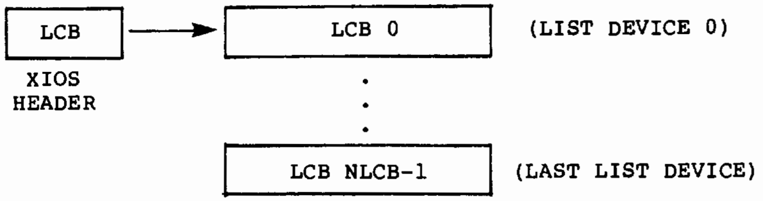


Figure 4-3. The LCB Table

Because the operating system uses the LCBs to manage processes that make list device calls, each LCB Table entry must be properly initialized, either by the XIOS INIT routine or at XIOS assembly time. The initialization values are discussed below under the individual fields.

00H	OWNER		RESERVED
08H	RESER- VED	M- SOURCE	

Figure 4-4. List Control Block (LCB)

Table 4-2. List Control Block Data Fields

Field	Explanation
OWNER	Address of the PD of the process that currently owns the List Device. If no process currently owns the list device, then OWNER=0. If OWNER=0FFFFH, this list device is mimicking a console device that is in CTRL-P mode.
MSOURCE	If OWNER=0FFFFH, MSOURCE contains the number of the console device this list device is mimicking; otherwise MSOURCE = 0FFH. **Note:** MSOURCE must be initialized to 0FFH. All other LCB fields must be initialized to 0.

IO_LSTST LIST STATUS

Return List Output Status

```
Entry Parameters:
    Register  AL:  03H (3)
              DL:  List Device number

Returned   Value:
    Register  AL:  0FFH if Device Ready
                   0    if Device Not Ready
              BL:  Same as AL

              ES, DS, SS, SP  preserved
```

The IO_LSTST function returns the output status of the specified list device.

IO_LSTOUT LIST OUTPUT

Output Character to Specified List Device

```
Entry Parameters:
    Register  AL:  04H (4)
              CL:  Character
              DL:  List Device number

Returned   Value:  None

              ES, DS, SS, SP  preserved
```

The IO_LSTOUT function sends a character to the specified List Device. List device numbers start at 0. It is the responsibility of the XIOS device driver to zero the parity bit for list devices that require it.

4.4 Auxiliary Device Functions

These XIOS functions are accessible only through the Concurrent CP/M-86 S_BIOS system call. Software that uses this call can access the AUX: device by placing the appropriate parameters in the Bios Descriptor. For further information, see the Concurrent CP/M-86 Operating System Programmer's Reference Guide under the S_BIOS system call.

If you choose not to implement the AUX: device then the IO_AUXOUT function can simply return, while IO_AUXIN should return a character 26 (1AH), CTRL-Z, indicating end of file.

IO_AUXIN   AUXILIARY INPUT

Input a character from the Auxiliary Device

```
Entry Parameters:
    Register  AL:  05H (5)

Returned  Value:
    Register  AL:  Character

               ES, DS, SS, SP  preserved
```

IO_AUXOUT AUXILIARY OUTPUT

Output a character to the Auxiliary Device

```
Entry Parameters:
    Register  AL:  06H (6)
              CL:  Character

Returned   Value:  None

              ES, DS, SS, SP  preserved
```

End of Section 4

Section 5
Disk Devices

In Concurrent CP/M-86, a disk drive is any I/O device that has a directory and is capable of reading and writing data in 128-byte logical sectors. The XIOS can therefore treat a wide variety of peripherals as disk drives if desired. The logical structure of a Concurrent CP/M-86 disk drive is presented in detail in Section 10, "OEM Utilities."

This section discusses the Concurrent CP/M-86 XIOS disk functions, their input and output parameters, associated data structures, and calculation of values for the XIOS disk tables.

5.1 Disk I/O Functions

Concurrent CP/M-86 performs Disk I/O with a single XIOS call to the IO_READ or IO_WRITE functions. These functions reference disk parameters contained in an Input/Output Parameter Block (IOPB), which is located on the stack, to determine which disk drive to access, the number of physical sectors to transfer, the track and sector to read or write, and the DMA offset and segment address involved in the I/O operation. See Section 5.2, "IOPB Data Structure." Prior to each IO_READ or IO_WRITE call, the BDOS initializes the IOPB.

If a physical error occurs during a IO_READ or IO_WRITE operation, the function routine should perform several retries (10 is recommended) to attempt to recover from the error before returning an error condition to the BDOS.

The Disk I/O routine interfaces in the Concurrent CP/M-86 XIOS are quite different from those in the CP/M-86 BIOS. The SETTRK, SETSEC, SETDMA, SETDMAB, XIOS functions no longer exist because IO_READ or IO_WRITE have absorbed their functions. WBOOT, HOME, SECTRAN, GETSEGB, GETIOB, and SETIOB are not used by any routines outside the I/O system, and so have been dropped. Also, hard loops within the disk routines must be changed to make either DEV_POLL or DEV_WAITFLAG system calls. See Sections 3.5, "Polled Devices"; 6.1, "IO_POLL Function"; and 3.6, "Interrupt Devices." For initial debugging, Concurrent CP/M-86 runs with the CP/M-86 BIOS physical sector read and write routines, with the addition of an IOPB-referencing routine, multisector read/write capability, and modification to handle the new DPH and DPB structures. Once the system runs well, all hard loops should be changed to either DEV_POLL or DEV_WAITFLAG system calls. See also the discussion in Sections 3.5 and 3.6 of this manual.

IO_SELDSK SELECT DISK

Select the specified Disk Drive

Entry Parameters:	AL:	09H (9)
	CL:	Disk Drive Number
	DL:	(bit 0): 0 if first select
Return Values:	AX:	offset of DPH if no error 00H if invalid drive
	BX:	Same as AX
	ES, DS, SS, SP	preserved

The IO_SELDSK function checks if the specified disk drive is valid and returns the address of the corresponding Disk Parameter Header if the drive is valid. The specified disk drive number is 0 for drive A, 1 for drive B, up to 15 for drive P. The sample XIOS supports two drives. On each disk select, IO_SELDSK must return the offset of the selected drive's Disk Parameter Header relative to the SYSDAT segment address.

If there is an attempt to select a nonexistent drive, IO_SELDSK returns 0000H as an error indicator. Although IO_SELDSK must return the Disk Parameter Header (DPH) address for the specified drive on each call, postpone the actual physical disk select operation until an I/O function, IO_READ or IO_WRITE, is performed. This is due to the fact that disk select operations can take place without a subsequent disk operation and thus disk access might be substantially slower using some disk controllers.

On entry to IO_SELDSK, you can determine whether it is the first time the specified disk has been selected. Register DL, bit 0 (least significant bit), is a zero if the drive has not been previously selected. This information is of interest in systems that read configuration information from the disk to dynamically set up the associated DPH and DPB. See Appendix B, "Auto Density Support." If Register DL, bit 0, is a one, IO_SELDSK must return a pointer to the same DPH as it returned on the initial select.

IO_READ READ SECTOR

Read sector(s) defined by the IOPB

Entry Parameters:	IOPB filled in (on stack)	
Register	AL:	0AH (10)
Return Values:	AL:	0 if no error 1 if physical error 0FFH if media density has changed
	BL:	Same as AL
	ES, DS, SS, SP preserved	

The IO_READ Function transfers data from disk to memory according to the parameters specified in the IOPB. The disk Input/Output Parameter Block (IOPB), located on the stack, contains all required parameters, including drive, multisector count, track, sector, DMA offset, and DMA segment, for disk I/O operations. See Section 5.2, "IOPB Data Structure." If the multisector count is equal to 1, the XIOS should attempt a single physical sector read based upon the parameters in the IOPB. If a physical error occurs, the read function should return a 1 after attempting several retries (10 is recommended).

For disk drivers with auto density select, IO_READ should immediately return 0FFH if the hardware detects a change in media density. The BDOS then performs an IO_SELDSK system call for that drive, reinitializing the drive's parameter tables in order to avoid writing erroneous data to disk.

If the multisector count is greater than 1, the IO_READ routine is required to read the specified number of physical sectors before returning to the BDOS. The IO_READ routine should attempt to read as many physical sectors as the specified drive's disk controller can handle in one operation. Additional calls to the disk controller are required when the disk controller cannot transfer the requested number of sectors in a single operation. If a physical error occurs during a multisector read, the read function should return a 1.

If the disk controller hardware can only read one physical sector at a time, the XIOS disk driver must make the number of single physical-sector reads defined by the multisector count. In any case, when more than one call to the controller is made, the XIOS must increment the sector number and add the number of bytes in each physical sector to the DMA address for each successive read. If, during a multisector read, the sector number exceeds the number of the last physical sector of the current track, the XIOS has to increment the track number and reset the sector number to 0. This concept is illustrated in Listing 5-1, part of a hard disk driver routine.

In this example, if the multisector count is zero, the routine returns with an error. Otherwise, it immediately calls the read/write routine for the present sector and puts the return code passed from it in AL. If there is no error, the multisector count is decremented. If the multisector count now equals zero, the read or write is finished and the routine returns. If not, the sector to read or write is incremented. If, however, the sector number now exceeds the number of sectors on a track (MAXSEC), the track number is incremented and the sector number set to zero. The routine then performs the number of reads or writes remaining to equal the multisector count, each time adding the size of a physical sector to the DMA offset passed to the disk controller hardware.

Listing 5-1 illustrates multisector operations:

```
;***************************************************
;*
;*      common code for hard disk read and write
;*
;***************************************************

hd_io:
        push es                 ;save UDA
        cmp mcnt,0              ;if multisector count = 0
        je hd_err               ;return error
hdiol:
          call iohost           ;read/write physical sector
          mov al,retcode        ;get return code
          or al,al              ;if not 0
          jnz hd_err            ;return error
          dec mcnt              ;decrement multisector count
          jz return_rw          ;if mcnt = 0 return
            mov ax,sector
            inc ax              ;next sector
            cmp ax,maxsec! jb same_trak  ;is sector < max sector
              inc track         ; no - next track
              xor ax,ax         ; initialize sector to 0
same_trak:
            mov sector,ax       ;save sector #
            add dmaoff,secsiz   ;increment dma offset by sector size
            jmps hdiol          ;read/write next sector
```

Listing 5-1. Multisector Operations

```
hd_err:
          mov al,1                ;return with error indicator
return_rw:
        pop es                    ;restore UDA
        ret                       ;return with error code in AL

;*****************************************************
;* IOHOST performs the physical reads and writes to  *
;* the physical disk.                                *
;*****************************************************

iohost:
 ...
 ...
 ...

         ret

;-----------------------------------------------------------------
```

Listing 5-1. (continued)

IO_WRITE   WRITE SECTOR

Write sector(s) defined by the IOPB

```
Entry Parameters:  IOPB filled in (on stack)
        Register AL:  0BH (11)

   Return Values:  AL:    0 if no error
                          1 if physical error
                          2 if Read/Only Disk
                       0FFH if media density
                              has changed
                   BL:  Same as AL
                   ES, DS, SS, SP  preserved
```

The IO_WRITE function transfers data from memory to disk according to the parameters specified in the IOPB. This function works in much the same way as the read function, with the addition of a Read/Only Disk return code. IO_WRITE should return this code when the specified disk controller detects a write-protected disk.

IO_FLUSH FLUSH BUFFERS

Write pending I/O system buffers to disk

Entry Parameters: Register AL: 0CH (12)

Returned Value:
Register AL: 0 if No Error
1 if Physical Error
2 if Read-Only Disk
ES, DS, SS, SP preserved

The IO_FLUSH function indicates that all blocking/deblocking buffers or disk-caching buffers used by the I/O system should be flushed, written to the disk. This does not include the LRU buffers that are managed by the BDOS. This function is called whenever a process terminates, a file is closed or a disk drive is reset. The XIOS must return the error code for the IO_FLUSH function in register AL, after 10 recovery attempts as described in the IO_READ function.

5.2 IOPB Data Structure

The purpose of this and the following sections is to present the organization and construction of tables and data structures within the XIOS that define the characteristics of the Concurrent CP/M-86 disk system. Since there is no Concurrent CP/M-86 GENDEF utility, you must code the XIOS DPHs and DPBs by hand, using values calculated from the information presented below.

The disk Input/Output Parameter Block (IOPB) contains the necessary data required for the IO_READ and IO_WRITE functions. These parameters are located on the stack, and appear at the example XIOS IO_READ and IO_WRITE function entry points as described below. The IOPB example at the end of this section assumes that the ENTRY routine calls the read or write routines through only one level of indirection; therefore, the XIOS has placed only only one word on the stack. RETADR is reserved for this local return address to the ENTRY routine. The XIOS disk drivers may index or modify IOPB parameters directly on the stack, since they are removed by the BDOS when the function call returns. Typically, the IOPB fields are defined relative to the BP and SS registers. The first instruction of the IO_READ and IO_WRITE routines sets the BP register equal to the SP register for indexing into the IOPB. Listing 5-2 illustrates this.

+14	DRV	MCNT	
+12	TRACK		
+10	SECTOR		
+8	DMASEG		
+6	DMAOFF		
+4	RETSEG		
+2	RETOFF		<== SP value at XIOS ENTRY
SP+0	RETADR		<== SP value at disk routines

Figure 5-1. Input/Output Parameter Block (IOPB)

Table 5-1. IOPB Data Fields

Data Field	Explanation
DRV	Logical Drive Number. The Logical Drive Number specifies the logical disk drive on which to perform the IO_READ or IO_WRITE function. The drive number may range from 0 to 15, corresponding to drives A through P respectively.
MCNT	Multisector Count. To transfer logically consecutive disk sectors to or from contiguous memory locations, the BDOS issues an IO_READ or IO_WRITE function call with the multisector count greater than 1. This allows the XIOS to transfer multiple sectors in a single disk operation. The maximum value of the multisector count depends on the physical sector size, ranging from 128 with 128-byte sectors to 4 with 4096-byte sectors. Thus, the XIOS can transfer up to 16K directly to or from the DMA address in a single operation. For a more complete explanation of multisector operations, along with example code and suggestions for implementation within the XIOS, see Section 5.3, "Multisector Operations on Skewed Disks."

