INTERTEC DATA SYSTEMS®

SUPERBRAIN II™

USERS MANUAL

$50.00

NOTICE

CONFIDENTIAL AND PROPRIETARY INFORMATION

USERS MANUAL FOR

INTERTEC'S

SUPERBRAIN™ II

VIDEO COMPUTER SYSTEM

IMPORTANT NOTICE

This version of the SuperBrain Users Manual is intended for use with the SuperBrain II Jr, SuperBrain II QD, or SuperBrain II SD Video Computer Systems.

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June, 1982

SUPERBRAIN II
USERS MANUAL REVISION RECORD

REV	DATE	APPROVAL	SHEETS/SECTIONS EFFECTED

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CONGRATULATIONS ON YOUR PURCHASE OF INTERTEC'S SUPERBRAIN II

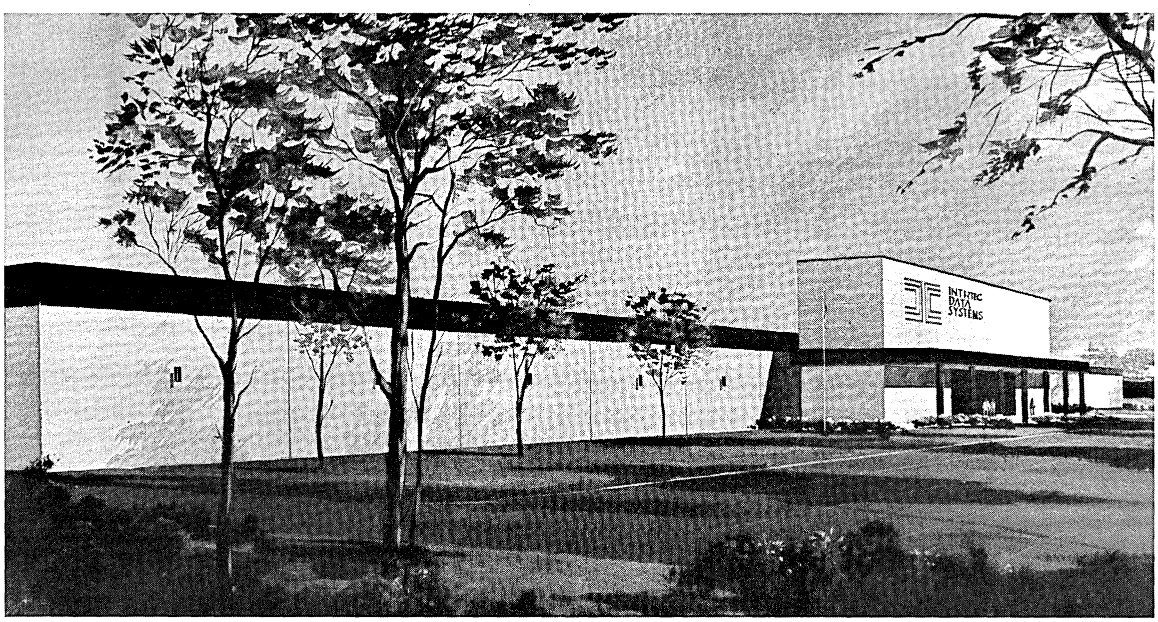
VIDEO COMPUTER SYSTEM

Your new SuperBrain II Video Computer was manufactured at Intertec's new 120,000 square foot plant in Columbia, South Carolina, under stringent quality control procedures to insure trouble-free operation for many years. **If you should encounter difficulties with the use or operation of your terminal, contact the dealer from whom the unit was purchased for instructions regarding the proper servicing techniques.** If service cannot be made available through your dealer, contact Intertec's Customer Services Department at (803) 798-9100.

As with all Intertec products, we would appreciate any comments you may have regarding your evaluation and application of this equipment. For your convenience, we have enclosed a customer comment card at the end of this manual. Please address your comments to:

Product Services Manager
Intertec Data Systems Corporation
2300 Broad River Road
Columbia, South Carolina 29210

The SuperBrain II is distributed worldwide through a network of dealer/OEM vendors and through Intertec's own marketing facilities. Contact us at (803) 798-9100 (TWX — 810-666-2115) regarding your requirement for this and other Intertec products.



INTERTEC DATA SYSTEMS®
Corporate Headquarters: 2300 Broad River Road, Columbia, South Carolina 29210 • 803/798-9100 • TWX: 810-666-2115

Intertec's new one hundred and twenty thousand square foot corporate and manufacturing facility in Columbia, South Carolina

THE SUPERBRAIN II VIDEO COMPUTER SYSTEM

WILL THE MICROCOMPUTER YOU BUY TODAY STILL BE THE BEST MICROCOMPUTER BUY TOMORROW?

Probably the best test in determining how to spend your microcomputer dollar wisely is to consider the overall versatility of your terminal purchase over the next three to five years. In the fast-paced, ever-changing world of data communications, new features to increase operator and machine efficiency are introduced into the marketplace daily. We at Intertec are acutely aware of this rapid infusion of new ideas into the small systems business. As a result, we have designed the SuperBrain II in such a manner as to virtually eliminate the possibility of obsolescence.

Many competitive alternatives to the SuperBrain II available today provide only limited capability for high level programming and system expansion. Indeed, most low-cost microcomputer systems presently available quickly become outdated because of the inability to expand the system. Intertec, however, realizes that increased demands for more efficient utilization of programming makes system expansion capability mandatory. That means a lot. Because the more you use your SuperBrain II, the more you'll discover its adaptability to virtually any small system requirement. Extensive use of "software-oriented" design concepts instead of conventional "hardware" designs assure you of compatibility with almost any application for which you intend to use the SuperBrain II.

Once you read our operator's manual and try out some of the features described herein, we are confident that you too will agree with our "top performance — bottom dollar" approach to manufacturing. The SuperBrain II offers you many more extremely flexible features at a lower cost than any other microcomputer we know of on the market today. The use of newly developed technologies, efficient manufacturing processes and consumer-oriented marketing programs enables us to be the first and only major manufacturer to offer such an incredible breakthrough in the microcomputer marketplace.

Browse through our operator's manual and sit down in front of a SuperBrain II for a few hours. Then, let us know what you think about our new system. There is a customer comment card enclosed in this manual for your convenience.

Thank you for selecting the SuperBrain II as your choice for a microcomputer system. We hope you will be selecting it many more times in the future.

*** IMPORTANT ***

Do not attempt to write or save programs on your system diskette. It has been 'write protected' by placing a small adhesive aluminum strip over the notch on the right hand side of the diskette. Such attempts will result in a 'WRITE' or 'BAD SECTOR' error.

Before using your SuperBrain II, please copy the System Diskette onto a new blank diskette. If you do not have such a diskette, contact your local dealer. He should be able to supply you with one. If you have any questions concerning this procedure, please contact your dealer before proceeding. Failure to do so may result in permanent damage to your System Diskette.

BEFORE APPLYING POWER TO THE MACHINE INSURE THAT NO DISKETTES ARE INSERTED INTO THE MACHINE. NEVER TURN THE MACHINE ON OR OFF WITH DISKETTES INSERTED IN IT. FAILURE TO OBSERVE THIS PRECAUTION WILL MOST DEFINITELY RESULT IN DAMAGE TO THE DISKETTES.

Section
1

INTRODUCTION

INTRODUCTION

The Superbrain II Video Computer System represents the latest technological advances in the microprocessor industry. The universal adaptability of the SuperBrain CP/M* Disk Operating System satisfies the general purpose requirement for a low cost, high performance microcomputer system.

From the standpoint of human engineering, the SuperBrain II has been designed to minimize operator fatigue through the use of a typewriter-oriented keyboard and a remarkably clear display. The SuperBrain II displays a total of 1,920 characters arranged in 24 lines with 80 characters per line. The video display characters can be varied between a primary and secondary character set. Blinking, half-intensity, underlining, and reverse video are user selectable display options. The video display is crisp and sharp due to Intertec's own specially designed video driver circuitry. And, the high quality, non-glare etched CRT face plate featured on every SuperBrain II assures ease of viewing and uniformity of brightness throughout the entire screen.

The SuperBrain II's unique internal design assures users of exceptional performance for just a fraction of what they would expect to pay for such "big system" capabilities. The SuperBrain II utilizes a single board "microprocessor" design which combines all processor, RAM, ROM, disk controller, and communications electronics on the same printed circuit board. This type of design engineering enables the SuperBrain II to deliver superior, competitive performance.

Standard features of every SuperBrain II include: two mini-floppy disk drives with up to 1.5 megabytes **formatted** disk storage, 64K of dynamic RAM memory, recognized CP/M* Disk Operating System featuring its own text editor, an assembler for assembly language programming, a program debugger and a disk formatter. Also standard are dual universal RS232 communication ports for serial data transmission between a host computer network via modem or an auxiliary serial printer. A number of transmission rates up to 9600 baud are available and selectable under program control.

Other standard features of the SuperBrain II include: special operator convenience keys, dual "restart" keys to insure simplified user operation, a full numeric keypad complement (whose values can be user reassigned by software), and a high quality typewriter compatible keyboard. Additionally, a real time clock is incorporated for time/date display and is user accessible.

For reliability, the SuperBrain II has been designed around five (5) basic modules packaged in an aesthetically pleasing desk-top unit. These major components are: the Keyboard/CPU module, the power supply module, the CRT assembly, the transition board, and the disk drives themselves. Failure of any component within the terminal may be corrected by simply replacing only the defective module. Individual modules are fastened to the chassis in such a manner to facilitate easy removal and reinstallation.

Terminal down-time can be greatly minimized by simply "swapping-out" one of the modules and having component level repair performed at one of Intertec's Service Centers. Spare modules may be purchased from an Intertec marketing office to support those customers who maintain their own "in-house" repair facilities.

The SuperBrain II cover assembly is exclusively manufactured "in-house" by Intertec. A high-impact structural-foam material is covered with a special "felt-like" paint to enhance the overall appearance. Since the cover assembly is injected-molded, there is virtually no possibility of cracks and disfigurations in the cover itself. By manufacturing and finishing the cover assembly in-house, Intertec is able to specify only high quality material on the external and internal cover components of your SuperBrain II to insure unparalleled durability over the years to come.

*CPM is a registered trademark of Digital Research

A wide variety of programming tools and options are either planned or available for the SuperBrain II. Software development tools available from Intertec include Basic (standard) and Fortran (optional) programming languages. A wide variety of applications packages (general ledger, accounts receivable, payroll, inventory, word processing, etc.) are available to operate under SuperBrain II CP/M Disk Operating System from leading software vendors in the industry. Disk storage capability is expandable by interfacing the SuperBrain II to a rigid disk which increases on-line storage to 10 megabytes or more.

The high performance ratio of the SuperBrain II has rarely been equalled in this industry. By employing innovative design techniques, the SuperBrain II is not only able to offer a competitive price advantage but boasts many features found only in systems costing three to five times as much. The SuperBrain II twin Z80A microprocessors insure extremely fast program execution even when faced with the most difficult programming tasks. Additionally, each unit must pass a grueling 48 hour burn-in before it is shipped to the customer. By combining advanced microprocessor technology with in-house manufacturing capability and stringent quality control requirements, your SuperBrain II should provide unparalleled reliability in any application into which it is placed.

SYSTEM SPECIFICATIONS

FEATURE	DESCRIPTION
CPU	
Microprocessors	Twin Z80A's with 4MHZ Clock Frequency. One Z80A (the host processor) performs all processor and screen related functions. The second Z80A is "down-loaded" by the host to execute disk I/O.
Word Size	8 bits
Execution Time	1.0 microsecond register to register
Machine Instructions	158
Interrupt Mode	All interrupts are vectored
FLOPPY DISK	
Storage Capacity (Formatted)	SuperBrain II Jr — 328 KB SuperBrain II QD — 680 KB SuperBrain II SD — 1.5 MB
Data Transfer Rate	250K bits/second
Average Access Time	250 milliseconds. 6 milliseconds track-to-track.
Media	5¼-inch mini-disk
Disk Rotation	300 RPM
INTERNAL MEMORY	
Dynamic RAM	64K bytes dynamic RAM
Static RAM	2048 bytes of static RAM is provided in addition to the main processor RAM. 1K x 8 of this RAM storage is used as a disk buffer. The remaining RAM is used for attribute storage.
FIRMWARE	2K x 8 bytes standard. Allows "bootstrapping" of system at power-on.
DAY/DATE CLOCK	Provides continuous time display. Maintains time and date information during power-off and compensates for variances in month/year lengths.
CRT	
Display Size	12 inch, specially focused, P4 phosphor, non-glare screen.
Display Format	24 lines x 80 characters per line

SYSTEM SPECIFICATIONS (continued)

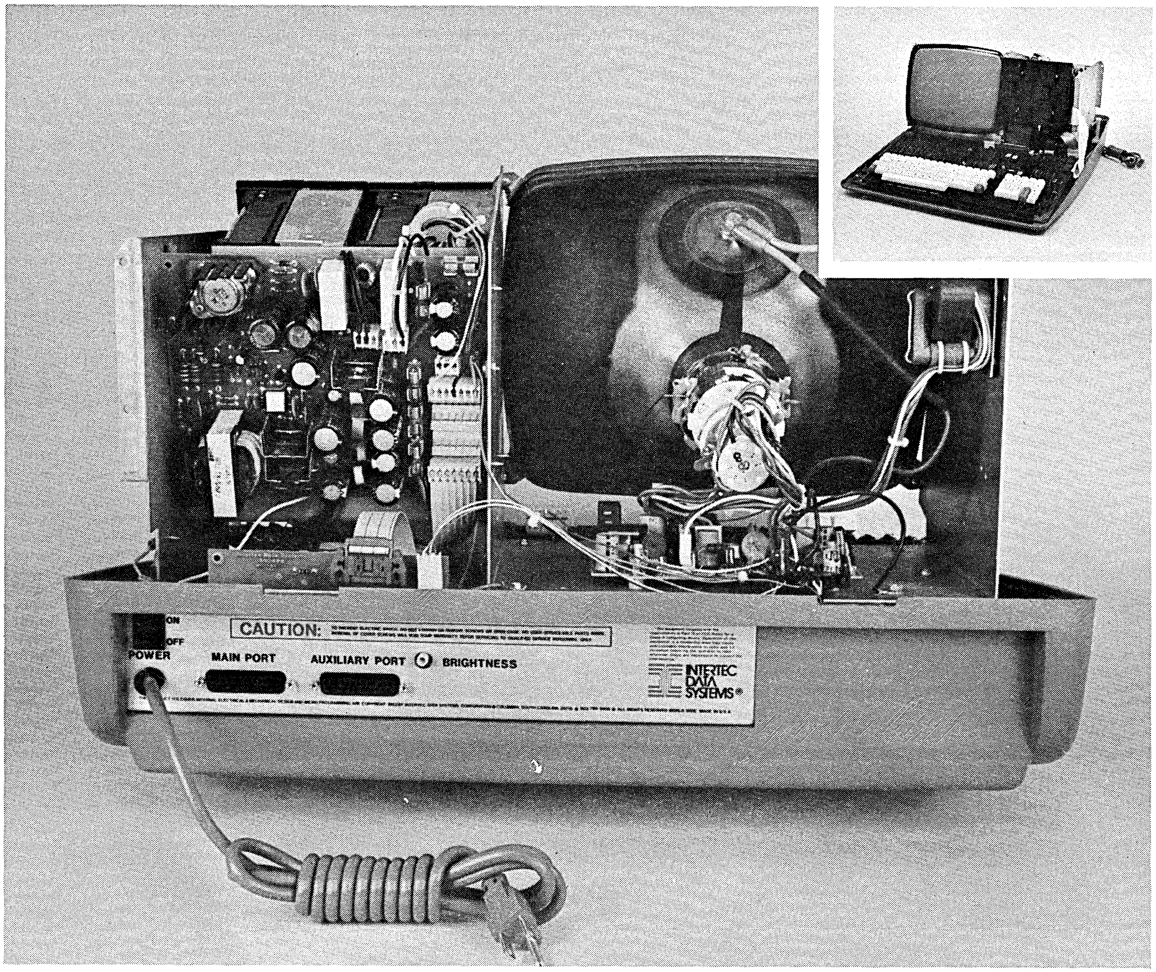
FEATURE	DESCRIPTION
Character Font	5 x 7 character matrix (with descenders) on a 7 x 10 character field. All displayed characters are derived from character sets stored on interchangeable EPROMS.
Display Presentation	Light characters on a dark background. Blinking, half-intensity, underlining, reverse video attributes standard; optional on-line secondary Character/Graphic set.
Bandwidth	20 MHZ
Cursor	Reversed image (block cursor)
COMMUNICATIONS	
Screen Data Transfer	Memory-mapped at 38 kilobaud.
Auxiliary Interface	Simplified RS-232 asynchronous. Parallel interface available. Baud rates are software selectable from 50 to 9600 baud.
Main Interface	Universal RS-232 asynchronous. Synchronous interface switch selectable. Baud rates are software selectable from 50 to 9600 baud.
Transparent Mode	Enables display of all incoming and outgoing control codes.
Parity	Choice of even, odd, none
Transmission Mode	Half or Full Duplex. One, one and one-half, or two stop bits.
Addressable Cursor	Direct positioning by either discrete or absolute addressing.
SYSTEM UTILITIES	
Disk Operating System	CP/M 2.2
DOS Software	An 8080 disk assembler, debugger, text editor and file handling utilities.
BASIC	Sequential and random disk access. Full string manipulation, interpreter.
OPTIONAL SOFTWARE	
Languages	FORTRAN; ANSI standard with relocatable, random and sequential disk access. Additionally, any user furnished CP/M compatible software package that can reside in 52K of memory.