Table 5-1. (continued)

Data Field	Explanation
TRACK	Logical Track Number. The Track Number defines the logical track for the specified drive to seek. The BDOS defines the Track Number relative to 0, so for disk hardware which defines track numbers beginning with a physical track of 1, the XIOS needs to increment the track number before passing it to the disk controller.
SECTOR	Sector Number. The Sector Number defines the logical sector for a read or write operation on the specified drive. The sector size is determined by the parameters PSH and PHM defined in the Disk Parameter Block. See Section 5.5. The BDOS defines the Sector Number relative to 0. For disk hardware that defines sector numbers beginning with a physical sector of 1, the XIOS will need to increment the sector number before passing it to the disk controller. If the specified drive uses a skewed-sector format, the XIOS must translate the sector number according to the translation table specified in the Disk Parameter Header.
DMASEG, DMAOFF	DMA Segment and Offset. The DMA offset and segment define the address of the data to transfer for the read or write operation. This DMA address may reside anywhere in the 1-megabyte address space of the 8086-8088 microprocessor. If the disk controller for the specified drive can only transfer data to and from a restricted address area, the IO_READ and IO_WRITE functions must block move the data between the DMA address and this restricted area before a write or following a read operation.
RETSEG,RETOFF	BDOS Return Segment and Offset. The BDOS return segment and offset are the Far Return address from the XIOS to the BDOS.
RETADR	Local Return Address. The local return address returns to the ENTRY routine in the example XIOS.

Listing 5-2 illustrates the IOPB definition, and how the IOPB is used in the IO_READ and IO_WRITE routines:

```
;********************************
;*
;*      IOPB Definition
;*
;********************************
;
;  Read and Write disk parameter equates
;
;  At the disk read and write function entries,
;   all disk I/O parameters are on the stack
;   and the stack at these entries appears as
;   follows:
;
;
;       +14    DRV    MCNT      Drive and Multisector count
;
;       +12       TRACK         Track number
;
;       +10      SECTOR         Physical sector number
;
;        +8      DMA_SEG        DMA segment
;
;        +6      DMA_OFF        DMA offset
;
;        +4      RET_SEG        BDOS return segment
;
;        +2      RET_OFF        BDOS return offset
;
;      SP+0      RET_ADR        Local ENTRY return address
;                                (assumes one level of call
;                                 from ENTRY routine)
;
;  These parameters can be indexed and modified
;   directly on the stack and will be removed
;   by the BDOS after the function is complete

drive   equ     byte ptr 14[bp]
mcnt    equ     byte ptr 15[bp]
track   equ     word ptr 12[bp]
sector  equ     word ptr 10[bp]
dmaseg  equ     word ptr 8[bp]
dmaoff  equ     word ptr 6[bp]

;*******************************************
```

Listing 5-2. IOPB Definition

```
;=======
IO_READ:       ; Function 11: Read sector
;=======
; Reads the sector on the current disk, track and
; sector into the current DMA buffer.
;       entry:  parameters on stack
;       exit:   AL = 00 if no error occurred
;               AL = 01 if an error occurred

        mov bp,sp               ;set BP for indexing into IOPB
          .
          .
          .
        ret

;=========
IO_WRITE:          ; Function 12: Write disk
;=========
; Write the sector in the current DMA buffer
; to the current disk on the current
; track in the current sector.
;       entry:  CL = 0 - Deferred Writes
;                    1 - non-deferred writes
;                    2 - def-wrt 1st sect unalloc blk
;       exit:   AL = 00H if no error occurred
;                  = 01H if error occurred
;                  = 02H if read only disk

        mov bp,sp               ;set BP for indexing into IOPB
          .
          .
          .
        ret
;---------------------------------------------------------------
```

Listing 5-2. (continued)

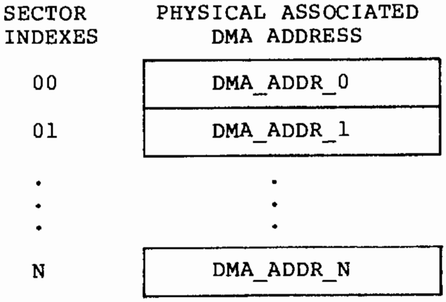
5.3 Multisector Operations on Skewed Disks

On many implementations of older Digital Research operating systems, disk performance is improved through sector skewing. This technique logically numbers the sectors on a track such that they are not sequential. An example of this is the standard Digital Research 8-inch disk format, where the sectors are skewed by a factor of 6. The following discussion illustrates how to optimize disk performance on skewed disks with multisector I/O requests.

Concurrent CP/M-86 supports multiple-sector read and write operations at the XIOS level to minimize rotational latency on block disk transfers. You must implement the multiple-sector I/O facility in the XIOS by using the multisector count passed in the IOPB.

When the disk format uses a skew table to minimize rotational latency for single-record transfers, it is more difficult to optimize transfer time for multisector operations. One method of doing this is to have the XIOS read/write function routine translate each logical sector number into a physical sector number. Then it creates a table of DMA addresses with each sector's DMA address indexed into the table by the physical sector number.

As a result, the requested sectors are sorted into the order in which they physically appear on the track. This allows all of the required sectors on the track to be transferred in as few disk rotations as possible. The data from each sector must be separately transferred to or from its proper DMA address. If during a multisector data transfer the sector number exceeds the number of the last physical sector of the current track, the XIOS will have to increment the track number and reset the sector number to 0. It can then complete the operation for the balance of sectors specified in the IO_READ or IO_WRITE function call. See the example accompanying the IO_READ function.



SECTOR INDEXES	PHYSICAL ASSOCIATED DMA ADDRESS
00	DMA_ADDR_0
01	DMA_ADDR_1
.	.
.	.
.	.
N	DMA_ADDR_N

Figure 5-2. DMA Address Table for Multisector Operations

If an error occurs during a multisector transfer, the XIOS should return the error immediately to terminate the read or write BDOS function call.

In Listing 5-3, common read/write code for an XIOS disk driver, the routine gets the DPH address by calling the IO_SELDSK function. It checks to verify a nonzero DPH address, and returns if the address is invalid (zero). Then the disk parameters are taken from the DPH and DPB and stored in local variables. Once the physical record size is computed from DPB values, the DMA address table can be initialized. The INITDMATBL routine fills the DMA address table with 0FFFFH word values. The size of the DMA table equals one word greater than the number of sectors per track, in case the sectors index relative to 1 for that particular drive. If the multisector count is zero, the routine returns an error. Otherwise, the sector number is compared to the number of sectors per track to determine if the track number should be incremented and the sector number set to zero. If this is the case, the sectors for the current track are transferred, and the DMA address table is reinitialized before the next tracks are read or written.

The current sector number is moved into AX and a check is made on the translation table offset address. If this value is zero, no translation table exists and translation is not performed; The sector number is translated and used to index into the DMA address table. The current DMA address, incremented by the physical sector size if a multisector operation, is stored in the table for use by the RW_SECTS routine. Local values, beginning with i, are initialized for the various parameters needed by the disk hardware, and the disk driver routine is called.

Listing 5-3 illustrates multisector unskewing:

```
;*****************************************************
;*
;*      DISK I/O EQUATES
;*
;*****************************************************

xlt     equ     0       ;translation table offset in DPH
dpb     equ     8       ;disk parameter block offset in DPH
spt     equ     0       ;sectors per track offset in DPB
psh     equ     15      ;physical shift factor offset in DPB

;*****************************************************
;*
;*      DISK I/O CODE AREA
;*
;*****************************************************

;
read_write:     ;unskews and reads or writes multisectors
;----------
;       input:  SI = read or write routine address
;       output: AX = return code

        mov cl,drive
        mov dl,1
        call seldsk             ;get DPH address
        or bx,bx! jnz dsk_ok    ;check if valid
```

Listing 5-3. Multisector Unskewing

```
ret_error:
          mov al,1              ; return error if not
          ret
dsk_ok:
        mov ax,xlt[bx]
        mov xltbl,ax            ;save translation table address
        mov bx,dpb[bx]
        mov ax,spt[bx]
        mov maxsec,ax           ;save maximum sector per track
        mov cl,psh[bx]
        mov ax,128
        shl ax,cl               ;compute physical record size
        mov secsiz,ax           ; and save it
        call initdmatbl         ;initialize dma offset table
        cmp mcnt,0
        je ret_error
rw_l:
          mov ax,sector         ;is sector < max sector/track
          cmp ax,maxsec! jb same_trk
            call rw_sects       ; no - read/write sectors on track
            call initdmatbl     ; reinitialize dma offset table
            inc track           ; next track
            xor ax,ax
            mov sector,ax       ; initialize sector to 0
same_trk:
          mov bx,xltbl          ;get translation table address
          or bx,bx! jz no_trans ;if xlt <> 0
            xlat al             ; translate sector number
no_trans:
          xor bh,bh
          mov bl,al             ;sector # is used as the index
          shl bx,1              ; into the dma offset table
          mov ax,dmaoff
          mov dmatbl[bx],ax     ;save dma offset in table
          add ax,secsiz         ;increment dma offset by the
          mov dmaoff,ax         ; physical sector size
          inc sector            ;next sector
          dec mcnt              ;decrement multisector count
          jnz rw_l              ;if mcnt <> 0 store next sector dma

rw_sects:                       ;read/write sectors in dma table
;---------
        mov al,1                ;preset error code
        xor bx,bx               ;initialize sector index
```

Listing 5-3. (continued)

```
rw_sl:
        mov di,bx
        shl di,1                ;compute index into DMA table
        cmp word ptr dmatbl[di],0ffffh
        je no_rw                ;nop if invalid entry
          push bx! push si      ;save index and routine address
          mov ax,track          ;get track # from IOPB
          mov itrack,ax
          mov isector,bl        ;sector # is index value
          mov ax,dmatbl[di]     ;get dma offset from table
          mov idmaoff,ax
          mov ax,dmaseg         ;get dma segment from IOPB
          mov idmaseg,ax
          call si               ;call read/write routine
          pop si! pop bx        ;restore routine address and index
          or al,al! jnz err_ret ;if error occurred return
no_rw:
        inc bx                  ;next sector index
        cmp bx,maxsec           ;if not end of table
        jbe rw_sl               ; go read/write next sector
err_ret:
        ret                     ;return with error code in AL
initdmatbl:     ;initialize DMA offset table
;----------
        mov di,offset dmatbl
        mov cx,maxsec           ;length = maxsec + 1  sectors may
        inc cx                  ; index relative to 0 or 1
        mov ax,0ffffh
        push es                 ;save UDA
        push ds! pop es
        rep stosw               ;initialize table to 0ffffh
        pop es                  ;restore UDA
        ret

;*****************************************************
;*
;*      DISK I/O DATA AREA
;*
;*****************************************************

xltbl   dw      0       ;translation table address
maxsec  dw      0       ;max sectors per track
secsiz  dw      0       ;sector size
dmatbl  rw      50      ;dma address table

;---------------------------------------------------------------
```

Listing 5-3. (continued)

5.4 Disk Parameter Header

Each disk drive has an associated Disk Parameter Header (DPH) that contains information about the drive and provides a scratchpad area for certain Basic Disk Operating System (BDOS) operations.

00H	XLT	0000	00	MF	0000
08H	DPB	CSV	ALV		DIRBCB
10H	DATBCB	HSTBL			

Figure 5-3. Disk Parameter Header (DPH)

Table 5-2. Disk Parameter Header Data Fields

Field	Explanation
XLT	Translation Table Address. The Translation Table Address defines a vector for logical-to-physical sector translation. If there is no sector translation (the physical and logical sector numbers are the same), set XLT to 0000h. Disk drives with identical sector skew factors can share the same translation tables. This address is not referenced by the BDOS and is only intended for use by the disk driver routines. Normally the translation table contains one byte per physical sector. If the disk has more than 256 sectors per track, the sector translation must consist of two bytes per physical sector. It is advisable, therefore, to keep the number of physical sectors per logical track to a reasonably small value to keep the translation table from becoming too large. In the case of disks with multiple heads, compute the head number from the track address rather than the sector address.
0000	Scratch Area. The 5 bytes of zeros are a scratch area which the BDOS uses to maintain various parameters associated with the drive. They must be initialized to zero by the INIT routine or the load image.

Table 5-2. (continued)

Field	Explanation
MF	Media Flag. The BDOS resets MF to zero when the drive is logged in. The XIOS must set this flag to 0FFH if it detects that the operator has opened the drive door. It must also set the global door open flag in the XIOS Header at the same time. If the flag is set to 0FFH, the BDOS checks for a media change before performing the next BDOS file operation on that drive. Note that the BDOS only checks this flag when first making a system call and not during an operation. Normally, this flag is only useful in systems that support door open interrupts. If the BDOS determines that the drive contains a new disk, the BDOS logs out this drive and resets the MF field to 00H. **Note:** if this flag is used, removable disk performance can be optimized as if it were a permanent drive. See the description of the CKS field in the Section 5.5, "Disk Parameter Block."
DPB	Disk Parameter Block Address. The DPB field contains the address of a Disk Parameter Block that describes the characteristics of the disk drive. The Disk Parameter Block itself is described in Section 5.5.
CSV	Checksum Vector Address. The Checksum Vector Address defines a scratchpad area the system uses for checksumming the directory to detect a media change. This address must be different for each Disk Parameter Header. There must be one byte for every 4 directory entries (or 128 bytes of directory). In other words, Length(CSV) = (DRM/4)+1. (DRM is a field in the Disk Parameter Block defined in Section 5.5.) If CKS in the DPB is 0000H or 8000H, no storage is reserved, and CSV may be zero. Values for DRM and CKS are calculated as part of the DPB Worksheet. If this field is initialized to 0FFFFH, GENCCPM will automatically create the checksum vector and initialize the CSV field in the DPH.

Table 5-2. (continued)

Field	Explanation
ALV	Allocation Vector Address. The Allocation Vector address defines a scratchpad area which the BDOS uses to keep disk storage allocation information. This address must be different for each DPH. The Allocation Vector must contain two bits for every allocation block (one byte per 4 allocation blocks) on the disk. Or, Length(ALV) = ((DSM/8)+1)*2. The value of DSM is calculated as part of the DPB Worksheet. If the CSV field is initialized to 0FFFFH, GENCCPM automatically creates the Allocation Vector in the SYSDAT Table Area, and sets the ALV field in the DPH.
DIRBCB	Directory Buffer Control Block Header Address. This field contains the offset address of the DIRBCB Header. The Directory Buffer Control Block Header contains the directory buffer link list root for this drive. See Section 5.6, "Buffer Control Block Data Area." The BDOS uses directory buffers for all accesses of the disk directory. Several DPHs can refer to the same DIRBCB, or each DPH can reference an independent DIRBCB. If this field is 0FFFFH, GENCCPM automatically creates the DIRBCB Header, DIRBCBs, and the Directory Buffer for the drive, in the SYSDAT Table Area. GENCCPM then sets the DIRBCB field to point to the DIRBCB Header.
DATBCB	Data Buffer Control Block Header Address. This field contains the offset address of the DATBCB Header. The Data Buffer Control Block Header contains the data buffer link list root for this drive (see Section 5.6, "Buffer Control Block Data Area"). 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, the DATBCB field of the DPH can be set to 0000H and no data buffers are allocated. If this field is 0FFFFH, GENCCPM automatically creates the DATBCB Header and DATBCBs and allocates space for the Data Buffers in the area following the RSPs.

Table 5-2. (continued)

Field	Explanation
HSTBL	Hash Table Segment. The Hash Table Segment contains the segment address of the optional directory hashing table associated with a DPH. The BDOS assumes the Hash Table Offset to be zero. If directory hashing is not used, set HSTBL to zero. Including a Hash Table dramatically improves disk performance. Each DPH using hashing must reference a unique hash table. If a hash table is desired, Length(hash_table) = 4*(DRM+1) bytes. DRM is computed as part of the DPB Worksheet. In other words, each entry in the hash table must hold four bytes for each directory entry of the disk. If this field is 0FFFFH, GENCCPM will automatically create the appropriate data structures following the RSP area. **Note:** the data areas for the Data Buffers and Hash Tables are not made part of the CCPM.SYS file by GENCCPM.

Listing 5-4 illustrates the DPH definition:

```
;**********************************
;*
;*      DPH Definition
;*
;**********************************

xlt     equ     word ptr 0
mf      equ     byte ptr 5
dpb     equ     word ptr 8
csv     equ     word ptr 10
alv     equ     word ptr 12
dirbdb  equ     word ptr 14
datbcb  equ     word ptr 16
hstbl   equ     word ptr 18
```

Listing 5-4. DPH Definition

```
dpbase  equu    offset $        ;Base of Disk Parameter Headers

dpe0    dw      xlt0            ;Translate Table
        db      0,0,0           ;Scratch Area
        db      0               ;Media Flag
        db      0,0             ;Scratch Area
        dw      dpb0            ;Dsk Parm Block
        dw      0FFFFH,0FFFFH   ;Check, Alloc Vectors
        dw      0FFFFH          ;Dir Buff Cntrl Blk
        dw      0FFFFH          ;Data Buff Cntrl Blk
        dw      0FFFFH          ;Hash Table Segment

;-----------------------------------------------------------
```

Listing 5-4. (continued)

Given n disk drives, the DPHs can be arranged in a table whose first row of 20 bytes corresponds to drive 0, with the last row corresponding to drive n-1. The DPH Table has the following format:

For automatic table generation by GENCCPM,
set these fields to 0FFFFH:

DPH_TBL:

						V	V	V	V	V
00	XLT00	0000H	0000H	0000H	DPB00	CSV00	ALV00	DIR00	DAT00	HST00
01	XLT01	0000H	0000H	0000H	DPB01	CSV01	ALV01	DIR00	DAT00	HST01

(and so forth)

Figure 5-4. DPH Table

where the label DPH_TBL defines the offset of the DPH Table in the XIOS.

The IO_SELDSK Function, defined in Section 5.1, returns the offset of the DPH from the beginning of the SYSDAT segment for the selected drive. The sequence of operations in Listing 5-5 returns the table offset, with a 0000H returned if the selected drive does not exist.

```
;*********************************************
;*                                           *
;*          DISK IO CODE AREA                *
;*                                           *
;*********************************************

;=========
IO_SELDSK:     ; Function 7:  Select Disk
;=========
;       entry:  CL = disk to be selected
;               DL = 00h if disk has not been previously selected
;                  = 01h if disk has been previously selected
;       exit:   AX = 0 if illegal disk
;                  = offset of DPH relative from
;                     XIOS Data Segment

        xor bx,bx               ; Get ready for error
        cmp cl,15               ; Is it a valid drive
        ja sel_ret              ; If not just exit
          mov bl,cl
          shl bx,1              ; Index into the Dph's
          mov bx,dph_tbl[bx]    ; get DPH address from table
                                ; in XIOS Header
sel_ret:
        mov ax,bx
        ret

;---------------------------------------------------------------
```

Listing 5-5. SELDSK XIOS Function

The Translation Vectors, XLT00 through XLTn-1, whose offsets are contained in the DPH Table as shown in Figure 5-4, are located elsewhere in the XIOS, and correspond one-for-one with the logical sector numbers zero through the sector count-1.

5.5 Disk Parameter Block

The Disk Parameter Block (DPB) contains parameters which define the characteristics of each disk drive. The Disk Parameter Header (DPH) points to a DPB thereby giving the BDOS necessary information on how to access a disk. Several DPHs can address the same DPB if their drive characteristics are identical. Each field of the Disk Parameter Block is described in Table 5-3, and a worksheet is included to help you calculate the value for each field.

```
00H |    SPT    | BSH | BLM | EXM |    DSM    |   DRM...
08H ..DRM | AL0 | AL1 |    CKS    |    OFF    | PSH |
10H | PHM |
```

Figure 5-5. Disk Parameter Block Format

Table 5-3. Disk Parameter Block Data Fields

Field	Explanation
SPT	Sectors Per Track. The number of Sectors Per Track equals the total number of physical sectors per track. Physical sector size is defined by PSH and PHM.
BSH	Allocation Block Shift Factor. This value is used by the BDOS to easily calculate a block number, given a logical record number, by shifting the record number BSH bits to the right. BSH is determined by the allocation block size chosen for the disk drive.
BLM	Allocation Block Mask. This value is used by the BDOS to easily calculate a logical record offset within a given block though masking a logical record number with BLM. The BLM is determined by the allocation block size.
EXM	Extent Mask. The Extent Mask determines the maximum number of 16K logical extents contained in a single directory entry. It is determined by the allocation block size and the number of blocks.
DSM	Disk Storage Maximum. The Disk Storage Maximum defines the total storage capacity of the disk drive. This equals the total number of allocation blocks for the drive, minus 1. 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 255.

Table 5-3. (continued)

Field	Explanation
DRM	Directory Maximum. The Directory Maximum defines the total number of directory entries on this disk drive. This equals the total number of directory entries that can be kept in the allocation blocks reserved for the directory, minus 1. Each directory entry is 32 bytes long. The maximum number of blocks that can be allocated to the directory is 16, which determines the maximum number of directory entries allowed on the disk drive.
AL0, AL1	Directory Allocation Vector. The Directory Allocation Vector is a bit map that is used to quickly initialize the first 16 bits of the Allocation Vector that is built when a disk drive is logged in. Each bit, starting with the high-order bit of AL0, represents an allocation block being used for the directory. AL0 and AL1 determine the amount of disk space allocated for the directory.
CKS	Checksum Vector Size. The Checksum Vector Size determines the required length, in bytes, of the directory checksum vector addressed in the Disk Parameter Header. Each byte of the checksum vector is the checksum of 4 directory entries or 128 bytes. A checksum vector is required for removable media in order to insure the integrity of the drive. The high-order bit in the CKS field indicates a permanent drive and allows far better performance by delaying writes. Typically, hard disk systems have the value 8000H, indicating no checksumming and permanent media. On machines that can detect the door open for removable media, a special case occurs where checksumming is only done when the Media Flag (MF) byte in the DPH is set to 0FFH. Normally, the disk is treated like a permanent drive, allowing more optimal use. In this case, adding 8000H to the CKS value indicated a permanent drive with checksumming.
OFF	Track Offset. The Track Offset is the number of reserved tracks at the beginning of the disk. OFF is equal to the zero-relative track number on which the directory starts. It is through this field that more than one logical disk drive can be mapped onto a single physical drive. Each logical drive has a different Track Offset and all drives can use the same physical disk drivers.

Table 5-3. (continued)

Field	Explanation
PSH	Physical Record Shift Factor. The Physical Record Shift Factor is used by the BDOS to quickly calculate the physical record number from the logical record number. The logical record number is shifted PSH bits to the right to calculate the physical record. **Note:** in this context, physical record and physical sector are equivalent terms.
PRM	Physical Record Mask. The Physical Record Mask is used by the BDOS to quickly calculate the logical record offset within a physical record by masking the logical record number with the PRM value.

Listing 5-6 illustrates the DPB definition:

```
;******************************
;*
;*   DPB Definition
;*
;******************************

spt     equu    word ptr 0
```

Listing 5-6. DPB Definition

```
dpb0    equ     offset $            ;Disk Parameter Block
        dw      26                  ;Sectors Per Track
        db      3                   ;Block Shift
        db      7                   ;Block Mask
        db      0                   ;Extnt Mask
        dw      242                 ;Disk Size - 1
        dw      63                  ;Directory Max
        db      192                 ;Alloc0
        db      0                   ;Alloc1
        dw      16                  ;Check Size
        dw      2                   ;Offset
        db      0                   ;Phys Sec Shift
        db      0                   ;Phys Rec Mask

;---------------------------------------------------------------
```

Listing 5-6. (continued)

5.5.1 Disk Parameter Block Worksheet

This worksheet is intended to help you create a Disk Parameter Block containing the specifications for the particular disk hardware you are implementing. After calculating the disk parameters according to the directions given below, enter the value into the disk parameter list following the Worksheet. That way, all the values you have calculated will be in one place for a convenient reference. The following steps, which result in values to be placed in the DPB, are labeled "field in Disk Parameter Block".

<A> Allocation Block Size

Concurrent CP/M-86 allocates disk space in a unit known as an allocation block. This is the minimum allocation of disk space given to a file. This value may be 1024, 2048, 4096, 8192, or 16384 decimal bytes, or 400H, 800H, 1000H, 2000H, or 4000H bytes, respectively. Choosing a large allocation block size allows more efficient usage of directory space for large files and allows a greater number of directory entries. On the other hand, a large allocation block size increases the average wasted space per disk file. This is the allocated disk space beyond the logical end of a disk file. Also, choosing a smaller block size increases the size of the allocation vectors because there is a greater number of smaller blocks on the same size disk. Several restrictions on the block size exist. If the block size is 1024 bytes, there cannot be more than 255 blocks present on a logical drive. In other words, if the disk is larger than 256K bytes, it is necessary to use at least 2048-byte blocks.

<B> BSH Block Shift field in Disk Parameter Block
<C> BLM Block Mask field in Disk Parameter Block

Determine the values of BSH and BLM from the following table given the value <A>.

Table 5-4. BSH and BLM Values

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

<D> Total Allocation Blocks

Determine the total number of allocation blocks on the disk drive. The total available space on the drive, in bytes, is calculated by multiplying the total number of tracks on the disk, minus reserved operating system tracks, by the number of sectors per track and the physical sector size. This figure is then divided by the allocation block size determined in <A> above. This latter value, rounded down to the next lowest integer value, is the Total Allocation Blocks for the drive.

<E> DSM Disk Size Max field in Disk Parameter Block

The value of DSM equals the maximum number of allocation blocks that this particular drive supports, minus 1.

Note: the product (Allocation Block Size)*(DSM+1) is the total number of bytes the drive holds and must be within the capacity of the physical disk, not counting the reserved operating system tracks.

<F> EXM Extent Mask field in Disk Parameter Block

Obtain the value of EXM from the following table, using the values of <A> and <E>. (N/A = not available)

Table 5-5. EXM Values

<A>	If <E> is less than 256	If <E> is greater than or equal to 256
1,024	0	N/A
2,048	1	0
4,096	3	1
8,192	7	3
16,384	15	7

<G> Directory Blocks

Determine the number of Allocation Blocks reserved for the directory. This value must be between 1 and 16.

<H> Directory Entries per Block

From the following table, determine the number of directory entries per Directory Block, given the Allocation Block size, <A>.

Table 5-6. Directory Entries per Block Size

<A>	# entries
1,024	32
2,048	64
4,096	128
8,192	256
16,384	512

<I> Total directory entries

Determine the total number of Directory Entries by multiplying <G> by <H>.

<J> DRM Directory Max field in Disk Parameter Block

Determine DRM by subtracting 1 from <I>

<K> AL0, AL1 Directory Allocation vector 0, 1 field in Disk Parameter Block

Determine AL0 and AL1 from the following table, given the number of Directory Blocks, <G>.

Table 5-7. AL0, AL1 Values

<G>	AL0	AL1	<G>	AL0	AL1
1	80H	00H	9	0FFH	80H
2	0C0H	00H	10	0FFH	0C0H
3	0E0H	00H	11	0FFH	0E0H
4	0F0H	00H	12	0FFH	0F0H
5	0F8H	00H	13	0FFH	0F8H
6	0FCH	00H	14	0FFH	0FCH
7	0FEH	00H	15	0FFH	0FEH
8	0FFH	00H	16	0FFH	0FFH

<L> CKS Checksum field in Disk Parameter Block

Determine the Size of the Checksum Vector. If the disk drive media is permanent, then the value should be 8000H. If the disk drive media is removable, the value should be (<J>/4)+1. If the disk drive media is removable and the Media Flag is implemented (door open can be detected through interrupt), CKS should equal ((<J>/4)+1)+ 8000H. The Checksum Vector should be CKS bytes long and addressed in the DPH.

<M> OFF Offset field in Disk Parameter Block

The OFF field determines the number of tracks that are skipped at the beginning of the physical disk. The BDOS automatically adds this to the value of TRACK in the IOPB and can be used as a mechanism for skipping reserved operating system tracks, or for partitioning a large disk into smaller logical drives.

<N> Size of Allocation Vector

In the DPH, the Allocation Vector is addressed by the ALV field. The size of this vector is determined by the number of Allocation Blocks. Each byte in the vector represents four blocks, or Size of Allocation Vector = ((<E>/8)+1)*2.