SYSTEM SPECIFICATIONS (continued)

FEATURE	DESCRIPTION
Application Packages	Extensive software development tools are available including software for the following applications: Payroll, Accounts Receivable, Accounts Payable, Inventory Control, General Ledger and Word Processing. Contact an Intertec Sales Office for complete details.
KEYBOARD	
Alphanumeric Character Set	Generates all 128 upper and lower case ASCII characters.
Special Features	N-key Rollover, type ahead, and key repeat
Numeric Pad	0-9, decimal point, comma, minus and four cursor control keys. Reprogrammable to other values for individual applications.
Cursor Control	Up, down, forward, backward
INTERNAL CONSTRUCTION	
Cabinetry	Structural foam
Component Layout	Five board modular design. All processor related functions, RAM, controllers and keyboard are on a single printed circuit board. All video, chaining, and power related circuits on separate boards.
ENVIRONMENT	
Weight	Approximately 45 pounds
Physical Dimensions	14-5/8" (H) x 21-3/8" (W) x 23-1/8" (D)
Environment	Operating 0° to 50° Storage: 0° to 85° C; 10 to 95% relative humidity — non condensing.
Power Requirements	115 VAC, 60 HZ, 1 AMP (optional 230 VAC/50HZ model available)

INTERNAL CONSTRUCTION

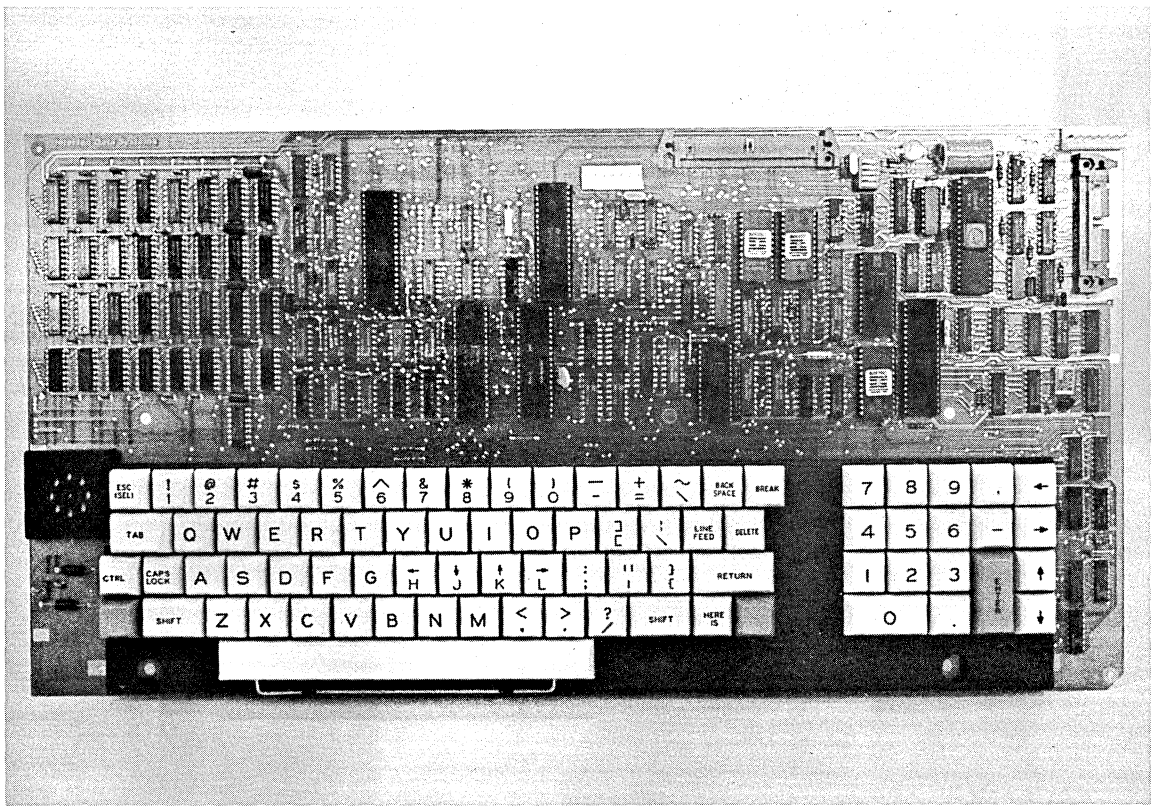
Perhaps the most remarkable feature of the SuperBrain II is its modular construction using only five major subassemblies which are clearly defined in their respective functions so as to facilitate ease of construction and repair. These five subassemblies are shown and described below.



KEYBOARD/CPU MODULE

The control section of the SuperBrain II Video Computer is based upon the widely acclaimed Z80A microprocessor. The result is far fewer components and the ability to perform a number of functions not possible with any other approach. The Keyboard/CPU module contains the SuperBrain II twin Z80A microprocessors. One Z80A (the host processor) performs all processor and screen related functions while the second Z80A can be "downloaded" to execute disk I/O handling routines. The result is extremely fast execution time for programs.

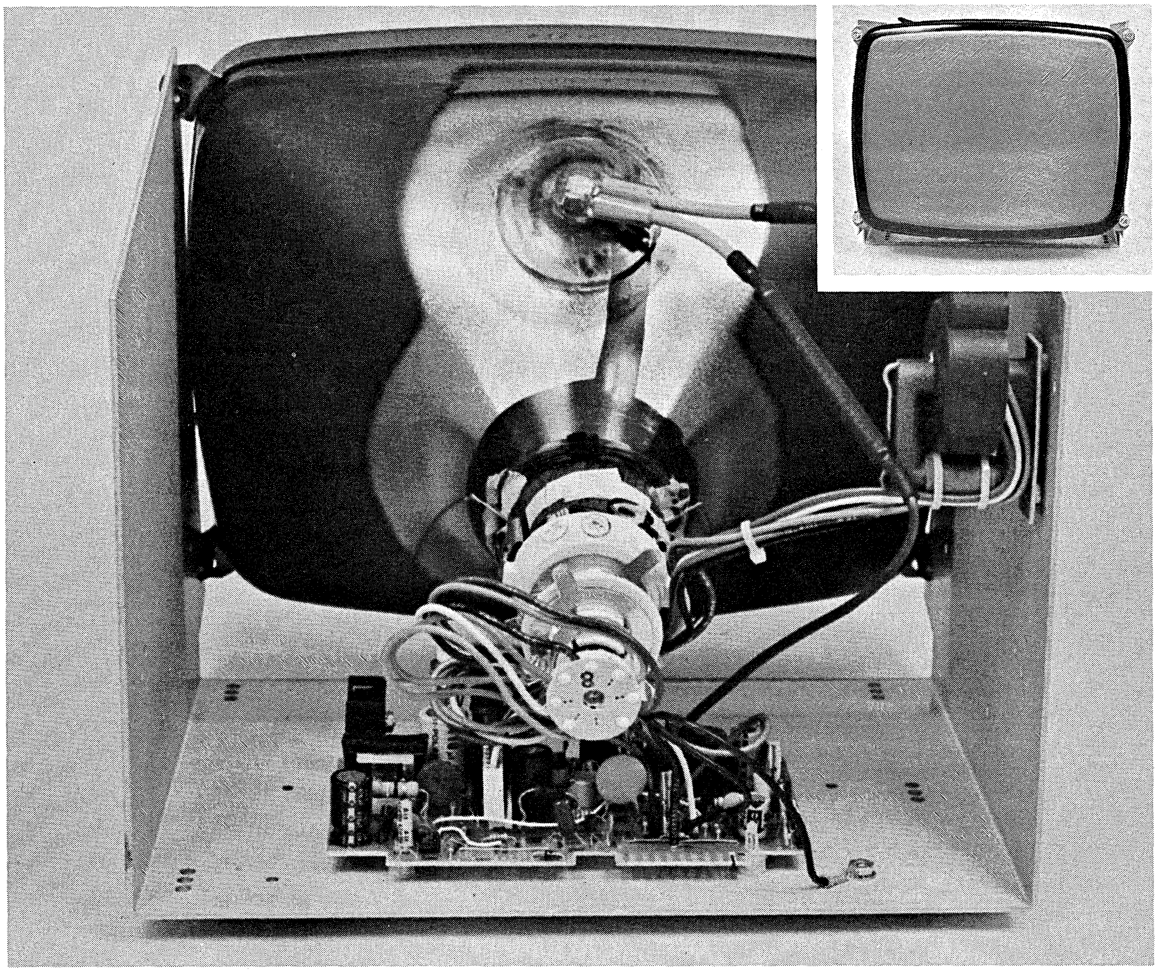
In addition to containing the SuperBrain II's microprocessor circuitry, the Keyboard/CPU module contains 64K of dynamic RAM. Also found on this module is: the character and keyboard encoder circuitry, the "bootstrap" EPROM, the disk controller and all communications electronics. Power is supplied to this module via a single 7 pin ribbon cable connected to the SuperBrain II's main power supply module. Connection of this module to the disk drive modules is via a separate ribbon cable. Separate connectors also exist for the CRT display signals and serial I/O ports.



CRT DISPLAY MODULE

The CRT Display Module consists of a 12 inch, high resolution, cathode ray tube mounted in a rigid aluminum chassis. The faceplate of the CRT is etched in order to reduce glare on the surface of the screen and provide uniform brightness throughout the entire screen area. The CRT display presentation is arranged in 24 lines of 80 characters per line for a total display capacity of 1,920 characters.

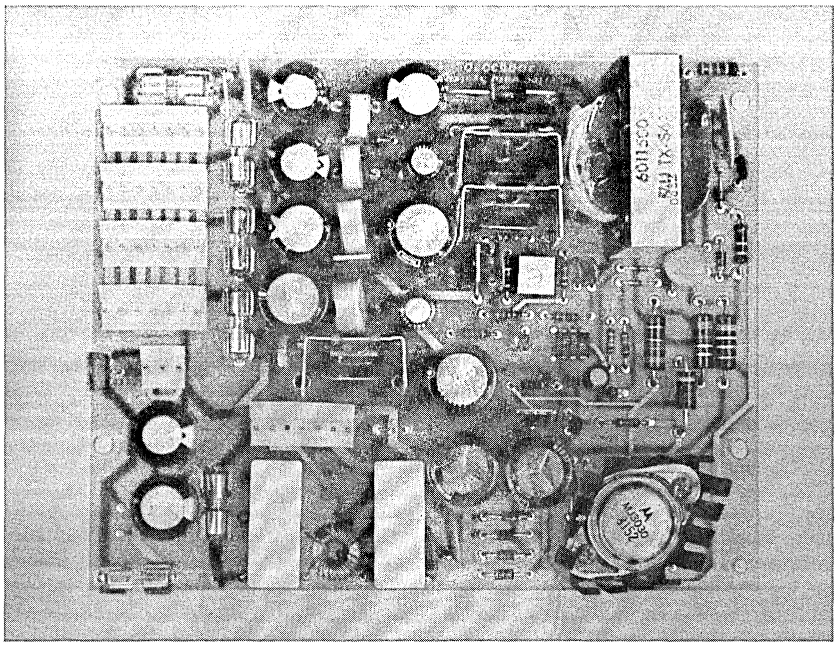
The CRT video driver circuitry is mounted in the base of the CRT chassis to facilitate ease of removal and subsequent repair. In this manner, either the CRT itself or the video circuitry can be easily exchanged without disrupting any of the other major modules within the terminal.



This module is easily removed for service or replacement. A single edge connector is provided for connection to SuperBrain II's Keyboard/CPU Module.

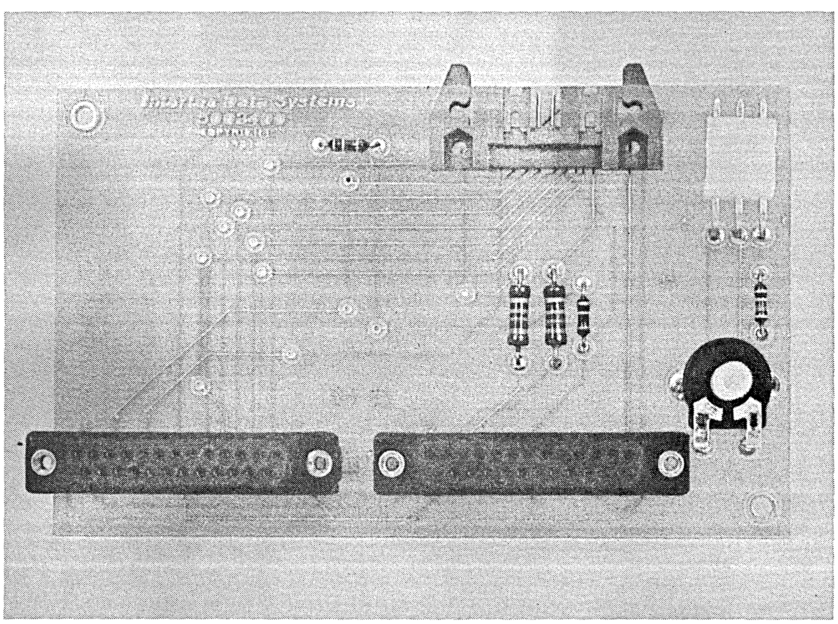
MAIN POWER SUPPLY MODULE

The SuperBrain II's power supply is of a "solid-state, switching" design and employs a voltage regulator to provide many years of trouble-free service. This design reduces heat dissipation and allows for efficient cooling of the entire terminal with a specially designed whisper fan to reduce environment noise. The entire power supply can be easily removed by unscrewing the screws holding it to the disk drive back plate. This module supplies the five voltages required to power the Keyboard/CPU module, the Video Module, and disk drive.



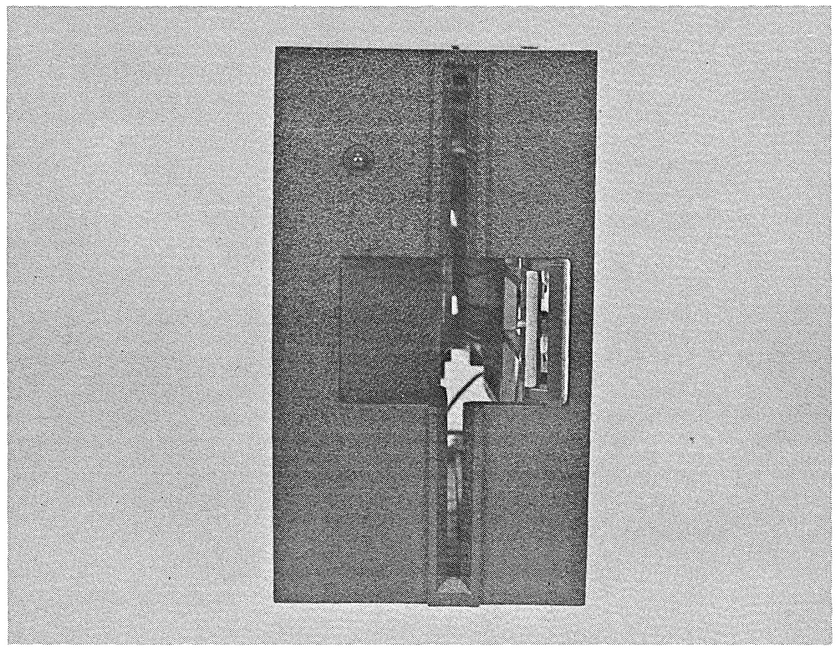
TRANSITION BOARD

This board contains the RS-232 serial I/O connectors and video brightness control. It connects to the video module and the keyboard/CPU module.

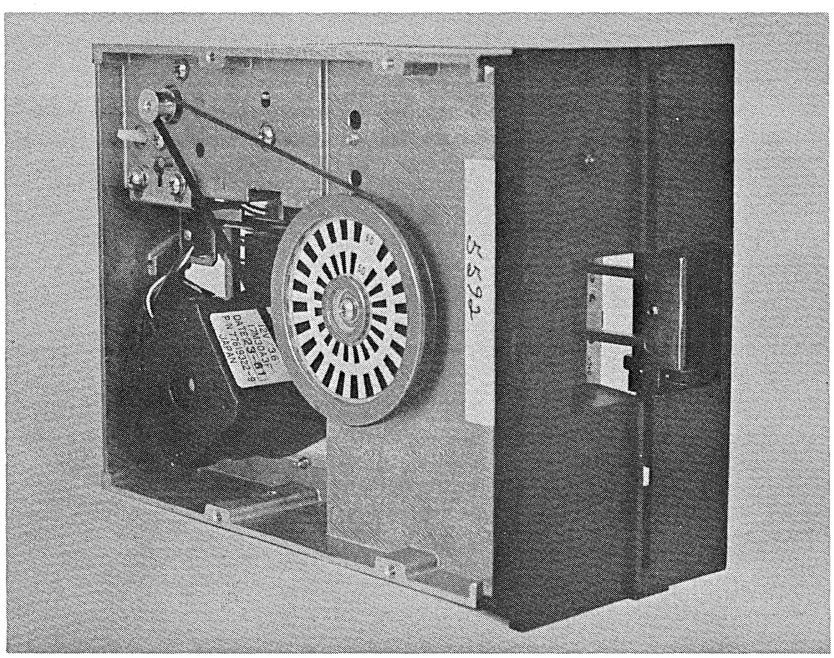


DISK DRIVE MODULES

The SuperBrain II has a specially designed double-density disk drive subassembly. Each SuperBrain II contains two of these type drives which are mounted conveniently just to the right of the CRT display module on a rugged aluminum mounting bracket so that they are flush mounted with the front "bezel" of the unit. Power to these drives is derived from the Power Supply Module located just behind the drive assemblies themselves. Data to and from these drives is routed via a single 34 pin ribbon cable connecting the drives to the Keyboard/CPU module.