<O> Physical Sector Size

Specify the Physical Sector Size of the Disk Drive. Note that the Physical Sector Size must be greater than or equal to 128 and less than 4096 or the Allocation Block Size, whichever is smaller. This value is typically the smallest unit that can be read or written to the disk.

<P> PSH Physical record SHift field in Disk Parameter Block
<Q> PRM Physical Record Mask in Disk Parameter Block

Determine the values of PSH and PRM from the following table given the Physical Sector Size.

Table 5-8. PSH and PRM Values

<O>	PSH	PRM
128	0	0
256	1	1
512	2	3
1024	3	7
2048	4	15
4096	5	31

5.5.2 Disk Parameter List Worksheet

<A> Allocation Block Size ________

<B> BSH field in Disk Parameter Block ________

<C> BLM field in Disk Parameter Block ________

<D> Total Allocation Blocks ________

<E> DSM field in Disk Parameter Block ________

<F> EXM field in Disk Parameter Block ________

<G> Directory Blocks ________

<H> Directory Entries per Block ________

<I> Total directory entries ________

<J> DRM field in Disk Parameter Block ________

<K> AL0,AL1 fields in Disk Parameter Block ________

<L> CKS field in Disk Parameter Block ________

<M> OFF field in Disk Parameter Block ________

<N> Size of Allocation Vector ________

<O> Physical Sector Size ________

<P> PSH field in Disk Parameter Block ________

<Q> PRM field in Disk Parameter Block ________

5.6 Buffer Control Block Data Area

The Buffer Control Blocks (BCBs) locate physical record buffers for the BDOS. BCBs are usually generated automatically by GENCCPM. The BDOS uses the BCB to manage the physical record buffers during processing. More than one Disk Parameter Header (DPH) can specify the same list of BCBs. The BDOS distinguishes between two kinds of BCBs, directory buffers, referenced by the DIRBCB field of the DPH, and data buffers, referenced by DATBCB field of the DPH.

The DIRBCB and DATBCB fields each contain the offset address of a Buffer Control Block Header. The BCB Header contains the offset of the first BCB in a linked list of BCBs. Each BCB has a LINK field containing the address of the next BCB in the list, or 0000H if it is the last BCB. All BCB Headers and BCBs must reside within the SYSDAT segment.

BCBLR	MBCBP

Figure 5-6. Buffer Control Block Header

Table 5-9. Buffer Control Block Header Data Fields

Field	Explanation
BCBLR	Buffer Control Block List Root. The Buffer Control Block List Root points to the first BCB in a linked list of BCB's.
MBCBP	Maximum BCB's per Process. The MBCBP is the maximum number of BCB's that the BDOS can allocate to any single process at one time. If the number of BCB's required by a process is greater than MBCBP, the BDOS reuses BCB's previously allocated to this process on a least-recently-used (LRU) basis.

Listing 5-7 illustrates the BCB Header definition:

```
;****************************
;*
;*   BCB Header Definition
;*
;****************************

bcblr   equ     word ptr 0
mbcbp   equu    byte ptr 2


dirbcb  dw      dirbcb0         ;BCB List Head
        db      4               ;Max # BCB's/Process

;--------------------------------------------------------------
```

Listing 5-7. BCB Header Definition

Figure 5-7 shows the format of the Directory Buffer Control Block:

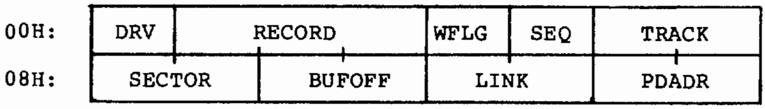


Figure 5-7. Directory Buffer Control Block (DIRBCB)

Table 5-10. DIRBCB Data Fields

Field	Explanation
DRV	Logical Drive Number. The Logical Drive Number identifies the disk drive associated with the physical sector contained in the buffer. The initial value of the DRV field must be 0FFH. If DRV = 0FFh then the BDOS considers that the buffer contains no data and is available for use.
RECORD	Record Number. The Record Number identifies the logical record position of the current buffer for the specified drive. The record number is relative to the beginning of the logical disk, where the first record of the directory is logical record number zero.
WFLG	Write Pending Flag. The BDOS sets the Write Pending Flag to 0FFH to indicate that the buffer contains unwritten data. When the data are written to the disk, the BDOS sets the WFLG to zero to indicate that the buffer is no longer dirty.
SEQ	Sequential Access Counter. The BDOS uses the Sequential Access Counter during blocking and deblocking to detect whether the buffer is being accessed sequentially or randomly. If sequential access is used, the BDOS allows reuse of the buffer to avoid consumption of all buffers during sequential I/O.
TRACK	Logical Track Number. The TRACK is the logical track number for the current buffer.
SECTOR	Physical Sector Number. SECTOR is the logical sector number for the current buffer.
BUFOFF	Buffer Offset. For DIRBCBs, this field equals the offset address of the buffer within SYSDAT.
LINK	Link to next DIRBCB. The Link field contains the offset address of the next BCB in the linked list, or 0000H, if this is the last BCB in the linked list.
PDADR	Process Descriptor Address. The BDOS uses the Process Descriptor Address to identify the process which owns the current buffer.

The buffer associated with the BCB must be large enough to accommodate the largest physical record (equivalent to physical sector) associated with any DPH referencing the BCBs. The initial value of the DRV field must be 0FFH. When the DRV field contains 0FFH, the BDOS considers that the buffer contains no data and is available for use. When WFLG equals 0FFH, the buffer contains data that the BDOS has to write to the disk before the buffer is available for other data.

Directory BCBs never have the BCB WFLG parameter set to 0FFH because directory buffers are always written immediately. The BDOS postpones only data buffer write operations. Thus, only data BCBs can have dirty buffers.

The data and directory BCBs must be separate. This is to ensure that a buffer with a clear WFLG is available when the BDOS verifies the directory. If all the buffers contain new data (WFLG set to 0FFH), the BDOS has to perform a write before it can verify that the disk media has changed. This could result in data being written on the wrong disk inadvertently. The following listing illustrates the DIRBCB definition:

```
;*******************************
;*
;*    DIRBCB Definition
;*
;*******************************

drv     equ     byte ptr 0
record  equ     byte ptr 1
wflg    equ     byte ptr 4
seq     equ     byte ptr 5
track   equ     word ptr 6
sector  equ     word ptr 8
bufoff  equ     word ptr 10
link    equ     word ptr 12
pdadr   equ     word ptr 14


dirbcb0 db      0ffh            ;Drive
        rb      3               ;Record
        rb      2               ;Pending, Sequence
        rw      2               ;Track, Sector
        dw      dirbuf0         ;Buffer Offset
        dw      dirbcb1         ;Link
        rw      1               ;PD Address

;--------------------------------------------------------------
```

Listing 5-8. DIRBCB Definition

Figure 5-8 shows the format of the Data Buffer Control Block (DATBCB):

<table>
<tr><td>00H:</td><td>DRV</td><td colspan="3">RECORD</td><td>WFLG</td><td>SEQ</td><td colspan="2">TRACK</td></tr>
<tr><td>08H:</td><td colspan="2">SECTOR</td><td colspan="2">BUFSEG</td><td colspan="2">LINK</td><td colspan="2">PDADR</td></tr>
</table>

Figure 5-8. Data Buffer Control Block (DATBCB)

The DATBCB is identical to the DIRBCB, except for the BUFSEG Field described in Table 5-11.

Table 5-11. DATBCB Data Fields

Field	Explanation
BUFSEG	Buffer Segment. For BCB's describing data buffers, this field equals the segment address of the Data Buffer. The offset address of the buffer is assumed to be zero. The actual buffer can be anywhere in memory on a paragraph boundary that is not in the system TPA.

Listing 5-9 illustrates the DATBCB definition:

```
;********************************
;*
;*   DATBCB Definition
;*
;********************************

drv     equu     byte ptr 0
```

Listing 5-9. DATBCB Definition

```
datbcb0 db      0ffh            ;Drive
        rb      3               ;Record
        rb      2               ;Pending, Sequence
        rw      2               ;Track, Sector
        dw      dirbuf0         ;Buffer Segment
        dw      dirbcbl         ;Link
        rw      1               ;PD Address

;---------------------------------------------------------------
```

Listing 5-9. (continued)

5.7 Memory Disk Application

A memory disk or "M disk" is a prime example of the ability of the Basic Disk Operating System to interface to a wide variety of disk drives. A memory disk uses an area of RAM to simulate a small capacity disk drive, making a very fast temporary disk. The M disk can be specified by GENCCPM as the temporary drive. The example XIOS implements an M disk for the IBM PC. This section discusses a similar M disk implementation as shown in Listing 5-10.

In Listing 5-10, the M disk memory space begins at the 0C000H paragraph boundary and extends for 128 Kbytes, through the 0DFFFH paragraph. It is assumed the XIOS INIT routine calls the INIT_M_DSK: code, which initializes the directory area of the M disk, the first 16 Kbytes, to 0E5H.

Both the M disk READ and WRITE routines first call the MDISK_CALC: routine. This code calculates the paragraph address of the current sector in memory, and the number of words of data to read or write. The number of sectors per track for the M disk is set to 8, simplifying the calculation of the sector address to a simple shift-and-add operation. The multisector count is multiplied by the length of a sector to give the number of words to transfer.

The READ_M_DISK: routine gets the current DMA address from the IOPB on the stack, and using the parameters returned by the MDISK_CALC: routine, block-moves the requested data to the DMA buffer. The WRITE_M_DISK: routine is similar except for the direction of data transfer.

A Disk Parameter Block for the M disk, illustrated at the end of the example, is provided for reference. A hash table is provided in order to increase performance to the maximum. However, this field can be set to zero if directory hashing is not desirable due to space limitations.

Listing 5-10 illustrates an M disk implementation:

```
;*****************************************************
;       M DISK EQUATES
;*****************************************************

mdiskbase       equ     0C000h  ;base paragraph
                                ;address of mdisk

;*****************************************************
;       M DISK INITIALIZATION
;*****************************************************
init_m_dsk:
        mov cx,mdiskbase
        push es ! mov es,cx
        xor di,di
        mov ax,0e5e5h           ;check if already initialized
        cmp es:[di],ax ! je mdisk_end
          mov cx,2000h          ;initialize 16K bytes
          rep stos ax           ;of M disk directory to 0E5h's
mdisk_end:
        pop es
        ret

;*****************************************************
;       M DISK CODE
;*****************************************************

;=======
IO_READ:        ; Function 11: Read sector
;=======
; Reads the sector on the current disk, track and
; sector into the current DMA buffer.
;       entry:  parameters on stack
;       exit:   AL = 00 if no error occurred
;               AL = 01 if an error occurred

read_m_dsk:
;----------
        call mdisk_calc         ;calculate byte address
        push es                 ;save UDA
        les di,dword ptr dmaoff ;load destination DMA address
        xor si,si               ;setup source DMA address
        push ds                 ;save current DS
        mov ds,bx               ;load pointer to sector in memory
        rep movsw               ;execute move of 128 bytes....
        pop ds                  ;then restore user DS register
        pop es                  ;restore UDA
        xor ax,ax               ;return with good return code
        ret
```

Listing 5-10. Example M disk implementation

```
;========
IO_WRITE:          ; Function 12: Write disk
;========
; Write the sector in the current Dma buffer
; to the current disk on the current
; track in the current sector.
;       entry:  CL = 0 - Deferred Writes
;                    1 - nondeferred writes
;                    2 - def-wrt 1st sect unalloc blk
;       exit:   AL = 00H if no error occurred
;                  = 01H if error occurred
;                  = 02H if read only disk

write_m_dsk:
;-----------
        call mdisk_calc         ;calculate byte address
        push es                 ;save UDA
        mov es,bx               ;setup destination DMA address
        xor di,di
        push ds                 ;save user segment register
        lds si,dword ptr dmaoff ;load source DMA address
        rep movsw               ;move from user to disk in memory
        pop ds                  ;restore user segment pointer
        pop es                  ;restore UDA
        xor ax,ax               ;return no error
        ret

mdisk_calc:
;----------
;       entry:  IOPB variables on the stack
;       exit:   BX = sector paragraph address
;               CX = length in words to transfer

        mov bx,track            ;pickup track number
        mov cl,3                ;times eight for relative
                                ;       sector number
        shl bx,cl
        mov cx,sector           ;plus sector
        add bx,cx               ;gives relative sector number
        mov cl,3                ;times eight for paragraph
                                ;       of sector start
        shl bx,cl
        add bx,mdiskbase        ;plus base address of disk
                                ;       in memory
        mov cx,64               ;length in words for move
                                ;       of 1 sector
        mov al,mcnt
        xor ah,ah
        mul cx                  ;length * multisector count
        mov cx,ax
        cld
        ret
```

Listing 5-10. (continued)

```
;*****************************************************
;       M DISK - DISK PARAMETER BLOCK
;*****************************************************

dpb0    equu    offset $            ;Disk Parameter Block
        dw      8                   ;Sectors Per Track
        db      3                   ;Block Shift
        db      7                   ;Block Mask
        db      0                   ;Extnt Mask
        dw      126                 ;Disk Size - 1
        dw      31                  ;Directory Max
        db      128                 ;Alloc0
        db      0                   ;Alloc1
        dw      0                   ;Check Size
        dw      0                   ;Offset
        db      0                   ;Phys Sec Shift
        db      0                   ;Phys Sec Mask

xlt5    equ     0                   ;No Translate Table
als5    equ     16*2                ;Allocation Vector Size
css5    equ     0                   ;Check Vector Size
hss5    equ     (32 * 4)            ;Hash Table Size

;-----------------------------------------------------------------
```

Listing 5-10. (continued)

End of Section 5

Section 6
Other XIOS Functions

6.1 IO_POLL Function

```
            IO_POLL    POLL DEVICE

 Poll Specified Device and Return Status

 Entry Parameters:
      Register AL:  0DH (13)
               DL:  Poll Device Number

 Returned   Value:
      Register AL:  0FFH if ready
                    0    if not ready
               BL:  Same as AL
               ES, DS, SS, SP  preserved
```

The IO_POLL function interrogates the status of the device indicated by the poll device number and returns its current status. It is called by the dispatcher.

A process polls a device only if the Concurrent CP/M-86 DEV_POLL system call has been made. The poll device number used as an argument for the DEV_POLL system call is the same number that the IO_POLL function receives as a parameter. Typically only the XIOS uses DEV_POLL. The mapping of poll device numbers to actual physical devices is maintained by the XIOS. Each polling routine must have a unique poll device number. For instance, if the console is polled, it must have different poll device numbers for console input and console output.

The sample XIOS shows the IO_POLL function taking the poll device number as an index to a table of poll functions. Once the address of the poll routine is determined, it is called and the return values are used directly for the return of the IO_POLL function.

6.2 Display Status Line

IO_STATLINE DISPLAY STATUS LINE

Display specified text on the status line

Entry Parameters:

Register AL:	08H (8)
CX:	if 0000H, continue to update the normal status line if CX = offset, print string at DX:CX if 0FFFFH, resume normal status line display
Register DX:	segment address of optional string

Return Values:	NONE ES, DS, SS, SP preserved

When IO_STATLINE is called with CX = 0, the normal status information is displayed by IO_STATLINE. The normal status line typically consists of the foreground virtual console number, the background mode of the foreground virtual console, the process that owns the foreground virtual console, the removable-media drives with open files, whether control P, S, or O are active, and the default printer number. The IO_STATLINE function in the example XIOS displays the above information, the state of the IBM PC "Caps Lock" and "Num Lock" keys and whether console output is to wrap around to the next line. The status line can be modified by the OEM, expanded to any size or displayed in a different area than the status line implemented in the example XIOS. A common addition to the status line is a time-of-day clock.

A status line is strongly recommended. However, if there are only 24 lines on the display device, the OEM might choose not to implement a status line. In this case IO_STATLINE can just return when called.

The normal status line is updated once per second by the CLOCK RSP. The operating system also requests normal status line updates when screen switches are made and when control P, S or O change state. The XIOS may call IO_STATLINE from other routines when some value displayed by the status line changes.

When IO_STATLINE is called with CX not equal to 0000H or 0FFFFH, then CX is assumed to be the byte offset and DX the paragraph address of an ASCII string to print on the status line. In the example XIOS the string is 80 characters maximum, to be displayed on the 25th line of the screen. This special status line remains on the screen until another special status line is requested, or IO_STATLINE is called with CX=0FFFFH. While a special status line is being displayed, calls to IO_STATLINE with CX=0000H are ignored. When IO_STATLINE function is called with CX=0FFFFH, the normal status line is displayed and subsequent calls with CX=0000H cause the status line to be updated with current information.

A process calling IO_STATLINE with a special status line (DX:CX = address of the string) must call IO_STATLINE before termination with CX=0FFFFH. Otherwise the normal status line will never be shown again. There is no provision for two processes calling IO_STATLINE at once, or for a process to find out which status line is being displayed.

End of Section 6

Section 7
XIOS TICK Interrupt Routine

The XIOS must continually perform two DEV_SETFLAG system calls. Once every system tick the system tick flag must be set if the TICK Boolean in the XIOS Header is 0FFH. Once every second, the second flag must be set. This requires the XIOS to contain an interrupt-driven tick routine that uses a hardware timer to count the time intervals between successive system ticks and seconds.

The recommended tick unit is a period of 16.67 milliseconds, corresponding to a frequency of 60 Hz. When operating on 50 Hz power, use a 20-millisecond period. The system tick frequency determines the dispatch rate for compute-bound processes. If the frequency is too high, an excessive number of dispatches occurs, creating a significant amount of additional system overhead. If the frequency is too low, compute-bound processes monopolize the CPU resource for longer periods.

Concurrent CP/M-86 uses Flag #2 to maintain the system time and day in the TOD structure in SYSDAT. The CLOCK process performs a DEV_WAITFLAG system call on Flag #2, and thus wakes up once per second to update the TOD structure. The CLOCK process also calls the IO_STATLINE XIOS function to update the status line once per second. The CLOCK process is an RSP and the source code is distributed in the OEM Kit. Any functions needing to be performed on a per-second basis can simply be added to the CLOCK.RSP.

After performing the DEV_SETFLAG calls described above, the XIOS TICK Interrupt routine must perform a Jump Far to the dispatcher entry point. This forces a dispatch to occur and is the mechanism by which Concurrent CP/M-86 effects process dispatching. The double-word pointer to the dispatcher entry used by the TICK interrupt is located at 0038H in the SYSDAT DATA. Please see Section 3.6, "Interrupt Devices," for more information on writing XIOS interrupt routines.

End of Section 7

Section 8
Debugging the XIOS

This section suggests a method of debugging Concurrent CP/M-86, requiring CP/M-86 running on the target machine, and a remote console. Hardware-dependent debugging techiniques (ROM monitor, in-circuit emulator) available to the XIOS implementor can certainly be used but are not described in this manual.

Implement the first cut of the XIOS using all polled I/O devices, all interrupts disabled including the system TICK, and Interrupt Vectors 1, 3, and 225, which are used by DDT-86 and SID-86, uninitialized. Once the XIOS functions are implemented as polling devices, change them to interrupt-driven I/O devices and test them one at a time. The TICK interrupt routine is usually the last XIOS routine to be implemented.

The initial system can run without a TICK interrupt, but has no way of forcing CPU-bound tasks to dispatch. However, without the TICK interrupt, console and disk I/O routines are much easier to debug. In fact, if other problems are encountered after the TICK interrupt is implemented, it is often helpful to disable the effects of the TICK interrupt to simplify the environment. This is accomplished by changing the TICK routine to execute an IRET instead of jumping to the dispatcher and not allowing the TICK routine to perform flag set system calls.

When a routine must delay for a specific amount of time, the XIOS usually makes a P_DELAY system call. An example is the delay required after the disk motor is turned on until the disk reaches operational speed. Until the TICK interrupt is implemented, P_DELAY cannot be called and an assembly language time-out loop is needed. To improve performance, replace these time-outs with P_DELAY system calls after the tick routine is implemented and debugged. See the MOTOR_ON: routine in the example XIOS for more details.

8.1 Running Under CP/M-86

To debug Concurrent CP/M-86 under CP/M-86, CP/M-86 must use a console separate from the console used by Concurrent CP/M-86. Usually a terminal is connected to a serial port and the console input, console output and console status routines in the CP/M-86 BIOS are modified to use the serial port. The serial port thus becomes the CP/M-86 console. Load DDT-86 under CP/M-86 using the remote console and read the CCPM.SYS image into memory using DDT-86. The Concurrent CP/M-86 XIOS must not reinitialize or use the serial port hardware that CP/M-86 is using.

It is somewhat difficult to use DDT-86 to debug an interrupt-driven virtual console handler. Because the DDT-86 debugger operates with interrupts left enabled, unpredictable results can occur.

Values in the CP/M-86 BIOS memory segment table must not overlap memory represented by the Concurrent CP/M-86 memory partitions allocated by GENCCPM. CP/M-86, in order to read the Concurrent CP/M-86 system image under DDT-86, must have in its segment tables the area of RAM that the Concurrent CP/M-86 system is configured to occupy. See Figure 8-1.

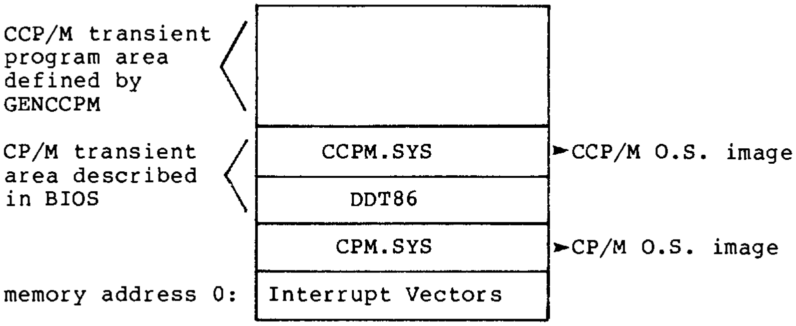


Figure 8-1. Debugging Memory Layout

Any hardware that is shared by both systems is usually not accessible to CP/M-86 after the Concurrent CP/M-86 initialization code has executed. Typically, this prevents you from getting out of DDT-86 and back to CP/M-86, or executing any disk I/O under DDT-86.

The technique for debugging an XIOS with DDT-86 running under CP/M-86 is outlined in the following steps:

1) Run DDT-86 on the CP/M-86 system.

2) Load the CCPM.SYS file under DDT-86 using the R command and the segment address of the Concurrent CP/M-86 system minus 8 (the length in paragraphs of the CMD file header). The segment address is specified to GENCCPM with the OSSTART option. Set up the CS and DS registers with the A-BASE values found in the CMD file Header Record. See the Concurrent CP/M-86 Operating System Programmer's Reference Guide description of the CMD file header.

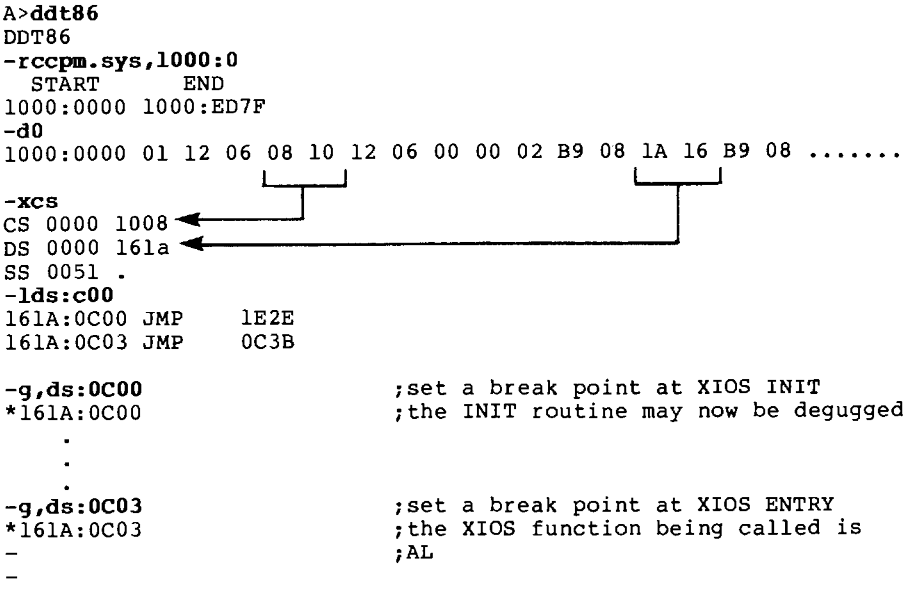
3) The addresses for the XIOS ENTRY and INIT routines can be found in the SYSDAT DATA at offsets 28H for ENTRY and 2CH for INIT. These routines will be at offset 0C03H and 0C00H relative to the data segment in DS.

4) Begin execution of the CCPM.SYS file at offset 0000H in the code segment. Breakpoints can then be set within the XIOS for debugging.

In the following figure, DDT-86 is invoked under CP/M-86 and the file CCPM.SYS is read into memory starting at paragraph 1000H. The OSSTART command in GENCCPM was specified with a paragraph address of 1008H when the CCPM.SYS file was generated. Using the DDT-86 D(ump) command the CMD header of the CCPM.SYS file is displayed. As shown, the A-BASE fields are used for the initial CS and DS segment register values. The following lines printed by GENCCPM also show the initial CS and DS values:

```
Code starts at 1008
Data starts at 161A
```

Two G(o) commands with breakpoints are shown, one at the beginning of the XIOS INIT routine and the other at the beginning of the ENTRY routine. These routines can now be stepped through using the the DDT-86 T(race) command. See the Programmer's Utility Guide for more information on DDT-86.



```
A>ddt86
DDT86
-rccpm.sys,1000:0
  START      END
1000:0000 1000:ED7F
-d0
1000:0000 01 12 06 08 10 12 06 00 00 02 B9 08 1A 16 B9 08 .......
-xcs
CS 0000 1008
DS 0000 161a
SS 0051 .
-lds:c00
161A:0C00 JMP    1E2E
161A:0C03 JMP    0C3B

-g,ds:0C00                    ;set a break point at XIOS INIT
*161A:0C00                    ;the INIT routine may now be degugged
    .
    .
    .
-g,ds:0C03                    ;set a break point at XIOS ENTRY
*161A:0C03                    ;the XIOS function being called is
-                             ;AL
-
```

Figure 8-2. Debugging CCP/M under DDT-86 and CP/M-86

When using SID-86 and symbols to debug the XIOS, extend the CCPM.SYS file to include unitialized data area not in the file. This ensures the symbols are not written over while in the debugging session. Assuming the same CCPM.SYS file as the preceding, use the following commands to extend the file.

```
SID86
#rccpm.sys,1000:0
  START      END
1000:0000 1000:ED7F
#xcs
CS 0000 1008
DS 0000 161c
SS 0051 .
#sw44
161C:0044 XXXX .                ;ENDSEG value from SYSDAT DATA
#
#wccpm.sys,1000:0,XXXX:0
#e                              ;release memory
#rccpm.sys,1000:0               ;read in larger file
  START      END
1000:0000 YYYY:ZZZZ
#e*xios                         ;get XIOS.SYM file
SYMBOLS
#
```

Figure 8-3. Debugging the XIOS Under SID-86 and CP/M-86

The preceding procedure to extend the file only needs to be performed once after the CCPM.SYS file is generated by GENCCPM.

End of Section 8

Section 9
Bootstrap Adaptation

This section discusses the example bootstrap procedure for Concurrent CP/M-86 on the IBM Personal Computer. This example is intended to serve as a basis for customization to different hardware environments.

9.1 Components of Track 0 on the IBM PC

Both Concurrent CP/M-86 and CP/M-86 for the IBM Personal Computer reserve track 0 of the 5-1/4 inch floppy disk for the bootstrap routines. The rest of the tracks are reserved for directory and file data. Track 0 is divided into two areas, sector 1 which contains the Boot Sector and sectors 2-8 which contain the Loader. Figure 9-1 shows the layout of track 0 of a Concurrent CP/M-86 boot disk for the IBM Personal Computer.