Front View of SuperBrain II Drive Assembly



Side View of SuperBrain II Drive Assembly

THEORY OF OPERATION

The SuperBrain II contains two Z80 microprocessors. uP1 is the main processor which executes all user programs from the 64K RAM main memory, while transparently managing the CRT Display processes. All user I/O is also connected to uP1. This I/O includes the Serial Ports, Interface Controller, Keyboard Encoder, Time/Date Clock, and the External Bus. uP2 performs all floppy disk control functions from instructions contained in the 2K Bootloader EPROM. Part of this same EPROM contains the Cold Bootloader for uP1, and is executed when a System Reset is performed. The Floppy Disk Control section also contains a 1K x 8 RAM buffer used for temporary storage of disk read/write data. This buffer can be accessed by either uP1 or uP2, therefore, a protocol exists to prevent microprocessor contention for this buffer.

The 64 kilobyte main memory consists of thirty-two 16K x 1 bit dynamic RAMS. These are divided in four banks (0-3) with each bank containing 16 kilobytes of storage. The RAS-CAS timing sequence necessary for memory access is created by the memory timing generator.

The CRT-VIDEO CONTROLLER circuitry is divided into three main areas: The CRT controller which generates all the timing signals for data display; the character generator circuitry which produces the character font; and the attribute generation circuitry which provides the special video capabilities of blinking, underlining, half-intensity, and reverse video in addition to normal video display.

The capability exists to install an alternate character set EPROM as an option. This would allow the CRT controller to access either character set during normal operation.

The CRT controller generates all the timing necessary to display 24 rows of characters with 80 characters per row. Thus the screen can display a total of 1,920 characters. These characters are stored in the CRT refresh buffer which is the upper 2,048 bytes (2K) of main memory.

Because the CRT buffer is not a separate buffer and the processor must also use the same bus to access memory, this bus must be timeshared between the two. This is accomplished by the CRT controller performing a direct memory access (DMA) cycle which is done at the last scan line of each character row. Each character row is divided into ten scan lines, therefore, during the last scan line time, the controller takes control of the processor bus by generating a bus request. After acquiring the bus, it reads 80 characters from the CRT buffer and loads them into the 80 x 8 shift register. This data is then recirculated in the buffer for the next nine scan lines to produce one row of video characters. Therefore, there are twenty-four DMA cycles performed per vertical frame.

There are also twenty-five interrupts generated — one for each row scan and one extra during vertical blanking. During the first twenty-four, the processor sets or resets the video blanking depending on whether that row is displayed or not. During the vertical blanking interrupt, the address registers in the CRT controller are initialized to the correct top-of-page address and the cursor register is also updated.

The Interface Controller is basically three 8 bit I/O ports (8255). Through this device, the processor can obtain status bits from other devices and react to the status by setting/resetting individual bits in the 8255.

The Keyboard Encoder scans the keyboard for a key depression, determines its position, and generates the correct ASCII code for the key. The processor is flagged by the 'Data Ready' signal via the Interface Controller. The character is then input by the processor.

The Time/Date clock is accessed directly by uP1 through an I/O address. The clock has a battery power supply and will maintain the correct time and date when the external power is removed.

The clock is also available as a real time clock for the user's access.

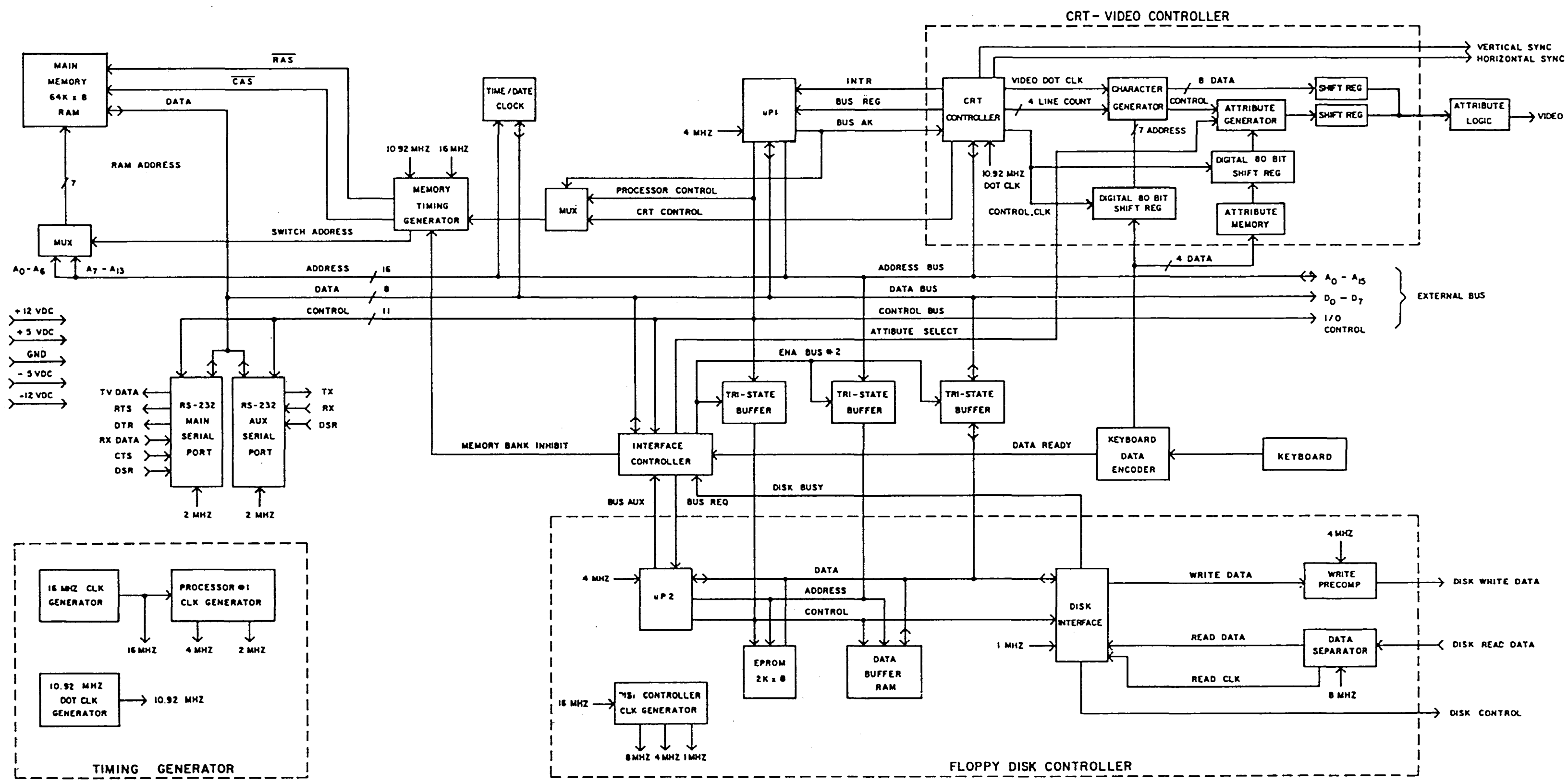
There are also two RS232C serial interface ports. The main port is capable of synchronous or asynchronous operation. The aux port is a simplified port used for asynchronous operation only. The baud rates are variable from 50 baud to 9600 baud. The mode of operation of the main port and the baud rate of both ports are set up by the operating system and can be changed by using the "CONFIGUR" program.

As previously mentioned, uP1 has the capability of communicating with the RAM and ROM in the FLOPPY DISK CONTROLLER. Because the amount of main memory used is the maximum that the processor addressing can support, different 16K banks of main memory must be switched off line when communicating with the disk RAM or EPROM. In these cases Bank 0 (0000H-3FFFH) is switched out when communicating with the EPROM, and Bank 2 (8000H-BFFFH) when communicating with the RAM.

The FLOPPY DISK CONTROLLER performs all disk related I/O functions upon command from the main processor. These commands are:

* Restore to track 0
* Read sector
* Write sector
* Write sector with verify
* Format

The parameters associated with drive, side, track, and sector numbers are loaded, a status word is set at a specified location in the disk RAM. When uP2 receives this status, it sets the 'disk busy' status bit and performs the indicated function. Upon completion, it resets the 'busy' bit thus allowing the main processor (uP1) to retrieve data and status from the RAM.



SUPERBRAIN II KEYBOARD / CPU II MODULE BLOCK DIAGRAM

INSTALLATION & OPERATING INSTRUCTIONS

INSTALLATION AND OPERATING INSTRUCTIONS

UNPACKING INSTRUCTIONS

Be sure to use extreme care when unpacking your SuperBrain II Video Computer System. The unit should be unpacked with the arrows on the outside of the shipping container facing up.

The MASTER SYSTEM DISKETTE is located inside the front cover of this manual. Be careful not to discard or misplace this diskette as it will be vital for the later operation of the equipment. If you ordered additional, optional software with your computer, it will be shipped under separate cover.

Now that you have located your system diskette you can proceed to remove the terminal. If you should experience any difficulties, rotate the carton on its side. With the terminal in this position, you should now be able to pull outward on the terminal and separate it from the box. Once the terminal is out of the carton, place it on a table and remove the protective plastic bag which should be surrounding the terminal. DO NOT DISCARD THE SHIPPING CARTON SINCE IT COULD POSSIBLY BE USED FOR RESHIPPING AT A LATER DATE.

SET UP

The first step in this procedure is to verify that your SuperBrain II is wired for a line voltage that is available in your area. This can be ascertained by checking the serial tag located at the right rear of the terminal. This tag should indicate that your unit is set up for either 110 or for a 220 VAC operation. DO NOT ATTEMPT TO CONNECT THE SUPERBRAIN II VIDEO COMPUTER SYSTEM TO YOUR LOCAL POWER OUTLET UNLESS THE VOLTAGE AT YOUR OUTLET IS IDENTICAL TO THE ONE SPECIFIED ON THE BACK OF YOUR TERMINAL. If the voltages differ, contact your dealer at once and do not proceed to connect the SuperBrain II to the power outlet.

Before connecting the SuperBrain II to the wall outlet, be sure that the power switch located at the left rear corner is turned OFF. You may now proceed to connect your computer system to the wall outlet. After completing this connection, turn the power switch to the ON position. At this time, you should hear a faint "whirring" sound coming from the fan in the computer. After approximately 60 seconds the message INSERT DISKETTE INTO DRIVE A will appear on the screen. If this message does not appear on the screen after approximately 60 seconds, simultaneously depress the two RED keys located on either side of the alphanumeric keyboard. These are the master system reset keys and should reinitialize the computer system, thereby displaying the 'INSERT' message on the screen. If, after several attempts at resetting the equipment you are unable to get this message to appear on the screen, turn the unit off for approximately 3 to 5 minutes and then reapply power to the unit. If you are still unable to get the appropriate message to appear on the screen, contact your Intertec representative.

SYSTEM DISKETTE

Now that you have power applied to the machine and the INSERT DISKETTE message has been displayed in the upper left hand corner, you are ready to proceed with loading the computer's operating system. This is accomplished by locating the small 5 ¼" diskette that was packed with this manual. Once you have located this diskette, you will notice that a small adhesive strip has been placed over the notch on the right hand side of the diskette. This aluminum strip is used to "WRITE PROTECT" the diskette. Therefore, you may only read programs from this diskette. If you wish to write or save programs on the system diskette, it will be necessary to remove the small adhesive aluminum strip from the diskette. This is NOT RECOMMENDED as it will subject your diskette to accidental errors that may be caused by you while you are getting familiar with the operating system.

You are now ready to proceed with inserting the system diskette into the machine. When facing the front of the machine, you will notice that there are two small openings on the right hand side of the machine. The leftmost opening is designated as drive A. The rightmost opening is designated as drive B. This distinction is important since the disk operating system can only be loaded from drive A.

Open the disk drive door on drive A (the leftmost drive). The drive can be opened by applying a very slight pressure outward on the small flat door located in the center of the opening. Once the drive door has been opened, insert the Operating System Diskette. The front of the diskette should contain a small white sticker located in the upper left hand corner of the diskette. This diskette should contain a message indicating that it is the SuperBrain II DOS Diskette with CP/M Version 2.2. Be careful to insure that (1) the small aluminum write protect strip is oriented towards the top edge of the diskette and that (2) the label located in the upper left hand corner of the operating system diskette is facing AWAY from the screen towards the right hand side of the terminal. Once you have oriented the diskette in this fashion, insert it into the terminal.

It is **EXTREMELY** important that the diskette be properly oriented before inserting it into the machine since improper orientation will not allow the operating system to properly load. Once the diskette has been placed in the machine, be sure that it has been inserted all the way by applying a gentle pressure on the rear edge of the diskette. Once you are certain that the diskette is fully inserted, close the disk drive door. This can be accomplished by applying a slight pressure on the door, pulling it back into the direction from which it was originally opened. Once you have closed the door, you will notice a small "swishing" sound. This sound is normal and indicates that the computer is now attempting to load the operating system. Some drives are quieter than others and therefore this noise may not be audible.

After closing the door the following message should appear in the upper left-corner of the screen:

```
SUPERBRAIN II DOS VER X.X, FOR CP/M 2.2
A>
```

If this message does not appear on the screen, try depressing the two RED keys located on either side of the keyboard. This should reset the terminal and thereby attempt to reload the operating system. If after several seconds, the message does not appear on the screen, try depressing the RED keys several more times. If repeated depressions of the RED keys do not bring up the indicated message, then open the door on the disk drive A and remove the system diskette and check to see if it was properly inserted. If you are unsure as to the proper orientation of the diskette, please contact the representative from whom you originally purchased your equipment.

After you have checked the orientation of the diskette, try reinserting it into drive A (do **NOT** insert the system diskette into drive B as it will not load from drive B). Once the diskette has been reinserted, close the door on drive A and depress the RED keys. If after several repeated depressions of the RED keys, the message SUPERBRAIN II DOS VER X.X, for CP/M 2.2, does not appear on the terminal then contact your dealer.

REVIEWING THE SYSTEM DISKETTE

After you have successfully loaded the System Diskette and Disk Operating System (DOS), the SuperBrain II is ready to accept your disk operating system commands. At this time we will review several of the commands in the operating system. However, it is recommended that you refer to the appropriate section in this manual for a detailed description of all such commands. (Introduction to CP/M Features and Facilities). The most used system command is the DIR command. This command directs the operating system to display the directory of all programs contained on the system diskette. You may enter this command by simply typing the letters DIR on the keyboard.

After you have typed these letters, it is necessary to depress the **RETURN** key. Depressing this key instructs the computer to process the line of data that you have just typed. After you depress the **RETURN** key the computer should respond by displaying all of the programs on the system diskette. These programs will appear in a form somewhat similar to the following:

A:ED.COM
A:DDT.COM
A:ASM.COM
A:LOAD.COM
A:DUMP.COM

To obtain a better understanding of just what this information means, let's take a look at the first line:

A:ED.COM

The first letter on this line is the letter A. This tells you that the information following this letter is located on drive A. The colon serves as a separator between the drive designator ("A") and the file NAME and file TYPE. The file NAME is, in this case, "ED" and the file TYPE is "COM." This line tells the operator that a program called ED (the disk operating system text editor) is located on the "A" drive and is a COM type of file. A more detailed treatment of this information can be found in the CP/M sections of this manual.

DUPLICATING THE OPERATING DISKETTE

Now that you have successfully loaded the Disk Operating System on Drive A, it is important to duplicate this diskette. This is necessary in order to preserve the original copy of the diskette and guard against any possible damage to the original media. To generate a copy of the operating system you will first need a new blank diskette. We recommend an Intertec diskette for this purpose. If you do not have any blank diskettes of similar quality, please contact the representative from whom you purchased your equipment. The representative should be able to supply you with an ample quantity of these diskettes.

Insert the blank diskette into drive B. Follow the procedures outlined in the previous paragraphs regarding the insertion of the operating system diskette. The only difference is that you will be inserting the new blank diskette into drive B. Be sure and leave the system diskette installed in drive A.

Once you have installed the new blank diskette in drive B, you are ready to "FORMAT" the new diskette. It is necessary to format all previously unused diskettes before attempting to transfer data to them. This is necessary because all information is stored on diskettes in what is known as a SOFT SECTORED FORMAT which necessitates the writing of certain information on the disks before user programs or data can be stored on them.

To format the diskette in drive B, enter the command **FORMAT** and depress the **RETURN** key. The operating system will respond by asking you to select one of the following:

* J — For formatting SuperBrain II Jr diskettes
* Q — For formatting SuperBrain II QD diskettes
* S — For formatting SuperBrain II SD diskettes

CAUTION: SuperBrain II Jr and QD diskettes cannot be formatted on SD machines and vice-versa.

Once the appropriate option is selected, the operating system will prompt the user to insert a blank diskette into drive B in case that has not already been done. Next, the user should depress the **F** key to begin formatting.

When a diskette is being formatted, the read/write heads position to track 0 and sequentially writes each track. The screen displays the current track numbers. The track value displayed will range from:

* 0-34 for the SuperBrain II Jr
* 0-69 for the SuperBrain II QD
* 0-159 for the SuperBrain II SD

After the disk has been completely formatted, the operating system will respond by asking you whether to "REBOOT" the operating system or whether you wish to format another disk. If you wish to format another disk, remove the newly formatted disk from drive B and insert a new blank diskette into drive B. You may now proceed to format this new diskette by once again entering the letter **F**. If you do not wish to format any more diskettes, simply enter a **RETURN.**

The Operating System should now reload and once again be ready to accept new commands.

Since the intent of this procedure was to copy the original disk operating system we are now ready to begin that procedure. This can be accomplished by entering the following command on the keyboard:

A>**PIP B:=*.*[V]** <**cr**>

After you have entered the above command at the keyboard, depress the **RETURN** key.

The system will now begin to copy and verify all of the programs on drive A over to drive B. As each program is copied, its name will be displayed on the screen. This procedure takes approximately 5 to 10 minutes. When the procedure completes, the control of the operating system will be returned to the user.

Now that you have completed copying the programs from the A drive to the B drive it is necessary to copy the disk operating system itself (which is located on tracks 0, 1) onto drive B. This may be accomplished by entering the following command at the keyboard:

A>**SYSGEN** <**cr**>

The SYSGEN command is used to read the operating system from a diskette and place it on the desired diskette. Once you have entered this command at the keyboard and typed **RETURN,** the disk operating system will ask you to select which drive you want to take the source from. The correct answer to this question is the letter "A". After entering **A** depress the **RETURN.**

The next question the program will ask is where do you want the source to be placed (the destination drive). The correct answer to this is the letter "B" indicating drive B. Once you have entered this, the operating system will be copied from drive A onto drive B.

After this process has been completed the operating system will ask whether you wish to make another copy or to reload the operating system. The correct response is to simply enter a **RETURN** which will reload the operating system.

Once the operating system has been reloaded, you may remove the master disk operating system in drive A. Once this disk has been removed, store it in a safe place, as you may need it later to generate additional copies of the disk operating system and its programs.

At this point you should have removed the master disk from drive A. Now remove the copy from drive B and reinstall it in drive A and close the door on drive A. After you have completed this, depress the RED reset keys located on either side of the keyboard. This will reset the machine and reload the newly installed operating system from the new system diskette.

IMPORTANT: If random, garbled information is displayed on the screen at this time, this indicates that an error was made in the use of the SYSGEN program. If this is the case, remove the new diskette from drive A and reinstall the original master system diskette and repeat the previously outlined procedure for generating a new disk operating system. If you still encounter difficulties, please refer to the CP/M sections of this manual for more detailed information concerning the SYSGEN procedure.

Now that you have successfully completed the generation of a new system diskette, please refer to the CP/M sections of this manual for a complete description of all of the operating system utility programs (DDT.COM, PIP.COM, SUBMIT.COM, etc.).

OPTIONAL SOFTWARE

MICROSOFT FORTRAN 80 — comparable to Fortran compilers on large mainframes and minicomputers. All of ANSI standard Fortran X3.9-1966 is included except the COMPLEX datatype. Therefore, users may take advantage of the many application programs already written in Fortran. Fortran 80 is unique in that it provides a microprocessor Fortran and assembly language development package that generates relocatable object modules. This means that only the subroutines and system routines required to run Fortran 80 programs are loaded before execution. Subroutines can be placed in a system library so that users develop a common set of subroutines that are used in their programs. Also, if only one module of a program is changed, it is necessary to recompile **only** that module. Additionally, numerous optional software packages are available for use with your SuperBrain II Video Computer System. If you would like additional information on these packages, please contact your local Intertec representative.

SUPERBRAIN II
SOFTWARE SUMMARY

SUPERBRAIN II SOFTWARE SUMMARY

The software distributed with the SuperBrain II is basically of two types. First, CP/M and miscellaneous software from Digital Research provide an operating system, and various utility programs. Second, there are utility programs prepared by Intertec for special features or functions of the SuperBrain II and an interpreted BASIC from MicroSoft. A summary of both categories follows:

CP/M SUMMARY

PROGRAM NAME	FUNCTION	ENTRY EXAMPLE
PIP.COM	Copies files between devices, logical and physical.	**PIP B:=A:*.*<cr>** **PIP CON:=A:FILE.TYP<cr>**
SYSGEN.COM	Generates a new operating system on diskette.	**SYSGEN<cr>**
ED.COM	Text Editor, allows changes to text files.	**ED PROGRAM.ASM<cr>**
ASM.COM	Assembles an 8080-type assembly language that produces a source listing and a 'HEX' file.	**ASM PROG<cr>**
LOAD.COM	Creates a binary object file from a 'HEX' file that can be executed.	**LOAD PROG<cr>**
DDT.COM	Allows user to debug and step through a 'COM' or 'HEX' file's execution.	**DDT PROG.COM<cr>** **DDT PROG.HEX<cr>**
SUBMIT.COM	Performs successive execution of a list of 'COM' files.	**SUBMIT MORNING<cr>**
XSUB.COM	Forces data entry into a process under control of SUBMIT.	**XSUB<cr>**
DUMP.COM	Produces a hexadecimal listing of a disk file's contents.	**DUMP PROG.COM<cr>**
STAT.COM	Display file status, device status, or system characteristics.	**STAT B:*.*<cr>** **STAT B:DSK:<cr>**
DIR*	Displays a disk directory.	**DIR<cr>** **DIR B:<cr>**
ERA*	Erases a disk file.	**ERA B:PROG.BAK<cr>**
REN*	Renames a disk file.	**REN PROG.ASM=PROG<cr>**
SAVE*	Saves memory contents on the disk.	**SAVE 10 A.COM<cr>**
TYPE*	Displays an ASCII listing of a disk file's contents.	**TYPE PROG.PRN<cr>**

*These are CP/M command level functions.

These programs or commands run under the CP/M 2.2 disk operating system (DOS). This DOS is customized for each SuperBrain II computer model available, which results in having three operating systems applicable to the SuperBrain II product line. These are:

* SBIICPM.COM — SuperBrain II Jr computer. The corresponding BIOS is SBIIBIOS.ASM.
* QDIICPM.COM — SuperBrain II QD computer. The corresponding BIOS is QDIIBIOS.ASM.
* SDIICPM.COM — SuperBrain II SD computer. The corresponding BIOS is SDIIBIOS.ASM.

The difference between these models of the SuperBrain II computer is the amount of on-board floppy disk storage each contains. The correct operating system is distributed with each computer.

Refer to later sections of this manual for detailed documentation of CP/M usage and capabilities.

INTERTEC UTILITY SUMMARY

Program Name	**Function**
CONFIGUR.COM	Establishes certain user selectable operating characteristics of the SuperBrain II.
FORMAT.COM	Prepares previously unused diskettes for use in the SuperBrain II disk drives by placing sector information on them.
HEXDUMP.COM	Generates an "Intel" hexadecimal format data stream from any binary object file in the SuperBrain II computer and outputs it to a port.
64KTEST.COM	Performs extensive memory testing for diagnostic purposes.
RX/TX.COM	A program pair that enables file transfers between two SuperBrain II computers.
CSEDIT.COM	A program that allows the user to generate or modify an alternate character set.
CSDUMP.COM	A program that allows the user to generate printed output of the alternate character set built with CSEDIT for documentation purposes.
TIME.COM	A program that allows the time maintained by the real time clock to be set and/or displayed.
DATE.COM	A program that allows the date to be entered or displayed.
MBASIC.COM	An interpreted type BASIC.

In general, the Intertec utility programs are self-documenting and designed for ease of use. To support this design further, documentation of these programs follows. The interpreted BASIC from MicroSoft is documented in a separate manual available from Intertec.

CONFIGUR.COM

This program enables the user to select various operating parameters for the SuperBrain II. This feature allows flexibility in your computer's use. The parameters affect the MAIN and AUXILIARY ports, the AC line frequency, keypad assignments, audio and visual feedback, and disk verification. By allowing the user to change these parameters, a variety of peripheral devices can be used with your SuperBrain II.

The CONFIGUR program is menu-driven; the user selects the parameter to change, and then follows the instructions listed. To initiate the CONFIGUR command, type **CONFIGUR<cr>** at the keyboard. CONFIGUR will then accept your commands for parameter changes. After you are finished, press the **RETURN** key (you may change several of the parameters if you wish); the screen will clear, and you will be instructed to press both RED keys on the keyboard. This action will force an operating system to reload containing your new parameters, and these parameters will be reloaded each time you reset the operating system.

Note that the CONFIGUR program will change the copy of the operating system located on the diskette in drive A. Even if your copy of CONFIGUR.COM is located on drive B, drive A will be affected. A summary of parameter selections is included for reference.

Vertical Scan Frequency
The vertical scan frequency is selectable for 50 or 60 Hertz. This compensates for the local AC line frequency to prevent the display from flickering.

Disk Write Verification
You may select to have the Operating System perform disk read-back verification after each floppy disk write. This feature will 'double-check' the write operation.

Time Display Enable/Disable
If you wish for the time of day to be constantly displayed in the upper right corner of the screen upon power-up, you may select this feature here. Note that the time is always maintained internally, even if you choose not to display it. Also note that this setting is only for power-up, and you may select/deselect the time during operation by typing a Control-T (14H).

Key Click Enable/Disable
You may choose to have the audible feedback feature enabled upon system power-up. Whenever the audible feedback is enabled, the computer will inform the operator with a slight 'click' at each key depression. Note that this setting is only for system power-up, and the key click feature can be changed during operation by typing a Control-B (02H).

Main and Aux Port Operation
Choosing these selections will permit you to change the operating parameters of the MAIN and AUX serial I/O ports located on the rear of your computer. The details of this selection are covered below including which ports are applicable for a given feature.

Operating Mode (MAIN Port Only)
The MAIN port operating mode selections are synchronous and asynchronous. Be certain that the peripheral with which you are communicating is capable of operating in the same mode; they cannot be different. Note also that when changing to synchronous mode, you may need to change the number of SYNC Characters and the SYNC Character value. When changing to the asynchronous mode, you may need to change the number of stop bits. Using the synchronous mode requires different switch settings to be modified on the Keyboard/CPU module. Refer to the Synchronous Communication topic in this section for further information.

Baud Rate (MAIN and AUX Ports)
A wide range of baud rates can be selected for the port including rates from 9600 baud (approximately 960 characters/second) to 50 baud (5 characters/second). Select the baud rate needed to communicate with your peripheral.

Number of SYNC Characters (Main Port Only)

This selection will affect the number of SYNC Characters sent to the USART upon system power-up. Select either one or two.

Number of Stop Bits (MAIN and AUX Ports)

This selection will choose the number of stop bits sent after each character when the port is operating in asynchronous mode. Select either 1, 1.5, or 2 stop bits.

Character Length (MAIN and AUX Ports)

You may select the length of the character to be transmitted and received. Many selections are provided to insure compatibility with older TTY and Baudot machines. Usually, eight bits is the standard character length. You may, however, select 5, 6, 7, or 8 bit character lengths.

Parity (MAIN and AUX Ports)

You may choose to check parity with each transmission. This will provide a limited 'checksum' to help insure that proper transmission has occurred. However, if parity is enabled, the application program will have to test the USART status register for parity error. You may also select Even or Odd parity. If you choose to check parity, be certain that the device with which you are communicating matches your setting.

Handshaking (MAIN and AUX Ports)

If you wish to check Data Set Ready prior to each character transmission, you should enable this function. This will permit a peripheral device to signal the computer whenever it cannot receive anymore characters.

SYNC Character Value (MAIN Port Only)

The SYNC Character is the byte that is sent to the USART after it has been programmed for synchronous communication. Generally, the ASCII value of 13H (SYN) is used, but any binary value may be substituted. Make certain that the SYNC Character value matches that of the peripheral device with which you are communicating. Enter the hexadecimal number desired.

KEYPAD REPROGRAMMING

The 18 key numeric keypad on the right side of the keyboard can be reprogrammed to any input values desired. You may, for example, wish to invert the numeric keys on the pad. They will then correspond to 'telephone style' with 1-2-3 on the top row and 7-8-9 on the bottom. You may wish to replace the keys with control-codes which are accepted by a word processing or text editing program. The key cap values could then be changed to descriptive messages which are easier to learn and understand. Any value from OOH to FFH can now be assigned to the numeric keys with CONFIGUR.

When this selection is entered, an image of the keypad appears on the screen. To change the value of any key, depress the **TAB** key until the cursor is over the key you wish to change. Then press the escape **ESC** key to indicate the change needed. The cursor will position itself on the last line, and a blinking asterisk will replace the cursor on the key being changed. Enter the new hexadecimal value for this key. Your input must be a valid hex number between O-F as invalid numbers will not be accepted. Press the **RETURN** key when you are finished.

To restore the keypad to its original values press the **R** key instead of the **ESC** or **TAB** keys. The screen will be updated instantly, and the cursor will be repositioned at the beginning of the display. When all changes have been entered, pressing the **RETURN** key (instead of the **ESC** or **TAB** keys) will return you to the main menu of selections.

FORMAT.COM

Before diskettes can be used by an Intertec computer, they must first be formatted. This process will erase the diskette of all data and write certain sector-header information on the diskette so that the operating system is able to properly locate data on the diskette. FORMAT.COM is a versatile program that will allow the user to format diskettes for the SuperBrain II.

To load the format program from diskette, type **FORMAT⟨cr⟩** at the keyboard. After loading, you should select the type of diskette you wish to format. Once your selection has been entered, you will be asked to place an unformatted diskette into drive B and type the **F** key to begin formatting. When the formatting is completed, you may continue formatting by placing another diskette into drive B and pressing the **F** key. You may repeat this process until all of your diskettes have been formatted. Press the **RETURN** key to end the formatting session.

The diskette that you format does not have to be a blank diskette. You may format an old diskette if you wish, but you should remember that **FORMAT** will destroy all data on a diskette. However, if the data on a diskette becomes damaged (or if you suspect that the data is damaged), copy the diskette onto another diskette and reformat the original. This way, you save some (or all) of the original data and you don't lose any diskettes.

HEXDUMP.COM

This is a utility designed to convert a **COM** file to the Intel Hex format and transmit it from the Aux or MAIN port to a desired port. Since the PIP program cannot transfer **COM** files, this utility is useful in effecting file transfers without the PIP program. To initiate the HEXDUMP facility, type the following at the keyboard: **HEXDUMP⟨cr⟩**. The program will be loaded and then await your instructions.

The first thing that the HEXDUMP procedure requests is the port to which you wish to dump the file. Here enter **1** for the MAIN port (corresponding to CP/M's PUN: and RDR: device), or **2** for the AUXILIARY port (corresponding to CP/M's LST: device). You must enter either a **1** or **2**; invalid entries will be ignored. Next you may choose whether or not you wish to have the **HEX** file echoed to the console (this will display the file as transmitted). Enter **1** if you do not wish to have the file echoed on the screen, or **2** if you wish to have the contents echoed. Again, invalid entries will be ignored.

Now you are ready to enter the file name. You must enter the drive designator, the file name and the file type. Separate the drive indicator from the file name with a colon (':'), and separate the type from the name with a period (.). Press the **RETURN** key after entering the name.

Example:

A⟩ **HEXDUMP⟨cr⟩**

HEXDUMP FILE UTILITY VER. 3.1

SELECT ONE OF THE FOLLOWING: (TYPE THE NUMBER)
1 — THE MAIN PORT (PUN:)
2 — THE AUX PORT (LST:)

2

SELECT ECHO ON THE CONSOLE:
1 — DO NOT ECHO ON THE CONSOLE
2 — ECHO TO THE CONSOLE

1

ENTER DISC, FILE-NAME, AND FILE-TYPE TO BE TRANSFERRED.

A:STAT.COM<cr>
FILE TRANSFER COMPLETED.
In the example above, the file STAT.COM was transferred from disk A through the auxiliary port.

HEXDUMP.COM will only transfer files which exist on drives A and B. If you enter an erroneous file-name or disk drive, the program will display an error message. If HEXDUMP.COM is unable to locate the given file, another error message will be given. When the transmission has completed, the screen will indicate this and return to the operating system.

64KTEST.COM

This program performs an extensive test on main memory by writing and reading all possible binary patterns to all locations in the random access memory (RAM). The process takes between eight and ten minutes to complete.

The test procedure begins by typing **64KTEST<cr>** at the keyboard. After the program is loaded into memory, you will be asked to remove all diskettes from their drives. If you have a Hard Disk Storage System connected to the terminal to be tested, either power down the hard disk or disconnect it from the terminal by removing the interconnecting cable. Be sure the Key Click feature is turned off before running the 64KTEST program. Otherwise, errors will be indicated that do not exist.

Once you have pressed the **G** key to start the test, the screen should fill with random text. The patterns on the screen should move around. This is because the memory for the screen is also undergoing the test. After the test is completed, the screen will display RAM OK, indicating that the test was successful. The test is an endless loop, and will repeat until the RED keys are depressed simultaneously. Therefore, you can test the RAM as long as you desire.

If an error is detected by the test, the test will stop and the audible tone will sound continuously. Should this occur, retry the test. If the error occurs frequently, please contact Intertec Customer Services Department.

TX.COM

The TX utility is written in standard CP/M assembly language. TX is designed to communicate via the computer's Main Port with the program RX running in the destination machine. Therefore, TX is considered the "Master" program, and RX is the "Slave" program. RX receives commands from TX such as "Open file", "Read incoming data block", "Write block to file", and so on. For this reason, the user should only be concerned with console operations for the machine in which TX is running. RX receives all directions from the communications link.

Unlike data transfer operations initiated with PIP, the TX/RX pair perform block verification, and retransmission in the event of error. TX/RX may be used to send any type of CP/M file without modification including .COM files.

TX is initiated by typing the command/ **TX<cr>**. The TX program will then "sign-on" with an identifying message and version number and then give the user an option to proceed or abort. The actual console dialogue appears as:

A> **TX<cr>**

INTERTEC File Transfer Utility Vers 1.X
HIT CR WHEN RECEIVE MACHINE READY OR Q TO ABORT

At this point, start up RX in the destination machine (See the RX.COM description that follows this TX description).