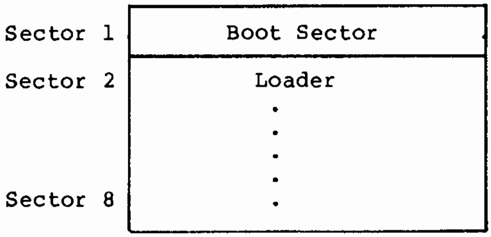


Figure 9-1. Track 0 on the IBM PC

The Boot Sector is brought into memory on reset or power-on by the IBM PC's ROM monitor. The Boot Sector then reads in all of track 0 and transfers control to the Loader.

The Loader is a simple version of Concurrent CP/M-86 that contains sufficient file processing capability to read the CCPM.SYS file, which contains the operating system image, from the boot disk to memory. When the Loader completes its operation, the operating system image receives control and Concurrent CP/M-86 begins execution.

The Loader consists of three modules: the Loader BDOS, the Loader Program, and the Loader BIOS. The Loader BDOS is an invariant module used by the Loader Program to open and read the system image file from the boot disk. The Loader Program is a variant module that opens and reads the CCPM.SYS file, prints the Loader sign-on message and transfers control to the system image. The Loader BIOS handles the variant disk I/O functions for the Loader BDOS. The term variant indicates that the module is implementation-specific. The layout of the Loader BDOS, the Loader Program, and the Loader BIOS is shown in Figure 9-2. The three-entry jump table at 0900H is used by the Loader BDOS to pass control to the Loader Program and the Loader BIOS.

Note: the Loader for the IBM PC example begins in sector 2 of track 0, and continues up to sector 8 along with the rest of the Loader BDOS, the Loader Program and the Loader BIOS.

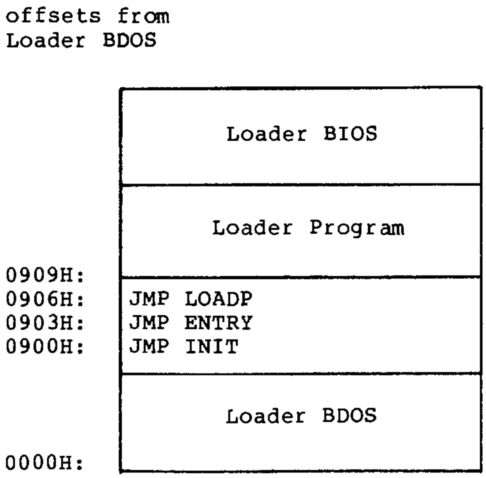


Figure 9-2. Loader Organization
(Sectors 2 through 8, Track 0 on IBM PC)

9.2 The Bootstrap Process

The sequence of events in the IBM PC after power-on is discussed in this section. Except for the functions that are performed by the IBM ROM monitor, the following process can be generalized to other 8086/8088 machines.

First the ROM monitor reads sector 1, track 0 on drive A: to memory location 0000:7C00H on power-on or reset. The ROM then transfers control to location 0000:7C00H by a JMPF (jump far) instruction. The Boot Sector program uses the ROM monitor to check for at least 160K of memory contiguous from 0. The ROM monitor is then used to read in the remainder of track 0 to memory location

2600:0000H (152K). Control is transferred to location 2620:0000H, which is the beginning of the second sector of track 0 and the beginning of the Loader. (Each sector is 512 bytes, or 20H paragraphs long.) The source code for the Boot Sector program can be found in the file BOOT.A86 on the Concurrent CP/M-86 distribution disk.

The exact location in memory of the Boot Sector and the Loader depend on the hardware environment and the system implementor. However, the Boot Sector must transfer control to the Loader BDOS with a JMPF (jump far) instruction, with the CS register set to paragraph address of the Loader BDOS and the IP register set to 0. Thus the Loader BDOS must be placed on a paragraph boundary. In the example Loader, the Loader BDOS begins execution with a CS register set to 2620H and the IP register set to 0000H.

The Loader BDOS sets the DS, SS, and ES registers equal to the CS register and sets up 64-level stack (128 bytes). The three Loader modules, the Loader BDOS, Program and BIOS, execute using an 8080 model (mixed code and data). It is assumed that the Loader BDOS, the Loader Program and the Loader BIOS will not require more than 64 levels of stack. If this is not true then the Loader Program and/or the Loader BIOS must perform a stack switch when necessary. The jump table at 0900H is an invariant part of the Loader, though the destination offsets of the jump instructions may vary.

After setting up the segment registers and the stack, the Loader BDOS performs a CALLF (call far) to the JMP INIT instruction at CS:900H. The INIT entry is for the Loader BIOS to perform any hardware initialization needed to read the CCPM.SYS file. Note that the Loader BDOS does not turn interrupts on or off, so if they are needed by the Loader, they must be turned on by the Boot Sector or the Loader BIOS. The example Loader BIOS executes an STI (Set Interrupt Enable Flag) instruction in the Loader BIOS INIT routine.

The Loader BIOS returns to the Loader BDOS by executing a RETF (Return Far) instruction. The Loader BDOS next initializes interrupt vector 224 (0E0H) and transfers control to the JMP LOADP instruction at 0906H, to start execution of the Loader Program.

The Loader Program opens and reads the CCPM.SYS file using the Concurrent CP/M-86 system calls supported by the Loader BDOS. The Loader Program transfers control to Concurrent CP/M-86 through the "JMPF CCPM" (Jump Far) instruction at the end the Loader Program, thus completing the loader sequence. The following sections discuss theorganization of the CCPM.SYS file and the memory image of Concurrent CP/M-86.

9.3 The Loader BDOS and Loader BIOS Function Sets

The Loader BDOS has a minimum set of functions required to open the system image file and transfer it to memory. These functions are invoked as under Concurrent CP/M-86 by executing a INT 224 (00E0H) and are documented in the Concurrent CP/M-86 Programmer's Reference Guide. The functions implemented by the Loader BDOS are in the following list. Any other function, if called, will return a 0FFFFh error code in registers AX and BX.

Func#	CL	Function Name
14	0Eh	Select Disk
15	0Fh	Open File
20	14h	Read Sequential
26	1Ah	Set DMA Offset
32	20h	Set/Get User Number
44	2Ch	Set Multisector Count
51	33h	Set DMA Segment

Blocking/Deblocking has been implemented in the Loader BDOS, as well as multisector disk I/O. This simplifies writing and debugging the loader BIOS and improves the system load time. File LBDOS.H86 includes the Loader BDOS.

The Loader BIOS must implement the minimum set of functions required by the Loader BDOS to read a file.

Func#	AL	Function Name
9	09H	IO_SELDSK (select disk)
10	0AH	IO_READ (read physical sectors)

To invoke IO_SELDSK or IO_READ in the Loader BIOS, the Loader BDOS performs a CALLF (Call Far) instruction to the jump instruction at ENTRY (0903H).

The Loader BIOS functions are implemented in the same way as the corresponding XIOS functions. Therefore the code used for the Loader BIOS may, with a few exceptions, be a subset of the system XIOS code. For example, the Loader BIOS does not use the DEV_WAITFLAG or DEV_POLL Concurrent CP/M-86 system functions. Certain fields in the Disk Parameter Headers and Disk Parameter Blocks can be initialized to 0, as in Figure 9-3:

Disk Parameter Header

00H	XLT	0000	00	00	0000
08H	DPB	0000	0000		DIRBCB
10H	DATBCB	0000			

Disk Parameter Block

00H	SPT	BSH	BLM	EXM	DSM	DRM...
08H	..DRM	00	00	0000	OFF	PSH
10H	PHM					

Figure 9-3. Disk Parameter Field Initialization

The Loader Program and Loader BIOS may be written as separate modules, or combined in a single module as in the example Loader. The size of these two modules can vary as dictated by the hardware environment and the preference of the system implementor. The LOAD.A86 file contains the Loader Program and the Loader BIOS. LOAD.A86 appears on the Concurrent CP/M-86 release disk, and may be assembled and listed for reference purposes.

The Loader Program and the Loader BIOS are in a contiguous section of the Loader to reduce the size of the Loader image. Grouping the variant code portions of the Loader into a single module, allows the implementation of nonfile-related functions in the most size-efficient manner. The example Loader BIOS implements the IO_CONOUT function in addition to IO_SELDSK and IO_READ. This Loader BIOS can be expanded to support keyboard input to allow the Loader Program to prompt for user options at boot time. However, the only Loader BIOS functions invoked by the Loader BDOS are IO_SELDSK and IO_READ, any other Loader BIOS functions must be invoked directly by the Loader Program.

9.4 Track 0 Construction

Track 0 for the example IBM PC bootstrap is constructed using the following procedure: The Boot Sector is 0200H (512) bytes long and is assembled with the command:

```
A>ASM86 BOOT
```

This results in the file BOOT.H86, which becomes a binary CMD file with the command:

```
        A>GENCMD BOOT 8080
```

The LOAD.A86 file, containing the the Loader Program and the Loader BIOS, is assembled using the command:

```
        A>ASM86 LOAD
```

The Loader BDOS starts a 0000H and ends at 0900H. The LOAD module starts at 0900H and ends at 0E00H. This equals the size of the 7 sectors remaining after the Boot Sector. The IBM PC disk format has eight 0200H-byte (512-byte) sectors, or 1000H (4K) bytes per track. Subtracting 0200H, the length of the Boot Sector, we get 0E00H. The LOADER.H86 file, containing the Loader BIOS, Loader Program and Loader BIOS, is constructed using the command:

```
        A>PIP LOADER.H86=LBDOS.H86,LOAD.H86
```

Next a binary CMD file is created from LOADER.H86 with GENCMD:

```
        A>GENCMD LOADER 8080
```

This results in the file LOADER.CMD with a header record defining the 8080 Model. Note this CMD file is not directly executable under any CP/M operating system; but can be debugged as outlined below. Next the BOOT.CMD and LOADER.CMD files are combined into a track image. Use DDT-86 or SID-86 to do this:

```
A>DDT86                      ; or SID86
-rboot.cmd
  START      END             ; aaaa is paragraph where DDT86
aaaa:0000 aaaa:027F          ; places BOOT.CMD
-wtrack0,80,107f             ; create the 4K file, TRACK0, without
                             ; a CMD header
-rtrack0                     ; read the 4K TRACK0 file into memory
  START      END
-bbbb:0000 bbbb:0FFF         ; TRACK0 starts at paragraph bbbb
-rloader.cmd                 ; read LOADER.CMD to another area of
  START      END             ; memory
-zzzz:0000 zzzz:0E7F         ; LOADER.CMD starts at paragraph zzzz
-mzzzz:80,0E7F,bbbb:0200     ; move the Loader to where sector 2
                             ; starts in the track image
-wtrack0,bbbb:0,0FFF         ; write the track image to the file
                             ; TRACK0
```

The final step is to place the contents of TRACK0 onto track 0. The TCOPY example program accomplishes this with the following command:

```
        A>TCOPY TRACK0
        A>TCOPY TRACK0
```

Scratch diskettes should be used for testing the Boot Sector and Loader. TCOPY is included as the source file TCOPY.A86, and needs to be modified to run in hardware environments other than the IBM PC. TCOPY only runs under CP/M-86 and cannot be used under Concurrent CP/M-86.

The Loader can be debugged separately from the Boot Sector under DDT-86 or SID-86, using the following commands:

```
A>DDT86                        ; or SID86
-rloader.cmd
  START      END               ; aaaa is paragraph where DDT86
aaaa:0000 aaaa:0E7F            ; places the Loader
-haaaa,8                       ; Add 8 paragraphs to skip over CMD
yyyy,zzzz                      ; header, aaaa + 8 = yyyy
-xcs
CS 0000 yyyy                   ; set CS for debugging
-l900                          ; IP is set to 0 by DDT86 or SID86
 ...
 ...
 ...
```

The l900 command lists the jumps to INIT, ENTRY and LOADP to verify the Loader Program and the Loader BIOS are at the correct offsets. Breakpoints can now be set in the Loader Program and Loader BIOS. The Boot Sector can be debugged in a similar manner, but sectors 2 through 8 need to contain the Loader image if the JMPF LOADER instruction in the Boot Sector is to be executed.

9.5 Other Bootstrap Methods

The preceding three sections outline the operation and steps for constructing a bootstrap loader for Concurrent CP/M-86 on the IBM PC. Many departures from this scheme are possible and they depend on the hardware environment and the goals of the implementor. The Boot Sector can be eliminated if the system ROM (or PROM) can read in the entire Loader at reset. The Loader can be eliminated if the CCPM.SYS file is placed on system tracks and the ROM can read in these system tracks at reset. However, this scheme usually requires too many system tracks to be practical. Alternatively, the Loader can be placed into a PROM and copied to RAM at reset, eliminating the need for any system tracks. If the Boot Sector and the Loader are eliminated, any initialization normally performed by the two modules must be performed in the XIOS initialization routine.

9.6 Organization of CCPM.SYS

The CCPM.SYS file, generated by GENCCPM and read by the Loader, consists of the seven *.CON files and any included *.RSP files. The CCPM.SYS file is prefixed by a 128-byte CMD Header Record, which contains the following two Group Descriptors:

G-Form	G-Length	A-Base	G-Min	G-Max
01h	xxxx	1008h	xxxx	xxxx
02h	xxxx	(varies)	xxxx	xxxx

Figure 9-4. Group Descriptors - CCPM.SYS Header Record

The first Group Descriptor represents the O.S. Code Group of the CCPM.SYS file and the second represents the Data. The preceding Code Group Descriptor has an A-Base load address at paragraph 1008H, or "paragraph:byte" address of 01008:0000H. The A-Base value in the Data Group Descriptor varies according to the modules included in this group by GENCCPM. The load address value shown above is only an example. The CCPM.SYS file can be loaded and executed at any address where there is sufficient memory space. The entire CCPM.SYS file appears on disk as shown in Figure 9-5.