When a carriage return is entered to TX, it will attempt to establish a linkage to the destination RX machine over the computer's Main Port. Given that a link can be established, TX will display the message:

LINK TO SLAVE MACHINE ESTABLISHED

or, if many attempts to link fail:

UNABLE TO ESTABLISH/MAINTAIN DATA LINK

(This probably indicates that some aspect of the connection with the destination machine is not correct, i.e. inconsistent baud rates, improper cabling, or excessive line noise.)

The TX program then prompts the user to enter both the source file name and the destination file name. These names must be fully qualified, non-ambiguous file references. This includes disk specifiers.

If the specified file already exists on the receiving machine, TX will display:

FILE ALREADY EXISTS ON RECEIVING MACHINE

and the link is terminated.

As an expediency, send the file again, but with a temporary destination file name.

As a file is being transmitted under TX/RX, both TX and RX will display a record count. This serves to indicate that the data is being transferred correctly. It is normal to see a difference of one record between the two counts upon completion of a file transfer.

If TX detects a failure in the data link, it will output the message:
UNABLE TO ESTABLISH/MAINTAIN DATA LINK
When a file has been transmitted, TX displays the message:
FUNCTION COMPLETE
TYPE R TO REPEAT, CR TO EXIT

If another file is to be transferred, enter the letter **R** and TX will request another pair of file names. Entry of a carriage return will cause TX to command RX to shutdown and both will terminate.

There are two other messages that could be output by TX.

As each data block is sent, a checksum is calculated and transmitted. If RX detects a discrepancy between the received checksum and that which has been calculated for the received data, it will request that TX re-send the block in question. If the block cannot be received correctly after several re-transmissions, the message:

HARD DATA TRANSMISSION ERROR

will be rendered. The most likely cause of this failure is hardware error.

If the diskette on which RX attempts to place the incoming data file is write protected, or if there is not enough space to contain the incoming file, TX will display:

RECEIVE CANNOT CLOSE FILE

RX.COM

RX is an assembly language program designed to receive data files transmitted by TX from the computer's Main Port. It operates as a slave to the TX program, receiving commands from TX to perform operations on the destination machine.

RX is initiated by typing the command **RX<cr>**. Upon initiation, RX displays a "sign-on" message of the form:

INTERTEC File Transfer Utility Vers 1.X

From this point on, unless an error condition occurs, no further operator action is required.

As each data block is received, RX outputs a running count of the data blocks received. At the end of each received file, RX displays the message:

END-OF-FILE RECEIVED

When all files have been received, TX will command RX to terminate and RX will display:

LINK TERMINATED

If the data link cannot be established or maintained (indicated by a message on the TX system), it will be necessary to reset the destination system. This is accomplished on the destination computer by depressing both RED keys simultaneously.

TIME

The TIME program is used to set or display the time data kept by the real time clock. To set the time, enter:

A > **TIME hh:mm (AM)(PM)<cr>**

To enter "military" time (0000 thru 2400), it is not necessary to enter AM or PM. Once the entry is made, the TIME program will request that any key be depressed to set the time. This allows the user an opportunity to synchronize the time with another timepiece. To display the time, enter:

A > **TIME<cr>**

DATE

The DATE program is used to set or display the date maintained by the real time clock. To set the date, enter:

A >**DATE 04/07/82 WED<cr>**

or

A > **DATE 04/07/82 WEDNESDAY<cr>**

To display the date, enter:

A > **DATE<cr>**

SECONDARY CHARACTER SET OPTION

As was stated in the theory of operation section, the SuperBrain II provides a means by which a secondary character set option may be added. This gives the user the ability, via the software, to select either set. Intertec will provide a limited number of these alternate character sets, or if required, the customer may create a character set using software that is supplied by Intertec. In the following sections, both of these methods will be explained.

INTERTEC FURNISHED SECONDARY CHARACTER SETS

The easiest and quickest way to have access to a secondary character set would be to purchase one of the sets available from Intertec. This character set would be contained on an EPROM that would be inserted into a vacant IC socket on the processor board. After the EPROM has been inserted into its socket, it can be initialized via the escape sequence given in the attribute program section. Secondary character set installation procedures will be provided with each set purchased from Intertec.

CUSTOMER CREATED SECONDARY CHARACTER SETS

For those requirements where Intertec does not offer a suitable secondary character set, one can be created by the user. The CP/M disk provided with the SuperBrain II contains two utility programs that provide the means for creating and verifying secondary character sets. These two programs are CSEDIT.COM and CSDUMP.COM.

CSEDIT.COM

The CSEDIT utility provides the means for creating a secondary character set. The program is loaded from the disk by typing **CSEDIT** and then pressing **RETURN**. The initial screen message will read:

> SuperBrain II Character Set Editor — Ver 1.X
>
> Enter the character set file name:

The new character set file name should then be entered in the normal format of **filename.typ** and then pressing **RETURN**. The next screen message will read:

> Enter hex value of character to edit (0-7F, eXit, Quit, or ?)

As indicated by the parenthesis, there are four options (0-7F, eXit, Quit, or ?) available at this point. Since the "?" is the help page and will explain the other 3 entries, type **?** and press **RETURN**. The following page will appear on the screen:

The input required at this point is the hex value of the ASCII character that you wish to edit. This value must be in the range of 00 to 7F hex. You may also enter a "X" to exit the program and update the character set file, or a "Q" to abort the program and not update the character set file.

"0" — Clear dot at current position
"." — Put dot at current position
ENT — Go to start of next line
"-" — Clear current line
"1" — Invert pattern dots
"2" — Save pattern in temp. buffer
"3" — Recall previously saved pattern
"7" — Clear character cell
ESC — End editing of character
BRK — Abort with no change to character

SECONDARY CHARACTER SET OPTION (continued)

All cursor keys on the keypad work as would be expected.

Hit **RETURN** to continue:

After reading the help page, pressing **RETURN** will cause the initial screen message of the program to reappear. At this time the user should be ready to start the process to create an alternate character set. The following examples are from the standard character set provided with the SuperBrain II.

```
     Editing Number - 41H
       0 1 2 3 4 5 6
  ----------------------------
0:                           :
1:                           :
2:        *  *  *            :
3:     *           *         :
4:     *           *         :
5:     *  *  *  *  *         :
6:     *           *         :
7:     *           *         :
8:     *           *         :
9:                           :
  ----------------------------
```

"." — Put dot at current position
"_" — Clear current line
"1" — Invert pattern dots
"3" — Recall previously saved pattern
ESC — End editing of character
"0" — Clear dot at current position
ENT — Go to start of next line
"2" — Save pattern in temp. buffer
"7" — Clear character cell
BRK — Abort with no change to pattern

```
     Editing Number - 65H
       0 1 2 3 4 5 6
  ----------------------------
0:                           :
1:                           :
2:                           :
3:        *  *  *            :
4:     *           *         :
5:     *  *  *  *  *         :
6:     *                     :
7:        *  *  *            :
8:                           :
9:                           :
  ----------------------------
```

"." — Put dot at current position
"_" — Clear current line
"1" — Invert pattern dots
"3" — Recall previously saved pattern
ESC — End editing of character
"0" — Clear dot at current position
ENT — Go to start of next line
"2" — Save pattern in temp. buffer
"7" — Clear character cell
BRK — Abort with no change to pattern

SECONDARY CHARACTER SET OPTION (continued)

```
        Editing Number - 0BH
          0 1 2 3 4 5 6
    ---------------------------
    0:                        :
    1:                        :
    2:                        :
    3:          *             :
    4:          *             :
    5:      * * * * *         :
    6:          *             :
    7:          *             :
    8:                        :
    9:                        :
    ---------------------------
```

"."	— Put dot at current position	"0"	— Clear dot at current position
"_"	— Clear current line	ENT	— Go to start of next line
"1"	— Invert pattern dots	"2"	— Save pattern in temp. buffer
"3"	— Recall previously saved pattern	"7"	— Clear character cell
ESC	— End editing of character	BRK	— Abort with no change to pattern

After all the secondary characters have been created, by typing "X" and pressing RETURN, the new character set will be written on the disk as a binary file and the verification process can begin.

CSDUMP.COM

The CSDUMP utility will be used to verify that the character set that was just created is what is needed. To run the CSDUMP program, insure the SuperBrain II is connected to a printer via the Auxiliary port. The printer is the only output device that will display the dump. Once this is accomplished, type **CSDUMP**, and press the **RETURN** key. The following message will appear on the screen.

SuperBrain II Character Set Dump - Ver 1.X

Enter character set file name :

Enter the file name and press the **RETURN** key. The character set will be dumped out to the printer and the resulting page set should look similar to the one shown on the Sample Page — Character Set Dump exhibit.

The character file generated by this procedure can then be transferred to an EPROM programming machine using the HEXDUMP.COM utility. Once the EPROM has been created, it should then be inserted into the empty IC socket Z75, as indicated in the Socket Z75 exhibit. The initialization of the new character set is contained in the Escape Sequence covered in the Attribute section of this manual.

The part numbers for the blank EPROM are, Intertec part number 30122516 or Texas Instruments part number TMS-2516JL-35 or equivalent.

Any questions concerning Intertec created secondary character sets or the procedures or materials necessary to create secondary character sets should be referred to the Customer Services Department at Intertec Data Systems Corporate Headquarters.

SAMPLE PAGE — CHARACTER SET DUMP EXHIBIT

File Name : A:STISET

```
Ø:
1:     * * *
2:   *       *
3:   *   * * *
4:   *   *   *
5:   *   * * *
6:   *
7:     * * *
8:
9:
   Ø 1 2 3 4 5 6
 ASCII value - 4Øh
```

```
Ø:
1:     * * *
2:   *       *
3:   *       *
4:   * * * * *
5:   *       *
6:   *       *
7:   *       *
8:
9:
   Ø 1 2 3 4 5 6
 ASCII value - 41h
```

```
Ø:
1:   * * * *
2:     *     *
3:     *     *
4:     * * *
5:     *     *
6:     *     *
7:   * * * *
8:
9:
   Ø 1 2 3 4 5 6
 ASCII value - 42h
```

```
Ø:
1:     * * *
2:   *       *
3:   *
4:   *
5:   *
6:   *       *
7:     * * *
8:
9:
   Ø 1 2 3 4 5 6
 ASCII value - 43h
```

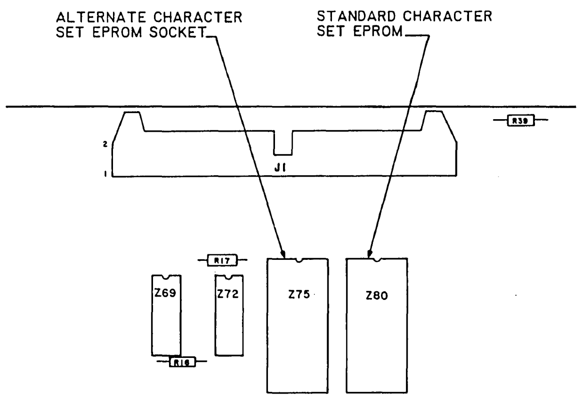
```
Ø:
1:   * * * *
2:     *     *
3:     *     *
4:     *     *
5:     *     *
6:     *     *
7:   * * * *
8:
9:
   Ø 1 2 3 4 5 6
 ASCII value - 44h
```

```
Ø:
1:   * * * * *
2:   *
3:   *
4:   * * * *
5:   *
6:   *
7:   * * * * *
8:
9:
   Ø 1 2 3 4 5 6
 ASCII value - 45h
```

```
Ø:
1:   * * * * *
2:   *
3:   *
4:   * * * *
5:   *
6:   *
7:   *
8:
9:
   Ø 1 2 3 4 5 6
 ASCII value - 46h
```

```
Ø:
1:     * * * *
2:   *
3:   *
4:   *   * * *
5:   *       *
6:   *       *
7:     * * * *
8:
9:
   Ø 1 2 3 4 5 6
 ASCII value - 47h
```

SOCKET Z75 EXHIBIT



Section 4

MISCELLANEOUS OPERATIONAL INFORMATION

MISCELLANEOUS OPERATIONAL INFORMATION

USING THE "INP:" AND "OUT:" FEATURES OF PIP

Files can be transferred using the PIP program as described in the SuperBrain II manual section entitled 'An Introduction to CP/M Features and Facilities.' The SuperBrain II is equipped with two RS232C Serial interface ports (labeled 'MAIN' and 'AUX' on the rear panel). Whenever the SuperBrain II transmits serial data via the 'MAIN' port, the destination is designated as a punch (PUN:); when receiving, the data source device is considered a reader (RDR:). When transmitting data to the 'AUX' port, the destination device is considered a list (LST:).

The 'MAIN' serial port may also be considered as an input (INP:) or output (OUT:) device. When used in this mode, the operator has the option of communicating with the sending or receiving device prior to file transfer by means of the SuperBrain II console. This interface is factory programmed for the following operational mode:

Asynchronous Communication
1200 Baud Rate
8 Bit Character Length
1 Stop Bit
No Parity
DSR Disabled

Files transferred via the 'MAIN' port must be in Intel 'HEX' or ASCII format. BASIC source programs must be saved in ASCII format before they can be transferred. Binary files (i.e., programs) must be transferred as HEX files, using the program HEXDUMP.COM.

PLEASE NOTE THE FOLLOWING:

1) Connect the SuperBrain II 'MAIN' port to the console input of the host computer. Make certain that the host computer and the SuperBrain are sending and receiving data in a compatible fashion (i.e., baud rate, character length, et.al.).
2) The largest file that can be transferred by PIP is 25K. If files are larger than 25K, they must be broken down into smaller segments of 25K or less.
3) Binary files (or .COM files) cannot be transferred via the serial ports using PIP. The DOS Diskette supplied with your SuperBrain II includes two facilities for binary file transfer. See TX/RX and HEXDUMP for more information.
4) The Clear-to-Send (CTS - Pin 5) line on the 'MAIN' port must be high (logical '1') before the SuperBrain II will send data through this port. Insure that these signals are properly connected between SuperBrain II and the host computer.
5) The 'MAIN' port is arranged so that the SuperBrain II appears as a processor rather than a terminal. If it is to be used as a terminal, pins 2 and 3 in the RS-232-C cable must be interchanged.

The following represents a sample file transfer session. Please note that bold characters are those typed by the operator, and the symbol '(cr)' means the 'RETURN' key.

A. Transfer an ASCII file from SuperBrain II to host computer:

(File name is ABC.FIL)

A〉**PIP OUT: = ABC.FIL〈cr〉**
ECHO (Y/N) **Y**

NOTE — The SuperBrain II will now perform as a terminal for the host computer. If you wish, you may transmit a line of text to the host computer before the file ABC.FIL is actually transferred. Anything typed at the console will be sent to the host computer. To initiate the file transfer, type Control-B.

Control-B (Hold down the CTRL Key, then 'B')

The file will be transferred, and should be displayed on the screen. Upon completion, PIP will exit and return to the operating system. When finished, it is necessary to signal end-of-file for the host computer. This is best done by using the EOF: facility of PIP:

A>**PIP OUT:=EOF:<cr>**
ECHO (Y/N) **Y**
+
CTRL B (Hold down the CTRL key, then 'B')

NOTE — The EOF presumes that the target machine uses a hex 1A (CTRL-Z) to indicate end of file.

The file transfer is now complete.

B. Transfer an ASCII file to the SuperBrain II from the host computer:

(File name is ABC.FIL)

A>**PIP ABC.PRN = INP:<cr>**
ECHO (Y/N) **Y**

The SuperBrain II is now ready to receive input from the host computer. Any further console entry at the SuperBrain II will be sent to the host computer. If the host computer does not send an end-of-file character, it will be necessary for you to place one into the file. This is done with the following command:

Control Z (Hold down the CTRL key, then 'Z')
End of File, Control Z? (The computer asks for confirmation)
Control Z (Hold down the CTRL key, then 'Z')

C. Transfer a Binary (or COM) file.

PIP does not permit binary files to be transferred via the serial port. Two system utilities, HEXDUMP and TX/RX, are provided to facilitate this. HEXDUMP will convert a binary file into a HEX format, and transmit out the 'MAIN' port. If HEXDUMP is used, the receiving unit must use PIP to accept the input from the sending unit. After the file transfer, the file can be converted back into a binary file using the DDT system program or the LOAD system program.

SYNCHRONOUS COMMUNICATION

Your computer system is factory configured to program the Universal Synchronous/Asynchronous Receiver/Transmitter (USART) to operate in the asynchronous mode. It is possible, however, to change this and permit the synchronous communication mode. You will be responsible for writing the software drivers that send and receive synchronous data through to the MAIN port at the rear of your terminal. This section will instruct you to properly program the USART which is the interface between the CPU and the main port of your computer.

Before proceeding, it would be helpful to read the specifications sheets for the 8251-type USART. On these sheets you are given the control words to reprogram the USART to enable synchronous communication. It is important that the timing dipswitch, located on the processor board, be properly set. This is necessary to coordinate the clock pulses between the two terminals communicating in the synchronous mode.

The SuperBrain II computer system stores the command byte for the 8251 USART in memory. To use a different type of communication, several steps are necessary. The USART command word must be changed in order to change the USART's operating mode. The operating system must also be prevented from resetting the USART during an interrupt cycle.

SuperBrain II Serial Communications DIPSWITCH

The serial communication DIP switch is located on the Keyboard/CPU printed circuit board inside the cabinet. It is accessed by removing the four screws from the bottom of the base that holds the cover in place. Next, make sure that the disk drive doors are closed, then lift off the cover. This will expose the Keyboard/CPU Module. The Dip switch is a five position switch on the top edge of the Keyboard/CPU Module. It is the only user settable switch on this module.

NOTE: When completing the procedures above, you may encounter a warranty certification seal. The seal will be positioned over one of the four bottom cover screws and clearly displays the warning, WARRANTY IS VOID IF LABEL REMOVED. This seal should not be removed if you intend to participate in any of Intertec's Satisfaction Assurance programs. Once this seal has been removed, the unit no longer qualifies for participation within these programs. For additional information concerning Intertec's Satisfaction Assurance programs, contact Intertec's Customer Services Department.

For the normal mode (*asynchronous communication mode), these switches should be set as follows:

1 — OFF, 2 — OFF, 3 — ON, 4 — ON, 5 — OFF

For the synchronous communication mode with another unit providing the transmitter and receiver clock, the switches should be set as follows:

1 — ON, 2 — ON, 3 — OFF, 4 — OFF, 5 — OFF

Listed below is a brief description of the function of each of these switches:

1 — External Clock to transmitter section of MAIN USART — originates from PIN #15 on MAIN RS232 connector at rear of terminal.

2 — External Clock to receiver section of MAIN USART — originates from PIN #17 on MAIN RS232 connector at rear of terminal.

3 — Internal TX Clock to MAIN USART — When on, this switch enables the built-in baud rate generator (Western Digital BR-1941).

NOTE: When this switch is in the 'ON' position, switch 1 **MUST** be in the 'OFF' position.

*THE SWITCHES WERE SET FOR THE ASYNCHRONOUS COMMUNICATION MODE BEFORE SHIPPING FROM THE FACTORY.

4 — Internal RX Clock to MAIN USART — When this switch is in the 'ON' position, switch 2 **MUST** be in the 'OFF' position.

5 — Internal Baud Clock to MAIN Port — This switch enables the transmission of the internal baud rate clock (Western Digital BR-1941) to the main RS232 port — this signal will also appear on PIN #24 of the main port when this switch is in the 'ON' position. If this switch is not used; it should be left in the 'OFF' position to avoid any possible conflict with external RS232 signals.

intel®

8251A/S2657
PROGRAMMABLE COMMUNICATION INTERFACE

- **Synchronous and Asynchronous Operation**
- **Synchronous 5-8 Bit Characters; Internal or External Character Synchronization; Automatic Sync Insertion**
- **Asynchronous 5-8 Bit Characters; Clock Rate—1, 16 or 64 Times Baud Rate; Break Character Generation; 1, 1½, or 2 Stop Bits; False Start Bit Detection; Automatic Break Detect and Handling**
- **Synchronous Baud Rate — DC to 64K Baud**
- **Asynchronous Baud Rate — DC to 19.2K Baud**
- **Full Duplex, Double Buffered, Transmitter and Receiver**
- **Error Detection — Parity, Overrun and Framing**
- **Fully Compatible with 8080/8085 CPU**
- **28-Pin DIP Package**
- **All Inputs and Outputs are TTL Compatible**
- **Single +5V Supply**
- **Single TTL Clock**

The Intel® 8251A is the enhanced version of the industry standard, Intel® 8251 Universal Synchronous/Asynchronous Receiver/Transmitter (USART), designed for data communications with Intel's new high performance family of microprocessors such as the 8085. The 8251A is used as a peripheral device and is programmed by the CPU to operate using virtually any serial data transmission technique presently in use (including IBM "bi-sync"). The USART accepts data characters from the CPU in parallel format and then converts them into a continuous serial data stream for transmission. Simultaneously, it can receive serial data streams and convert them into parallel data characters for the CPU. The USART will signal the CPU whenever it can accept a new character for transmission or whenever it has received a character for the CPU. The CPU can read the complete status of the USART at any time. These include data transmission errors and control signals such as SYNDET, TxEMPTY. The chip is constructed using N-channel silicon gate technology.

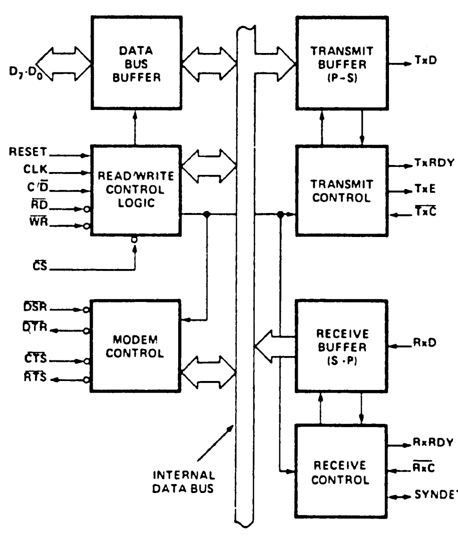


Figure 1. Block Diagram

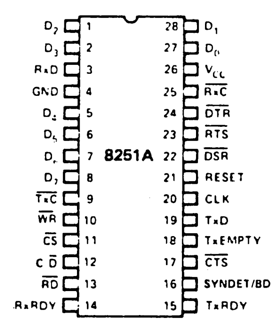


Figure 2. Pin Configuration

FEATURES AND ENHANCEMENTS

8251A is an advanced design of the industry standard USART, the Intel® 8251. The 8251A operates with an extended range of Intel microprocessors that includes the new 8085 CPU and maintains compatibility with the 8251. Familiarization time is minimal because of compatibility and involves only knowing the additional features and enhancements, and reviewing the AC and DC specifications of the 8251A.

The 8251A incorporates all the key features of the 8251 and has the following additional features and enhancements:

- 8251A has double-buffered data paths with separate I/O registers for control, status, Data In, and Data Out, which considerably simplifies control programming and minimizes CPU overhead.
- In asynchronous operations, the Receiver detects and handles "break" automatically, relieving the CPU of this task.
- A refined Rx initialization prevents the Receiver from starting when in "break" state, preventing unwanted interrupts from a disconnected USART.
- At the conclusion of a transmission, TxD line will always return to the marking state unless SBRK is programmed.
- Tx Enable logic enhancement prevents a Tx Disable command from halting transmission until all data previously written has been transmitted. The logic also prevents the transmitter from turning off in the middle of a word.
- When External Sync Detect is programmed, Internal Sync Detect is disabled, and an External Sync Detect status is provided via a flip-flop which clears itself upon a status read.
- Possibility of false sync detect is minimized by ensuring that if double character sync is programmed, the characters be contiguously detected and also by clearing the Rx register to all ones whenever Enter Hunt command is issued in Sync mode.
- As long as the 8251A is not selected, the $\overline{RD}$ and $\overline{WR}$ do not affect the internal operation of the device.
- The 8251A Status can be read at any time but the status update will be inhibited during status read.
- The 8251A is free from extraneous glitches and has enhanced AC and DC characteristics, providing higher speed and better operating margins.
- Synchronous Baud rate from DC to 64K.
- Fully compatible with Intel's new industry standard, the MCS-85.

FUNCTIONAL DESCRIPTION

General

The 8251A is a Universal Synchronous/Asynchronous Receiver/Transmitter designed specifically for the 80/85 Microcomputer Systems. Like other I/O devices in a Microcomputer System, its functional configuration is programmed by the system's software for maximum flexibility. The 8251A can support virtually any serial data technique currently in use (including IBM "bi-sync").

In a communication environment an interface device must convert parallel format system data into serial format for transmission and convert incoming serial format data into parallel system data for reception. The interface device must also delete or insert bits or characters that are functionally unique to the communication technique. In essence, the interface should appear "transparent" to the CPU, a simple input or output of byte-oriented system data.

Data Bus Buffer

This 3-state, bidirectional, 8-bit buffer is used to interface the 8251A to the system Data Bus. Data is transmitted or received by the buffer upon execution of INput or OUTput instructions of the CPU. Control words, Command words and Status information are also transferred through the Data Bus Buffer. The command status and data in, and data out are separate 8-bit registers to provide double buffering.

This functional block accepts inputs from the system Control bus and generates control signals for overall device operation. It contains the Control Word Register and Command Word Register that store the various control formats for the device functional definition.

RESET (Reset)

A "high" on this input forces the 8251A into an "Idle" mode. The device will remain at "Idle" until a new set of control words is written into the 8251A to program its functional definition. Minimum RESET pulse width is 6 t_{CY} (clock must be running).

CLK (Clock)

The CLK input is used to generate internal device timing and is normally connected to the Phase 2 (TTL) output of the 8224 Clock Generator. No external inputs or outputs are referenced to CLK but the frequency of CLK must be greater than 30 times the Receiver or Transmitter data bit rates.

$\overline{WR}$ (Write)

A "low" on this input informs the 8251A that the CPU is writing data or control words to the 8251A.

$\overline{RD}$ (Read)

A "low" on this input informs the 8251A that the CPU is reading data or status information from the 8251A.

C/$\overline{D}$ (Control/Data)

This input, in conjunction with the $\overline{WR}$ and $\overline{RD}$ inputs, informs the 8251A that the word on the Data Bus is either a data character, control word or status information.
1 = CONTROL/STATUS 0 = DATA

$\overline{CS}$ (Chip Select)

A "low" on this input selects the 8251A. No reading or writing will occur unless the device is selected. When $\overline{CS}$ is high, the Data Bus in the float state and $\overline{RD}$ and $\overline{WR}$ will have no effect on the chip.

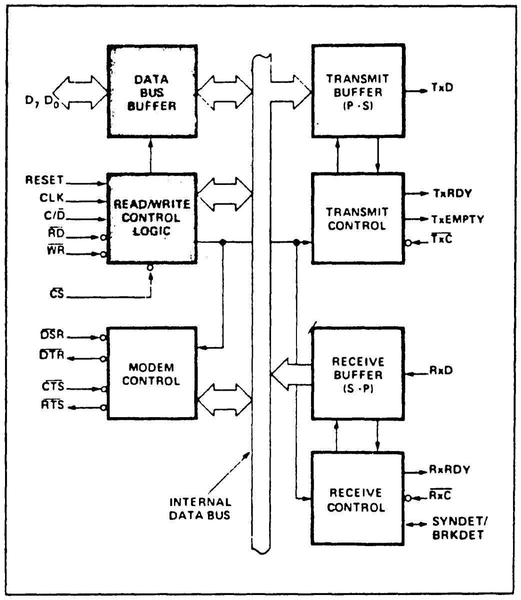


Figure 3. 8251A Block Diagram Showing Data Bus Buffer and Read/Write Logic Functions

C/$\overline{D}$	$\overline{RD}$	$\overline{WR}$	$\overline{CS}$	
0	0	1	0	8251A DATA ⇒ DATA BUS
0	1	0	0	DATA BUS ⇒ 8251A DATA
1	0	1	0	STATUS ⇒ DATA BUS
1	1	0	0	DATA BUS ⇒ CONTROL
X	1	1	0	DATA BUS ⇒ 3-STATE
X	X	X	1	DATA BUS ⇒ 3-STATE

Modem Control

The 8251A has a set of control inputs and outputs that can be used to simplify the interface to almost any Modem. The Modem control signals are general purpose in nature and can be used for functions other than Modem control, if necessary.

$\overline{DSR}$ (Data Set Ready)

The $\overline{DSR}$ input signal is a general purpose, 1-bit inverting input port. Its condition can be tested by the CPU using a Status Read operation. The $\overline{DSR}$ input is normally used to test Modem conditions such as Data Set Ready.

$\overline{DTR}$ (Data Terminal Ready)

The $\overline{DTR}$ output signal is a general purpose, 1-bit inverting output port. It can be set "low" by programming the appropriate bit in the Command Instruction word. The $\overline{DTR}$ output signal is normally used for Modem control such as Data Terminal Ready or Rate Select.

$\overline{RTS}$ (Request to Send)

The $\overline{RTS}$ output signal is a general purpose, 1-bit inverting output port. It can be set "low" by programming the appropriate bit in the Command Instruction word. The $\overline{RTS}$ output signal is normally used for Modem control such as Request to Send.

$\overline{CTS}$ (Clear to Send)

A "low" on this input enables the 8251A to transmit serial data if the Tx Enable bit in the Command byte is set to a "one." If either a Tx Enable off or CTS off condition occurs while the Tx is in operation, the Tx will transmit all the data in the USART, written prior to Tx Disable command before shutting down. On the 8251A/S2657 if CTS off or Tx Enable off condition occurs before the last character written appears in the serial bit stream, that character will be transmitted again upon CTS on or Tx Enable on condition.

Transmitter Buffer

The Transmitter Buffer accepts parallel data from the Data Bus Buffer, converts it to a serial bit stream, inserts the appropriate characters or bits (based on the communication technique) and outputs a composite serial stream of data on the TxD output pin on the falling edge of $\overline{TxC}$. The transmitter will begin transmission upon being enabled if $\overline{CTS}$ = 0. The TxD line will be held in the marking state immediately upon a master Reset or when Tx Enable/$\overline{CTS}$ off or TxEMPTY.

Transmitter Control

The transmitter Control manages all activities associated with the transmission of serial data. It accepts and issues signals both externally and internally to accomplish this function.

TxRDY (Transmitter Ready)

This output signals the CPU that the transmitter is ready to accept a data character. The TxRDY output pin can be used as an interrupt to the system, since it is masked by Tx Disabled, or, for Polled operation, the CPU can check TxRDY using a Status Read operation. TxRDY is automatically reset by the leading edge of $\overline{WR}$ when a data character is loaded from the CPU.

Note that when using the Polled operation, the TxRDY status bit is *not* masked by Tx Enabled, but will only indicate the Empty/Full Status of the Tx Data Input Register.

TxE (Transmitter Empty)

When the 8251A has no characters to transmit, the TxEMPTY output will go "high". It resets automatically upon receiving a character from the CPU if the transmitter is enabled. TxEMPTY can be used to indicate the end of a transmission mode, so that the CPU "knows" when to "turn the line around" in the half-duplexed operational mode.

In SYNChronous mode, a "high" on this output indicates that a character has not been loaded and the SYNC character or characters are about to be or are being transmitted automatically as "fillers". TxEMPTY does not go low when the SYNC characters are being shifted out.

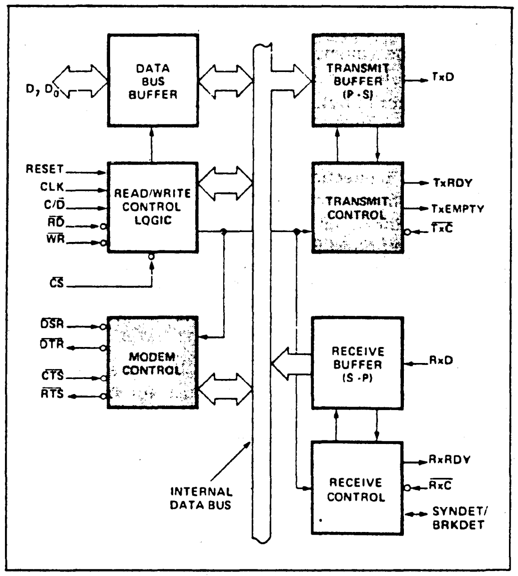


Figure 4. 8251A Block Diagram Showing Modem and Transmitter Buffer and Control Functions

$\overline{TxC}$ (Transmitter Clock)

The Transmitter Clock controls the rate at which the character is to be transmitted. In the Synchronous transmission mode, the Baud Rate (1x) is equal to the $\overline{TxC}$ frequency. In Asynchronous transmission mode the baud rate is a fraction of the actual $\overline{TxC}$ frequency. A portion of the mode instruction selects this factor; it can be 1, 1/16 or 1/64 the $\overline{TxC}$.

For Example:

If Baud Rate equals 110 Baud,
$\overline{TxC}$ equals 110 Hz (1x)
$\overline{TxC}$ equals 1.76 kHz (16x)
$\overline{TxC}$ equals 7.04 kHz (64x).

The falling edge of $\overline{TxC}$ shifts the serial data out of the 8251A.

Receiver Buffer

The Receiver accepts serial data, converts this serial input to parallel format, checks for bits or characters that are unique to the communication technique and sends an "assembled" character to the CPU. Serial data is input to RxD pin, and is clocked in on the rising edge of $\overline{\mathrm{RxC}}$.

Receiver Control

This functional block manages all receiver-related activities which consist of the following features:

The RxD initialization circuit prevents the 8251A from mistaking an unused input line for an active low data line in the "break condition". Before starting to receive serial characters on the RxD line, a valid "1" must first be detected after a chip master Reset. Once this has been determined, a search for a valid low (Start bit) is enabled. This feature is only active in the asynchronous mode, and is only done once for each master Reset.

The False Start bit detection circuit prevents false starts due to a transient noise spike by first detecting the falling edge and then strobing the nominal center of the Start bit (RxD = low).

The Parity Toggle F/F and Parity Error F/F circuits are used for parity error detection and set the corresponding status bit.

The Framing Error Flag F/F is set if the Stop bit is absent at the end of the data byte (asynchronous mode), and also sets the corresponding status bit.

RxRDY (Receiver Ready)

This output indicates that the 8251A contains a character that is ready to be input to the CPU. Rx RDY can be connected to the interrupt structure of the CPU or, for Polled operation, the CPU can check the condition of RxRDY using a Status Read operation.

Rx Enable off both masks and holds RxRDY in the Reset Condition. For Asynchronous mode, to set RxRDY, the Receiver must be Enabled to sense a Start Bit and a complete character must be assembled and transferred to the Data Output Register. For Synchronous mode, to set RxRDY, the Receiver must be enabled and a character must finish assembly and be transferred to the Data Output Register.

Failure to read the received character from the Rx Data Output Register prior to the assembly of the next Rx Data character will set overrun condition error and the previous character will be written over and lost. If the Rx Data is being read by the CPU when the internal transfer is occurring, overrun error will be set and the old character will be lost.