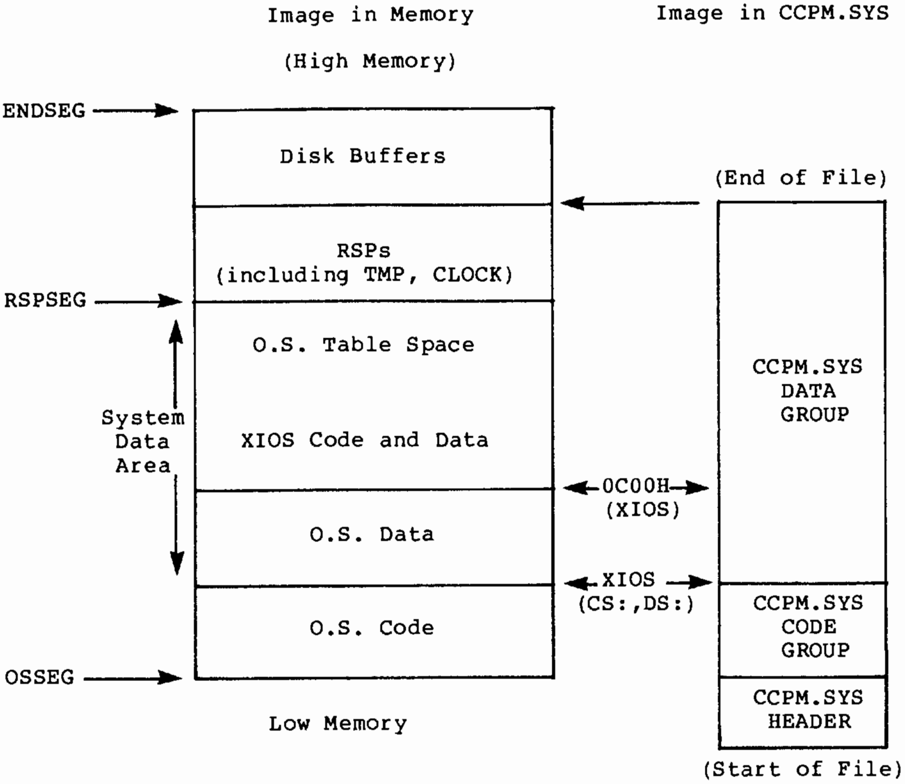


Figure 9-5. CCPM System Image and the CCPM.SYS File

The CCPM.SYS file is read into memory by the Loader beginning at the address given by Code Group A-Base (in the example shown above, paragraph address 1008H), and control is passed to the Supervisor INIT function when the Loader Program executes a JMPF instruction (Jump Far) to 1008:0000H. The Supervisor INIT must be entered with CS set to the value found in the A-BASE field of the code Group Descriptor, the IP register equal to 0 and the DS register equal to A-BASE value found in the data Group Descriptor.

End of Section 9

Section 10
OEM Utilities

A commercially viable Concurrent CP/M-86 system requires OEM-supported capabilities. These capabilities include methods for formatting disk and image backups of disks. Typically, an OEM supplies the following utilities:

- Disk Formatting Utility (FORMAT.CMD)
- Disk Copy Utility (DCOPY.CMD)

These utilities are usually hardware-specific and either make direct XIOS calls or go directly to the hardware.

10.1 Bypassing the BDOS

When special OEM utilities bypass the BDOS by making direct XIOS calls or going directly to the hardware, several programming precautions are necessary to prevent conflicts due to the Concurrent CP/M-86 multitasking environment. The following steps must be taken to prevent other processes from accessing the disk system:

1) Warn the user. This program bypasses the operating system. No other programs should be running while this program is being used.

2) Check for Version 2 of Concurrent CP/M-86 through the S_OSVER function. The following steps are specific to this version of Concurrent CP/M-86. They do not work in previous Digital Research operating systems, nor are they guaranteed to work in future Digital Research operating systems.

3) Set the process priority to 150 or better through the P_PRIORITY function. If another program is running on a background console, it cannot obtain the CPU resource while this program needs it.

4) Set the P_KEEP flag in the Process Descriptor to prevent termination of the operation without proper cleanup.

5) Make sure the program is running in the foreground and that the console is in DYNAMIC mode. Then lock the console into the foreground by setting the NOSWITCH flag in the CCB. This prevents the user from initiating a program on another virtual console while this program is running in the background. Because the file system is locked, a program cannot load from disk.

6) Make sure there are no open files in the system. This also detects background virtual consoles in BUFFERED mode.

7) Lock the BDOS by reading the MXdisk queue message.

8) You can now safely perform the FORMAT and DCOPY operations on the disk system, independent of the BDOS.

9) Once the operations are complete, allow the disk system to be reset by setting the login sequence number in each affected DPH to 0. When the disk system is reset, these drives are reset even if they are permanent. The login sequence field is 06h bytes from the beginning of the DPH.

10) Release the BDOS by writing the MXdisk queue message.

11) Reset the Disk System with the DRV_ALLRESET function.

12) Unlock the console system allowing console switching by unsetting the NOSWITCH bit of the CCB_FLAG field in the CCB.

13) Reset the P_KEEP flag in the Process Descriptor.

14) Terminate.

Listing 10-1 illustrates these steps and shows how to make direct XIOS calls to access the disk system. The routines corresponding to the steps are labeled for cross-reference purposes.

```
PAGEWIDTH       80
;
;*****************************************************
;*
;*      PHYSICAL.A86
;*
;*      Sample Program Illustrating Direct Calls to
;*      the Disk Routines in the XIOS.
;*
;*      This program will lock the console and disk
;*      systems, read a physical sector into memory
;*      and gracefully terminate.
;*
;*****************************************************

true            equ     0ffffh
false           equ     0

cr              equ     0dh
lf              equ     0ah

ccpmint         equ     224
ccpmver2        equ     01420H

        ; XIOS functions

io_seldsk       equ     09h
io_read         equ     0ah
io_write        equ     0bh

        ; SYSDAT Offsets

sy_xentry       equ     028h
sy_nvcns        equ     047h
sy_ccb          equ     054h
sy_openfile     equ     088h

        ; Process Descriptor
p_flag          equ     word ptr 06h
p_uda           equ     word ptr 010h
pf_keep         equ     00002h

        ; Console Control Block
ccb_size        equ     02ch
ccb_state       equ     word ptr 0eh
cf_buffered     equ     00001h
cf_background   equ     00002h
cf_noswitch     equ     00008h
```

Listing 10-1. Disk Utility Programming Example

```
        ; Disk Parameter Header

dph_lseq        equ     byte ptr 06h

        ; drvvec bits

drivea          equ     00001h
driveb          equ     00002h
drivec          equ     00004h

;*****************************************************
;*
;*      CODE SEGMENT
;*
;*****************************************************

        CSEG
        ORG     0

        ; Switch Stacks to make sure we have enough.
        ; This is done with interrupts off.
        ; Old 8086's and 8088's will allow an
        ; interrupt between SS and SP setting.

        pushf ! pop bx
        cli
        mov ax,ds ! mov ss,ax
        mov sp,offset tos
        push bx ! popf

        ; Step 1. - Warn the user.

        mov dx,warning ! call c_writebuf

        ; Step 2. - Check for Concurrent CP/M-86 V2.x

        call s_osver
        and ax,0fff0h
        cmp ax,ccpmver2 ! je good_version
            jmp bad_version
good_version:

        ; Step 3 - Set priority to 150

        mov dl,150
        call p_priority         ;priority = 150

        call get_osvalues       ;get OS values
```

Listing 10-1. (continued)

```
        ; Step 4 - Set the P_KEEP flag in PD

        call no_terminate       ;set p_keep flag

        ; Step 5 - Lock the console

        call lock_con           ;lock consoles

        ; Step 6 and 7 - Lock the BDOS,
        ;       make sure there are no open files

        call lock_disk          ;lock bdos

        ; Step 8 - Perform the Operation

        call operation          ;do operation

        jmp terminate           ;terminate

operation:
;---------
; Do our disk operations.  If we make changes to a
; disk, make sure to set the appropriate bit in the
; drvvec variable to force the BDOS to reinitialize
; the drive.  In this example are only going to
; read a physical sector from disk.

        ;  Lets read Track 2 Sector 2 of drive B
        ;  with DMA set to sectorbuf
        ;  Setup for Direct IO_READ call with
        ;  IOPB on Stack.

        mov ax,ds               ;save for DMA seg
        push es ! push ds
        mov es,udaseg
        mov ds,sysdat
        mov ch,1                ;mscnt = 1
        mov cl,1 ! push cx      ;drive = B
        mov cx,2 ! push cx      ;track = 2
        mov cx,2 ! push cx      ;sector = 2
        push ax                 ;DMA Seg = Our DS
        mov cx,offset sectorbuf
        push cx                 ;DMA Ofst
        mov ax,io_read
                ; do the read
        callf dword ptr .sy_xentry
        add sp,10
        pop ds ! pop es
        cmp al,0 ! je success
            mov dx,offset physerr
            call c_writebuf
```

Listing 10-1. (continued)

```
success:
                ; force a keystroke to allow testing
                ; of locking mechanisms
        jmp c_read

get_osvalues:
;------------
; get system addresses for later use

                ; Get System Data Area Segment
        push es
        call s_sysdat
        mov sysdat,es

                ; Get Process Descriptor Address
        call p_pdadr
        mov pdaddr,bx

                ; Get User Data Area Segment for
                ; XIOS calls
        mov ax,es:p_uda[bx]
        mov udaseg,ax
        pop es
        ret

no_terminate:
;------------
; Set the pf_keep flag.  We cannot be terminated.

        mov bx,pdaddr
        push ds ! mov ds,sysdat
        or p_flag[bx],pf_keep
        pop ds
        ret

lock_disk:
;---------
; Lock the BDOS.  No BDOS calls will be allowed in
; the system until we unlock it.

                ;get currently logged in drives
                ;for later reset
        call drv_loginvec
        mov drvvec,ax
                ;read mxdisk queue message
        mov dx,offset mxdiskqpb ! call q_open
        mov dx,offset mxdiskqpb ! call q_read
                ;turn on bdoslock flag for
                ;terminate
        mov bdoslock,true
```

Listing 10-1. (continued)

```
                ;verify no open files.  This will
                ;also check background consoles in
                ;buffered mode since they have open
                ;files when active.
        push ds ! mov ds,sysdat
        cmp word ptr .sy_openfile,0
        pop ds
        je lckb
                ;Error, open files
            jmp openf
lckb:   ret

bdos_unlock:
;------------
; unlock the BDOS.  Reset all logged in drives to
; make sure BDOS reinitializes them internally.

                ;reset all loggedin drives as well
                ;as drives we have played with.
        xor cx,cx
        mov ax,drvvec
resetd: cmp cx,16 ! je rdone
            test ax,1 ! jz nextdrv
                        ; we have a logged in drive,
                        ; get DPH address from XIOS
                push cx ! push ax
                push es ! push ds
                mov es,udaseg
                mov ds,sysdat
                mov ax,io_seldsk
                mov dx,0
                callf dword ptr .sy_xentry
                        ; if legal drive, set
                        ; login sequence # to 0.
xret:           cmp bx,0 ! je nodisk
                    mov dph_lseq[bx],0
nodisk:         pop ds ! pop es
                pop ax ! pop cx
                        ;try another drive
nextdrv:    inc cx
            shr ax,1
            jmps resetd
                ; all drives can be reset,
                ; write mxdisk queue message
                ; reset all drives
rdone:  mov dx,offset mxdiskqpb
        call q_write
        jmp drv_resetall
```

Listing 10-1. (continued)

```
lock_con:
;--------
; Lock the console system

        call getccbadr
        mov bx,ccbadr
        push ds ! mov ds,sysdat
        pushf ! cli
                ; make sure our console is
                ; foreground, dynamic
        cmp ccb_state[bx],0 ! je foreg
            popf ! pop ds
            jmp in_back

foreg:
                ; set console to NOSWITCH
        or ccb_state[bx],cf_noswitch
        popf ! pop ds
                ; turn on conlock flag for
                ; terminate
        mov conlock,true
        ret

con_unlock:
;----------
; Set console to switchable.

        mov bx,ccbadr
        push ds ! mov ds,sysdat
        and ccb_state[bx],not cf_noswitch
        pop ds
        ret

getccbadr:
;---------
; Calculate the CCB address for this console.

        call c_getnum
        xor ah,ah
        mov cx,ccb_size ! mul cx
        push ds ! mov ds,sysdat
        add ax,.sy_ccb
        pop ds
        mov ccbadr,ax
        ret

bad_version:
;-----------
        mov dx,offset wrong_version
        jmps errout
```

Listing 10-1. (continued)

```
in_back:
;-------
        mov dx,offset in_background
        jmps errout
openf:
;-----
        mov dx,offset openfiles
errout:
        call c_writebuf
terminate:
;---------

        ; Step 9,10,11  Clean up the file system

        cmp bdoslock,false ! je t01
            call bdos_unlock

        ; Step 12 - Unlock the console system

t01:    cmp conlock,false ! je t02
            call con_unlock

        ; Step 13 - Unset the P_KEEP flag in PD

t02:    mov bx,pdaddr
        push ds ! mov ds,sysdat
        and p_flag[bx],not pf_keep
        pop ds

        ; Step 14 - Terminate

        jmp p_termcpm

;-------------
; OS functions
;-------------

c_getnum:       mov cl,153 ! jmps ccpm
c_read:         mov cl,1 ! jmps ccpm
c_writebuf:     mov cl,9 ! jmps ccpm
drv_loginvec:   mov cl,24 ! jmps ccpm
drv_resetall:   mov cl,13 ! jmps ccpm
p_pdadr:        mov cl,156 ! jmps ccpm
p_priority:     mov cl,145 ! jmps ccpm
p_termcpm:      mov cl,0 ! jmps ccpm
q_open:         mov cl,135 ! jmps ccpm
q_read:         mov cl,137 ! jmps ccpm
q_write:        mov cl,139 ! jmps ccpm
s_osver:        mov cl,163 ! jmps ccpm
s_sysdat:       mov cl,154 ! jmps ccpm
ccpm:           int ccpmint
                ret
```