$\overline{\mathrm{RxC}}$ (Receiver Clock)

The Receiver Clock controls the rate at which the character is to be received. In Synchronous Mode, the Baud Rate (1x) is equal to the actual frequency of $\overline{\mathrm{RxC}}$. In Asynchronous Mode, the Baud Rate is a fraction of the actual $\overline{\mathrm{RxC}}$ frequency. A portion of the mode instruction selects this factor; 1, 1/16 or 1/64 the $\overline{\mathrm{RxC}}$.

For Example:

Baud Rate equals 300 Baud, if
$\overline{\mathrm{RxC}}$ equals 300 Hz (1x)
$\overline{\mathrm{RxC}}$ equals 4800 Hz (16x)
$\overline{\mathrm{RxC}}$ equals 19.2 kHz (64x).

Baud Rate equals 2400 Baud, if
$\overline{\mathrm{RxC}}$ equals 2400 Hz (1x)
$\overline{\mathrm{RxC}}$ equals 38.4 kHz (16x)
$\overline{\mathrm{RxC}}$ equals 153.6 kHz (64x).

Data is sampled into the 8251A on the rising edge of $\overline{\mathrm{RxC}}$.

NOTE: In most communications systems, the 8251A will be handling both the transmission and reception operations of a single link. Consequently, the Receive and Transmit Baud Rates will be the same. Both $\overline{\mathrm{TxC}}$ and $\overline{\mathrm{RxC}}$ will require identical frequencies for this operation and can be tied together and connected to a single frequency source (Baud Rate Generator) to simplify the interface.

SYNDET (SYNC Detect)/BRKDET (Break Detect)

This pin is used in SYNChronous Mode for SYNDET and may be used as either input or output, programmable through the Control Word. It is reset to output mode low upon RESET. When used as an output (internal Sync mode), the SYNDET pin will go "high" to indicate that the 8251A has located the SYNC character in the Receive mode. If the 8251A is programmed to use double Sync characters (bisync), then SYNDET will go "high" in the middle of the last bit of the second Sync character. SYNDET is automatically reset upon a Status Read operation.

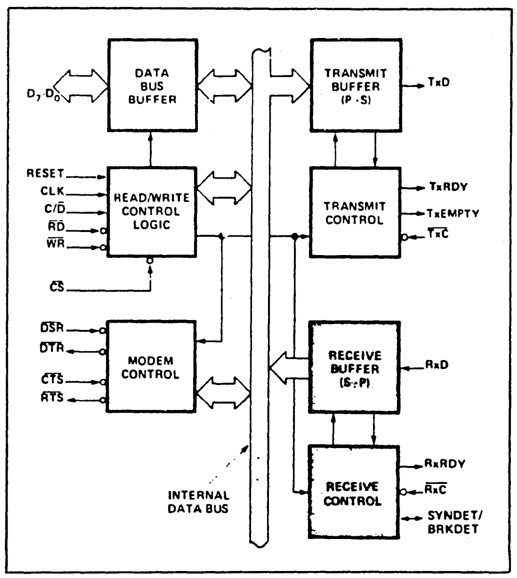


Figure 5. 8251A Block Diagram Showing Receiver Buffer and Control Functions

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When used as an input (external SYNC detect mode), a positive going signal will cause the 8251A to start assembling data characters on the rising edge of the next $\overline{RxC}$. Once in SYNC, the "high" input signal can be removed. When External SYNC Detect is programmed, the Internal SYNC Detect is disabled.

BREAK DETECT (Async Mode Only)

This output will go high whenever the receiver remains low through two consecutive stop bit sequences (including the start bits, data bits, and parity bits). Break Detect may also be read as a Status bit. It is reset only upon a master chip Reset or Rx Data returning to a "one" state.

NOTE: On the 8251A/S2657, if the RxData returns to a "one" state during the last bit of the next character after the break, break detect will latch-up, and the device must be cleared by a Chip Reset.

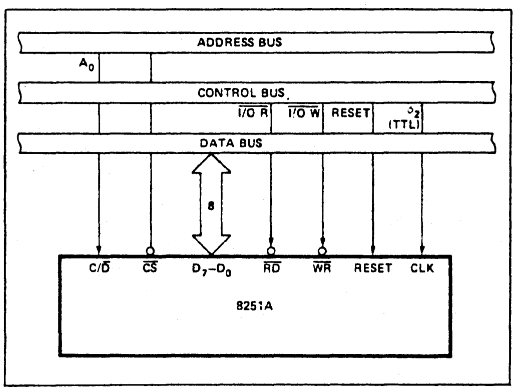


Figure 6. 8251A Interface to 8080 Standard System Bus

DETAILED OPERATION DESCRIPTION

General

The complete functional definition of the 8251A is programmed by the system's software. A set of control words must be sent out by the CPU to initialize the 8251A to support the desired communications format. These control words will program the: BAUD RATE, CHARACTER LENGTH, NUMBER OF STOP BITS, SYNCHRONOUS or ASYNCHRONOUS OPERATION, EVEN/ODD/OFF PARITY, etc. In the Synchronous Mode, options are also provided to select either internal or external character synchronization.

Once programmed, the 8251A is ready to perform its communication functions. The TxRDY output is raised "high" to signal the CPU that the 8251A is ready to receive a data character from the CPU. This output (TxRDY) is reset automatically when the CPU writes a character into the 8251A. On the other hand, the 8251A receives serial data from the MODEM or I/O device. Upon receiving an entire character, the RxRDY output is raised "high" to signal the CPU that the 8251A has a complete character ready for the CPU to fetch. RxRDY is reset automatically upon the CPU data read operation.

The 8251A cannot begin transmission until the Tx Enable (Transmitter Enable) bit is set in the Command Instruction and it has received a Clear To Send ($\overline{CTS}$) input. The TxD output will be held in the marking state upon Reset.

Programming the 8251A

Prior to starting data transmission or reception, the 8251A must be loaded with a set of control words generated by the CPU. These control signals define the complete functional definition of the 8251A and must immediately follow a Reset operation (internal or external).

The control words are split into two formats:

1. Mode Instruction
2. Command Instruction

Mode Instruction

This format defines the general operational characteristics of the 8251A. It must follow a Reset operation (internal or external). Once the Mode Instruction has been written into the 8251A by the CPU, SYNC characters or Command Instructions may be inserted.

Command Instruction

This format defines a status word that is used to control the actual operation of the 8251A.

Both the Mode and Command Instructions must conform to a specified sequence for proper device operation. The Mode Instruction must be inserted immediately following a Reset operation, prior to using the 8251A for data communication.

All control words written into the 8251A after the Mode Instruction will load the Command Instruction. Command Instructions can be written into the 8251A at any time in the data block during the operation of the 8251A. To return to the Mode Instruction format, the master Reset bit in the Command Instruction word can be set to initiate an internal Reset operation which automatically places the 8251A back into the Mode Instruction format. Command Instructions must follow the Mode Instructions or Sync characters.

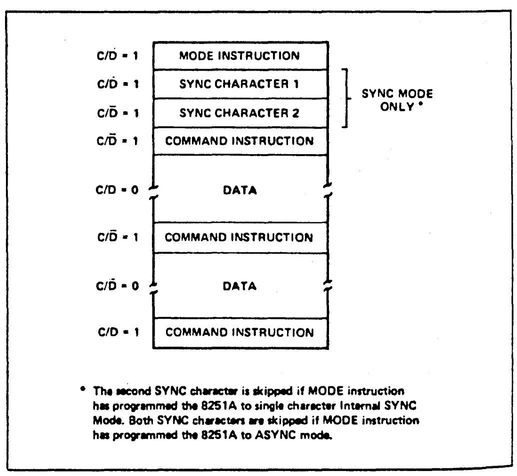


Figure 7. Typical Data Block

Mode Instruction Definition

The 8251A can be used for either Asynchronous or Synchronous data communication. To understand how the Mode Instruction defines the functional operation of the 8251A, the designer can best view the device as two separate components sharing the same package, one Asynchronous the other Synchronous. The format definition can be changed only after a master chip Reset. For explanation purposes the two formats will be isolated.

NOTE: When parity is enabled it is not considered as one of the data bits for the purpose of programming the word length. The actual parity bit received on the Rx Data line cannot be read on the Data Bus. In the case of a programmed character length of less than 8 bits, the least significant Data Bus bits will hold the data; unused bits are "don't care" when writing data to the 8251A, and will be "zeros" when reading the data from the 8251A.

Asynchronous Mode (Transmission)

Whenever a data character is sent by the CPU the 8251A automatically adds a Start bit (low level) followed by the data bits (least significant bit first), and the programmed number of Stop bits to each character. Also, an even or odd Parity bit is inserted prior to the Stop bit(s), as defined by the Mode Instruction. The character is then transmitted as a serial data stream on the TxD output. The serial data is shifted out on the falling edge of $\overline{TxC}$ at a rate equal to 1, 1/16, or 1/64 that of the $\overline{TxC}$, as defined by the Mode Instruction. BREAK characters can be continuously sent to the TxD if commanded to do so.

When no data characters have been loaded into the 8251A the TxD output remains "high" (marking) unless a Break (continuously low) has been programmed.

Asynchronous Mode (Receive)

The RxD line is normally high. A falling edge on this line triggers the beginning of a START bit. The validity of this START bit is checked by again strobing this bit at its nominal center (16X or 64X mode only). If a low is detected again, it is a valid START bit, and the bit counter will start counting. The bit counter thus locates the center of the data bits, the parity bit (if it exists) and the stop bits. If parity error occurs, the parity error flag is set. Data and parity bits are sampled on the RxD pin with the rising edge of $\overline{RxC}$. If a low level is detected as the STOP bit, the Framing Error flag will be set. The STOP bit signals the end of a character. Note that the *receiver* requires only *one* stop bit, regardless of the number of stop bits programmed. This character is then loaded into the parallel I/O buffer of the 8251A. The RxRDY pin is raised to signal the CPU that a character is ready to be fetched. If a previous character has not been fetched by the CPU, the present character replaces it in the I/O buffer, and the OVERRUN Error flag is raised (thus the previous character is lost). All of the error flags can be reset by an Error Reset Instruction. The occurrence of any of these errors will not affect the operation of the 8251A.

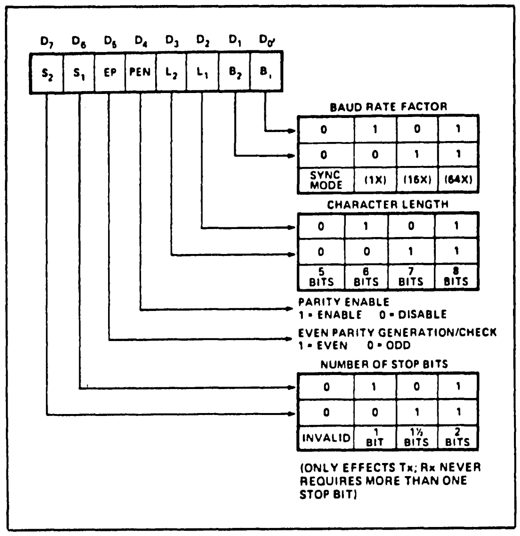


Figure 8. Mode Instruction Format, Asynchronous Mode

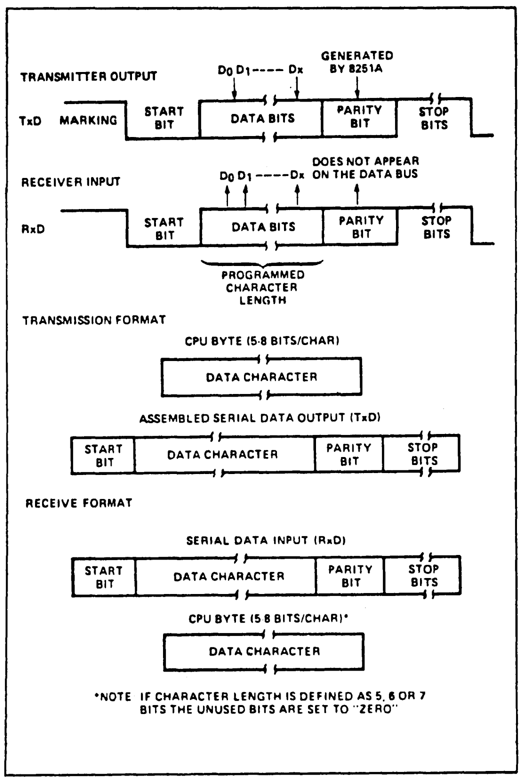


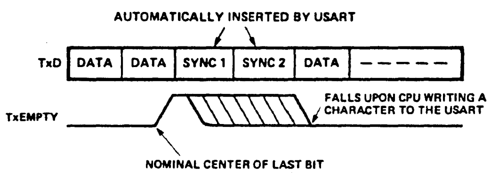
Figure 9. Asynchronous Mode

Section 4

Synchronous Mode (Transmission)

The TxD output is continuously high until the CPU sends its first character to the 8251A which usually is a SYNC character. When the $\overline{CTS}$ line goes low, the first character is serially transmitted out. All characters are shifted out on the falling edge of $\overline{TxC}$. Data is shifted out at the same rate as the $\overline{TxC}$.

Once transmission has started, the data stream at the TxD output must continue at the $\overline{TxC}$ rate. If the CPU does not provide the 8251A with a data character before the 8251A Transmitter Buffers become empty, the SYNC characters (or character if in single SYNC character mode) will be automatically inserted in the TxD data stream. In this case, the TxEMPTY pin is raised high to signal that the 8251A is empty and SYNC characters are being sent out. TxEMPTY does not go low when the SYNC is being shifted out (see figure below). The TxEMPTY pin is internally reset by a data character being written into the 8251A.



Synchronous Mode (Receive)

In this mode, character synchronization can be internally or externally achieved. If the SYNC mode has been programmed, ENTER HUNT command should be included in the first command instruction word written. Data on the RxD pin is then sampled in on the rising edge of $\overline{RxC}$. The content of the Rx buffer is compared at every bit boundary with the first SYNC character until a match occurs. If the 8251A has been programmed for two SYNC characters, the subsequent received character is also compared; when both SYNC characters have been detected, the USART ends the HUNT mode and is in character synchronization. The SYNDET pin is then set high, and is reset automatically by a STATUS READ. If parity is programmed, SYNDET will not be set until the middle of the parity bit instead of the middle of the last data bit.

In the external SYNC mode, synchronization is achieved by applying a high level on the SYNDET pin, thus forcing the 8251A out of the HUNT mode. The high level can be removed after one $\overline{RxC}$ cycle. An ENTER HUNT command has no effect in the asynchronous mode of operation.

Parity error and overrun error are both checked in the same way as in the Asynchronous Rx mode. Parity is checked when not in Hunt, regardless of whether the Receiver is enabled or not.

The CPU can command the receiver to enter the HUNT mode if synchronization is lost. This will also set all the used character bits in the buffer to a "one", thus preventing a possible false SYNDET caused by data that happens to be in the Rx Buffer at ENTER HUNT time. Note that the SYNDET F/F is reset at each Status Read, regardless of whether internal or external SYNC has been programmed. This does not cause the 8251A to return to the HUNT mode. When in SYNC mode, but not in HUNT, Sync Detection is still functional, but only occurs at the "known" word boundaries. Thus, if one Status Read indicates SYNDET and a second Status Read also indicates SYNDET, then the programmed SYNDET characters have been received since the previous Status Read. (If double character sync has been programmed, then both sync characters have been contiguously received to gate a SYNDET indication.) When external SYNDET mode is selected, internal Sync Detect is disabled, and the SYNDET F/F may be set at any bit boundary.

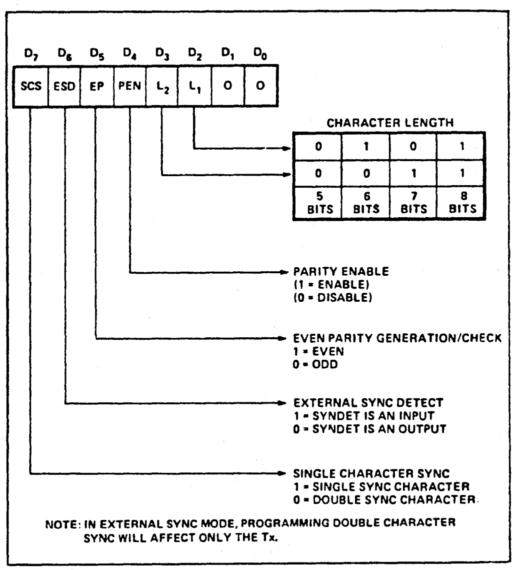


Figure 10. Mode Instruction Format, Synchronous Mode

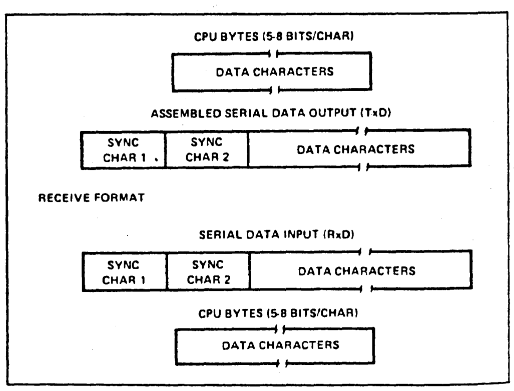
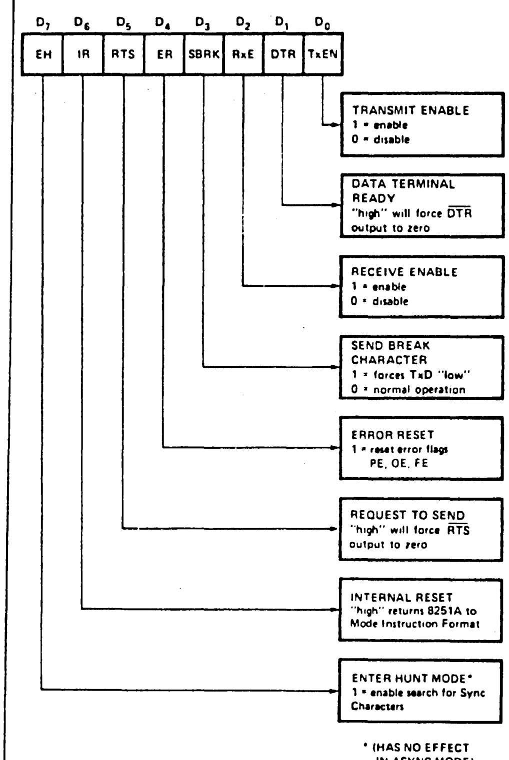


Figure 11. Data Format, Synchronous Mode

COMMAND INSTRUCTION DEFINITION

Once the functional definition of the 8251A has been programmed by the Mode Instruction and the Sync Characters are loaded (if in Sync Mode) then the device is ready to be used for data communication. The Command Instruction controls the actual operation of the selected format. Functions such as: Enable Transmit/Receive, Error Reset and Modem Controls are provided by the Command Instruction.