Listing 10-1. (continued)

```
;******************************************************
;*
;*      DATA SEGMENT
;*
;******************************************************

        DSEG
        ORG     0100H

sysdat          dw      0
pdaddr          dw      0
udaseg          dw      0
ccbadr          dw      0
drvvec          dw      0
bdoslock        db      false
conlock         db      false

mxdiskqpb       dw      0,0,0,0
                db      'mxdisk  '

        ;  ERROR MESSAGES

warning         db      'PHYSICAL: This program '
                db      'bypasses the operating '
                db      'system.',cr,lf
                db      'Make sure no other '
                db      'programs are running.'
                db      cr,lf,'$'

in_background   db      'PHYSICAL: must be run '
                db      'in the foreground, in'
                db      ' DYNAMIC mode.',cr,lf,'$'

wrong_version   db      'PHYSICAL: runs only on '
                db      'Concurrent CP/M-86 Version 2'
                db      cr,lf,'$'

open_files      db      'PHYSICAL: cannot run'
                db      'while there are open files.'
                db      cr,lf
                db      'If any virtual consoles are'
                db      ' in BUFFERED mode,',cr,lf
                db      'Use the VCMODE D command to'
                db      ' set a virtual console to '
                db      'DYNAMIC mode.',cr,lf,'$'

physerr         db      'Physical Error on Read.'
                db      cr,lf,'$'

sectorbuf       rb      1024
```

Listing 10-1. (continued)

```
        ; Lots of Stack.  Bottom prefilled with 0cch
        ; (INT 3 instruction) to see if we are
        ; overrunning the stack.  Also if we
        ; accidently execute it under DDT86,
        ; a breakpoint occurs.

        DW      0CCCCH,0CCCCH,0CCCCH
        DW      0CCCCH,0CCCCH,0CCCCH
        DW      0CCCCH,0CCCCH,0CCCCH
        DW      0CCCCH,0CCCCH,0CCCCH
        DW      0CCCCH,0CCCCH,0CCCCH
        DW      0CCCCH,0CCCCH,0CCCCH
        DW      0CCCCH,0CCCCH,0CCCCH
        DW      0CCCCH,0CCCCH,0CCCCH

        RW      0100H
tos     DW      0CCCCH          ; DW at end of DATA SEG
                                ; to make sure HEX is
                                ; generated.

        END     ; End of PHYSICAL.A86

;---------------------------------------------------------------
```

Listing 10-1. (continued)

10.2 Directory Initialization in the FORMAT Utility

The FORMAT utility initializes fresh disk media for use with Concurrent CP/M-86. It is written by the OEM and packaged with Concurrent CP/M-86 as a system utility. The physical formatting of a disk is hardware-dependent and therefore is not discussed here. This section discusses initialization of the directory area of a new disk.

The FORMAT program can initialize the directory with or without time and date stamping enabled. This can be a user option in the FORMAT program. If time and date stamps are not initialized, the user can independently enable this feature through the INITDIR and SET utilities.

It is highly recommended that the OEM supports the advanced features of Concurrent CP/M-86 including time and date stamping in the FORMAT program. This allows the user to use these features in their default disk format. Otherwise, the user must first learn that date stamps are possible and then must use the INITDIR and SET utilities to allow the use of this feature. If the disk directory is too close to being full, the INITDIR program will not allow the restructuring of the directory that is necessary to include SFCB's.

The cost of enabling the time and date stamp feature on a given disk is 25% of its total directory space. This space is used to store the time and date information in special directory entries called SFCB's. For time and date stamping, every fourth directory entry must be an SFCB. Each SFCB is logically an extension of the previous three directory entries. This method of storing date-stamp information allows efficient update of date stamps since all of the directory information for a given file resides within a single 128-byte logical disk record.

A disk under Concurrent CP/M-86 is divided into three areas, the reserved tracks, the directory area and the data area. The size of the directory and reserved areas is determined by the Disk Parameter Block, described in Section 5.5. The data area starts on the first disk allocation block boundary following the directory area.

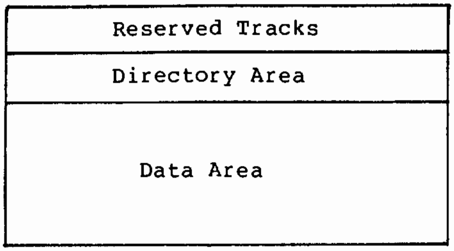


Figure 10-1. Concurrent CP/M-86 Disk Layout

The reserved area and the data area do not need to be initialized to any particular value before use as a Concurrent CP/M-86 disk. The directory area, on the other hand, must be initialized to indicate that no files are on the disk. Also, as discussed below, the FORMAT program can reserve space for time and date information and initialize the disk to enable this feature.

The directory area is divided into 32-byte structures called Directory Entries. The first byte of a Directory Entry determines the type and usage of that entry. For the purposes of directory initialization, there are three types of Directory Entries that are of concern: the unused Directory Entry, the SFCB Directory Entry and the Directory Label.

A disk directory initialized without time and date stamps have only the unused type of Directory Entry. An unused Directory Entry is indicated by a 0E5H in its first byte. The remaining 31 bytes in a Directory Entry are undefined and can be any value.

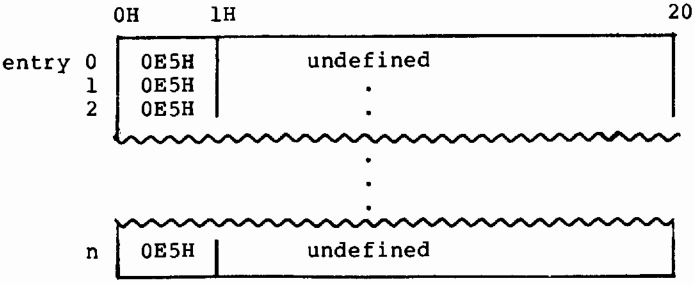


Figure 10-2. Directory Initialization Without Time Stamps

A disk directory initialized to enable time and date stamps must have SFCB's as every fourth Directory Entry. An SFCB has a 021H in the first byte and all other bytes must be 0H. Also a directory label must be included in the directory. This is usually the first Directory Entry on the disk. The directory label must be initialized as shown in Figure 10-3.

0H	1H	0CH	0DH	0EH	0FH	10H
20H	NAME	DATA	00H	00H	00H	

10H	11H	12H	13H	14H	15H	16H	17H	18H
20H	20H	20H	20H	20H	20H	20H	20H	

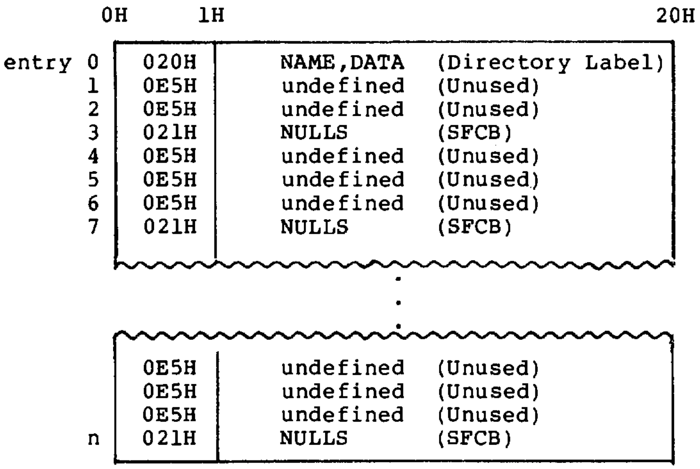
18H	19H	1AH	1BH	1CH	1DH	1EH	1FH	20H
00H	00H	00H	00H	00H	00H	00H	00H	

Figure 10-3. Directory Label Initialization

Table 10-1. Directory Label Data Fields

Field	Explanation
NAME	An 11 byte field containing an ASCII name for the drive. Unused bytes should be initialized to blanks (20H).
DATA	A bit field that tells the BDOS general characteristics of files on the disk. The DATA field can assume the following values: ● 060H enables date of last modification and date of last access to be updated when appropriate. ● 030H enables date of last modification and date of creation to be updated when appropriate.

The FORMAT program should ask the user for the name of the disk and whether to use the date of last access or the date of creation for files on this disk. The date of last modification should always be used. If the DATA field is 0H or if the Directory Label does not exist, the time and date feature is not enabled. The DATA Field must be 0H if SFCB's are not initialized in the directory.



```
          0H    1H                                  20H
entry 0 | 020H | NAME,DATA   (Directory Label) |
      1 | 0E5H | undefined   (Unused)          |
      2 | 0E5H | undefined   (Unused)          |
      3 | 021H | NULLS       (SFCB)            |
      4 | 0E5H | undefined   (Unused)          |
      5 | 0E5H | undefined   (Unused)          |
      6 | 0E5H | undefined   (Unused)          |
      7 | 021H | NULLS       (SFCB)            |
                        .
                        .
                        .
        | 0E5H | undefined   (Unused)          |
        | 0E5H | undefined   (Unused)          |
        | 0E5H | undefined   (Unused)          |
      n | 021H | NULLS       (SFCB)            |
```

Figure 10-4. Directory Initialization With Time Stamps

End of Section 10

Section 11

End-user Documentation

OEMs must be aware that the documentation supplied by Digital Research for the generic release of Concurrent CP/M-86 describes only the example XIOS implementation. If the OEM decides to change, enhance, or eliminate a function which impacts the Concurrent CP/M-86 operator interface, he must also issue documentation describing the new implementation. This is best done by purchasing reprint rights to the Concurrent CP/M-86 system publications, rewriting them to reflect the changes, and distributing them along with the OEM-modified system.

One area that is highly susceptible to modification by the OEM is the Status Line XIOS function. Depending upon the implementation, it might be desirable to display different, more, or even no status parameters. The documentation supplied with Concurrent CP/M-86, however, assumes that the Status Line function is implemented exactly like the example XIOS presented herein.

Another area which the OEM might want to change is the default login disk. At system boot time, the default system disk as specified in the system GENCCPM session is automatically logged-in and displayed in the first system prompt. However, a startup command file, STARTUP.N, where N is the Virtual Console number, can be implemented for each Virtual Console. This file can switch the default logged-in disk drive to any drive desired. However, the Concurrent CP/M-86 Operating System User's Guide assumes that the prompt will show the system disk. For more information on startup files, see the Concurrent CP/M-86 Operating System User's Guide and the Concurrent CP/M-86 Operating System Programmer's Reference Guide.

The Concurrent CP/M-86 system prompt is similar to the CP/M 3 prompt in that the User Number is not displayed for User 0. If the user changes to a higher User Number, then the User Number is displayed as the first character of the prompt, for example 5A>. If the OEM wants to change this, or any other function of the user interface, such as implementing Programmable Function Keys, he can rewrite the TMP module source code included with the system. However, documenting these changes is entirely the OEM's responsibility.

End of Section 11

Appendix A
Removable Media

All disk drives are classified under Concurrent CP/M-86 as having either permanent or removable media. Removable-media drives support media changes; permanent drives do not. Setting the high-order bit of the CKS field of the drive's DPB marks the drive as a permanent-media drive. See Section 5.5, "Disk Parameter Block."

The BDOS file system makes two important distinctions between permanent and removable-media drives. If a drive is permanent, the BDOS always accepts the contents of physical record buffers as valid. It also accepts the results of hash table searches on the drive.

BDOS handling of removable-media drives is more complex. Because the disk media can be changed at any time, the BDOS discards directory buffers before performing most system calls involving directory searches. By rereading the disk directory, the BDOS can detect media changes. When the BDOS reads a directory record, it computes a checksum for the record and compares it to the current value in the drive's checksum vector. If the values do not match, the BDOS assumes the media has been changed, aborts the system call routine, and returns an error code to the calling process. Similarly, the BDOS must verify an unsuccessful hash table search for a removable-media drive by accessing the directory. The point to note is that the BDOS can only detect a media change by reading the directory.

Because of the frequent necessity of directory access on removable-media drives, there is a considerable performance overhead on these drives compared to permanent drives. Another disadvantage is that, since the BDOS can detect media removal only by a directory access, inadvertantly changing media during a disk write operation results in writing erroneous data onto the disk.

If, however, the disk drive and controller hardware can generate an interrupt when the drive door is opened, another option for preventing media change errors becomes available. By using the following procedure, the performance penalty for removable-media drives is practically eliminated.

1) Mark the drive as permanent by setting the value of the CKS field in the drive's DPB to 8000H plus the total number of directory entries divided by 4. For example, you would set the CKS for a disk with 96 directory entries to 8018H.

2) Write a Door Open Interrupt routine that sets the DOOR field in the XIOS Header and the DPH Media Flag for any drive signalling an open door condition.

The BDOS checks the XIOS Header DOOR flag on entry to all disk-related XIOS function calls. If the DOOR flag is not set, the BDOS assumes that the removable media has not been changed. If the DOOR flag is set (0FFH), the BDOS checks the Media Flag in the DPH of each currently logged-in drive. It then reads the entire directory of the drive to determine whether the media has been changed before performing any operations on the drive. The BDOS also temporarily reclassifies the drive as a removable-media drive, and discards all directory buffers to force all subsequent directory-related operations to access the drive.

In summary, using the DOOR and Media Flag facilities with removable-media drives offers two important benefits. First, performance of removable-media drives is enhanced. Second, the integrity of the disk system is greatly improved because changing media can at no time result in a write error.

End of Appendix A

Appendix B
Auto Density Support

Auto Density Support is defined as the ability to support different types of media on the same drive. Some floppy disk drives can read many different disk formats. Auto Density Support enables the XIOS to determine the density of the diskette when the IO_SELDSK function is called, and to detect a change in density when the IO_READ or IO_WRITE functions are called.

To implement Auto Density Support, the XIOS disk driver must include a DPB for each disk format expected, or routines to generate proper DPB values automatically in real time. It must also be able to determine the type and format of the disk when the IO_SELDSK function is called for the first time, set the DPH to address the DPB that describes the media, and return the address of the DPH to the BDOS. If unable to determine the format, the IO_SELDSK function can return a zero, indicating that the select operation was not successful. On all subsequent IO_SELDSK calls, the XIOS must continue to return the address of the same DPH; a return value of zero is only allowed on the initial IO_SELDSK call.

Once the IO_SELDSK routine has determined the format of the disk, the IO_READ and IO_WRITE routines assume this format is correct until an error is detected. If an XIOS function encounters an error and determines that the media has been changed to another format, it must abandon the operation and return 0FFH to the BDOS. This prompts the BDOS to make another initial IO_SELDSK call to reestablish the media type. XIOS routines must not modify the drive's DPH or DPB until the IO_SELDSK call is made. This is because the BDOS can also determine that the media has changed, and can make an initial IO_SELDSK call even though the XIOS routines have not detected any change.

End of Appendix B

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