Once the Mode Instruction has been written into the 8251A and Sync characters inserted, if necessary, then all further "control writes" (C/$\overline{D}$ = 1) will load a Command Instruction. A Reset Operation (internal or external) will return the 8251A to the Mode Instruction format.



Note: Error Reset must be performed whenever RxEnable and Enter Hunt are programmed.

Figure 12. Command Instruction Format

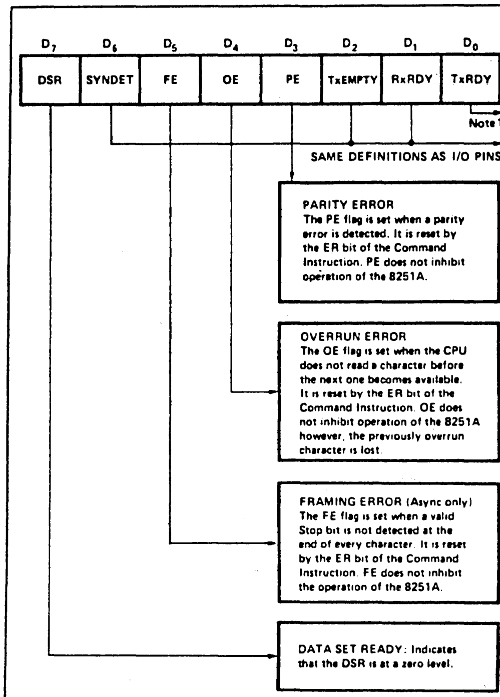
STATUS READ DEFINITION

In data communication systems it is often necessary to examine the "status" of the active device to ascertain if errors have occurred or other conditions that require the processor's attention. The 8251A has facilities that allow the programmer to "read" the status of the device at any time during the functional operation. (The status update is inhibited during status read).

A normal "read" command is issued by the CPU with C/$\overline{D}$ = 1 to accomplish this function.

Some of the bits in the Status Read Format have identical meanings to external output pins so that the 8251A can be used in a completely Polled environment or in an interrupt driven environment. TxRDY is an exception.

Note that status update can have a maximum delay of 28 clock periods from the actual event affecting the status.



Note 1: TxRDY status bit has different meanings from the TxRDY output pin. The former is not conditioned by $\overline{CTS}$ and TxEN; the latter is conditioned by both $\overline{CTS}$ and TxEN.

i.e. TxRDY status bit = DB Buffer Empty

TxRDY pin out = DB Buffer Empty · (CTS=0) · (TxEN=1)

Figure 13. Status Read Format

APPLICATIONS OF THE 8251A

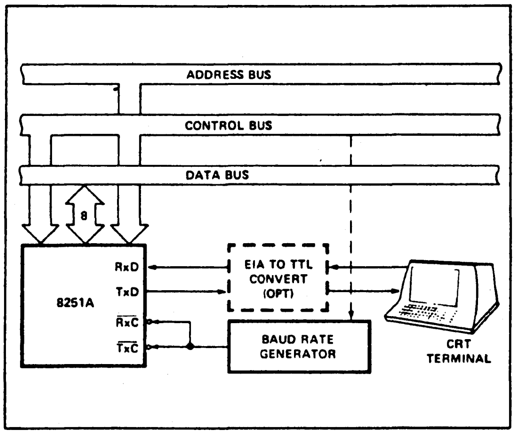


Figure 14. Asynchronous Serial Interface to CRT Terminal, DC—9600 Baud

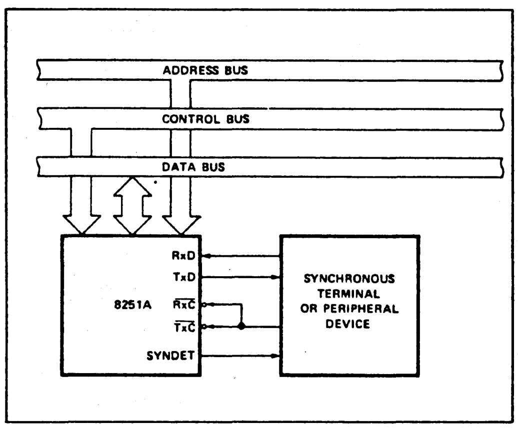


Figure 15. Synchronous Interface to Terminal or Peripheral Device

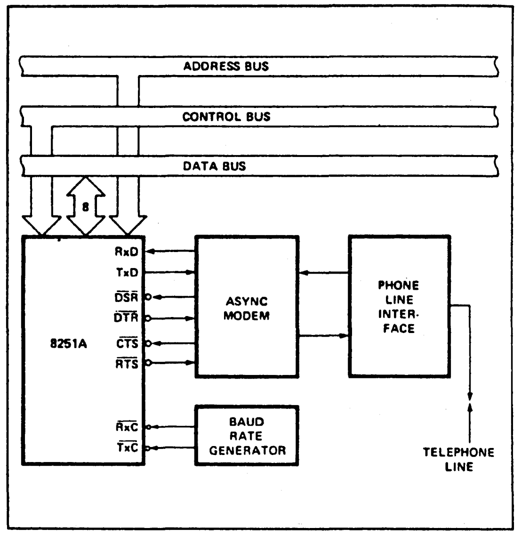


Figure 16. Asynchronous Interface to Telephone Lines

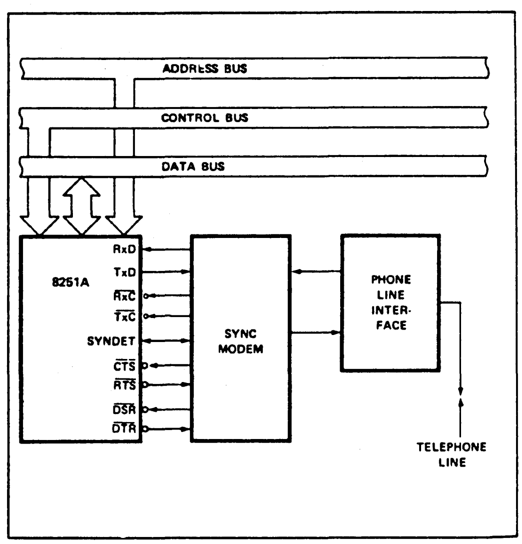


Figure 17. Synchronous Interface to Telephone Lines

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ABSOLUTE MAXIMUM RATINGS*

Ambient Temperature Under Bias. . . . . 0°C to 70°C
Storage Temperature . . . .−65°C to +150°C
Voltage On Any Pin
With Respect to Ground . . . . −0.5V to +7V
Power Dissipation . . . . 1 Watt

NOTICE: Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

D.C. CHARACTERISTICS (T_A = 0°C to 70°C, V_{CC} = 5.0V ±5%, GND = 0V)

Symbol	Parameter	Min.	Max.	Unit	Test Conditions
V_{IL}	Input Low Voltage	−0.5	0.8	V	
V_{IH}	Input High Voltage	2.2	V_{CC}	V	
V_{OL}	Output Low Voltage		0.45	V	I_{OL} = 2.2 mA
V_{OH}	Output High Voltage	2.4		V	I_{OH} = −400 μA
I_{OFL}	Output Float Leakage		±10	μA	V_{OUT} = V_{CC} TO 0.45V
I_{IL}	Input Leakage		±10	μA	V_{IN} = V_{CC} TO 0.45V
I_{CC}	Power Supply Current		100	mA	All Outputs = High

CAPACITANCE (T_A = 25°C, V_{CC} = GND = 0V)

Symbol	Parameter	Min.	Max.	Unit	Test Conditions
C_{IN}	Input Capacitance		10	pF	fc = 1MHz
$C_{I/O}$	I/O Capacitance		20	pF	Unmeasured pins returned to GND

A.C. CHARACTERISTICS (T_A = 0°C to 70°C, V_{CC} = 5.0V ±5%, GND = 0V)

Bus Parameters (Note 1)

READ CYCLE

Symbol	Parameter	Min.	Max.	Unit	Test Conditions
t_{AR}	Address Stable Before $\overline{READ}$ ($\overline{CS}$, C/$\overline{D}$)	50		ns	Note 2
t_{RA}	Address Hold Time for $\overline{READ}$ ($\overline{CS}$, C/$\overline{D}$)	50		ns	Note 2
t_{RR}	$\overline{READ}$ Pulse Width	250		ns	
t_{RD}	Data Delay from $\overline{READ}$		250	ns	3, C_L = 150 pF
t_{DF}	$\overline{READ}$ to Data Floating	10	100	ns	

Section 4

A.C. CHARACTERISTICS (Continued)

WRITE CYCLE

Symbol	Parameter	Min.	Max.	Unit	Test Conditions
t_{AW}	Address Stable Before $\overline{\text{WRITE}}$	50		ns	
t_{WA}	Address Hold Time for $\overline{\text{WRITE}}$	50		ns	
t_{WW}	$\overline{\text{WRITE}}$ Pulse Width	250		ns	
t_{DW}	Data Set Up Time for $\overline{\text{WRITE}}$	150		ns	
t_{WD}	Data Hold Time for $\overline{\text{WRITE}}$	50		ns	
t_{RV}	Recovery Time Between WRITES	6		t_{CY}	Note 4

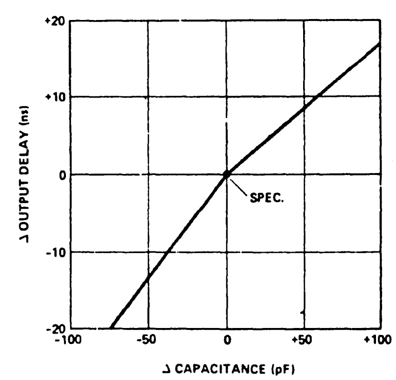
OTHER TIMINGS

Symbol	Parameter	Min.	Max.	Unit	Test Conditions
t_{CY}	Clock Period	320	1350	ns	Notes 5, 6
t_{ϕ}	Clock High Pulse Width	140	t_{CY}-90	ns	
$t_{\overline{\phi}}$	Clock Low Pulse Width	90		ns	
t_R, t_F	Clock Rise and Fall Time		20	ns	
t_{DTx}	TxD Delay from Falling Edge of $\overline{\text{TxC}}$		1	µs	
f_{Tx}	Transmitter Input Clock Frequency				
	1x Baud Rate	DC	64	kHz	
	16x Baud Rate	DC	310	kHz	
	64x Baud Rate	DC	615	kHz	
t_{TPW}	Transmitter Input Clock Pulse Width				
	1x Baud Rate	12		t_{CY}	
	16x and 64x Baud Rate	1		t_{CY}	
t_{TPD}	Transmitter Input Clock Pulse Delay				
	1x Baud Rate	15		t_{CY}	
	16x and 64x Baud Rate	3		t_{CY}	
f_{Rx}	Receiver Input Clock Frequency				
	1x Baud Rate	DC	64	kHz	
	16x Baud Rate	DC	310	kHz	
	64x Baud Rate	DC	615	kHz	
t_{RPW}	Receiver Input Clock Pulse Width				
	1x Baud Rate	12		t_{CY}	
	16x and 64x Baud Rate	1		t_{CY}	
t_{RPD}	Receiver Input Clock Pulse Delay				
	1x Baud Rate	15		t_{CY}	
	16x and 64x Baud Rate	3		t_{CY}	
t_{TxRDY}	TxRDY Pin Delay from Center of last Bit		8	t_{CY}	Note 7
$t_{TxRDY\ CLEAR}$	TxRDY ↓ from Leading Edge of $\overline{\text{WR}}$		6	t_{CY}	Note 7
t_{RxRDY}	RxRDY Pin Delay from Center of last Bit		24	t_{CY}	Note 7
$t_{RxRDY\ CLEAR}$	RxRDY ↓ from Leading Edge of $\overline{\text{RD}}$		6	t_{CY}	Note 7
t_{IS}	Internal SYNDET Delay from Rising Edge of $\overline{\text{RxC}}$		24	t_{CY}	Note 7
t_{ES}	External SYNDET Set-Up Time Before Falling Edge of $\overline{\text{RxC}}$	16		t_{CY}	Note 7
$t_{TxEMPTY}$	TxEMPTY Delay from Center of Last Bit	20		t_{CY}	Note 7
t_{WC}	Control Delay from Rising Edge of WRITE (TxEn, $\overline{\text{DTR}}$, $\overline{\text{RTS}}$)	8		t_{CY}	Note 7
t_{CR}	Control to READ Set-Up Time ($\overline{\text{DSR}}$, $\overline{\text{CTS}}$)	20		t_{CY}	Note 7

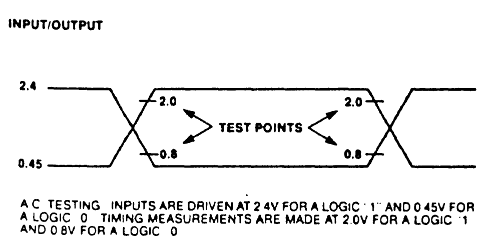
A.C. CHARACTERISTICS (Continued)

NOTES:
1. AC timings measured $V_{OH} = 2.0$, $V_{OL} = 0.8$, and with load circuit of Figure 1.
2. Chip Select (CS) and Command/Data (C/D) are considered as Addresses.
3. Assumes that Address is valid before $R_D\downarrow$.
4. This recovery time is for Mode Initialization only. Write Data is allowed only when TxRDY = 1. Recovery Time between Writes for Asynchronous Mode is 8 t_{CY} and for Synchronous Mode is 16 t_{CY}.
5. The TxC and RxC frequencies have the following limitations with respect to CLK: For 1x Baud Rate, f_{Tx} or $f_{Rx} \leq 1/(30\ t_{CY})$; For 16x and 64x Baud Rate, f_{Tx} or $f_{Rx} \leq 1/(4.5\ t_{CY})$.
6. Reset Pulse Width = 6 t_{CY} minimum; System Clock must be running during Reset.
7. Status update can have a maximum delay of 28 clock periods from the event affecting the status.

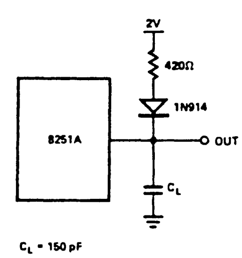
TYPICAL Δ OUTPUT DELAY VS. Δ CAPACITANCE (pF)



A.C. TESTING INPUT, OUTPUT WAVEFORM



A.C. TESTING LOAD CIRCUIT



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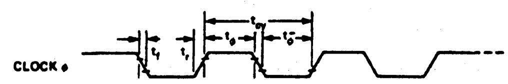
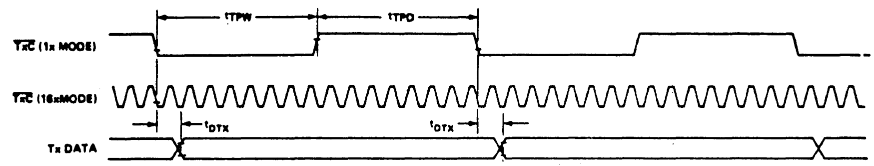
WAVEFORMS

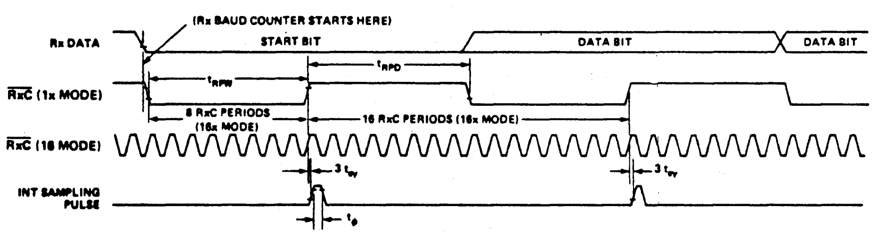
SYSTEM CLOCK INPUT



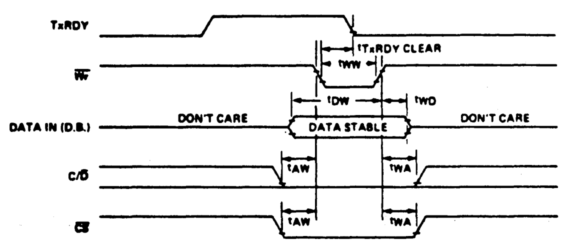
TRANSMITTER CLOCK AND DATA



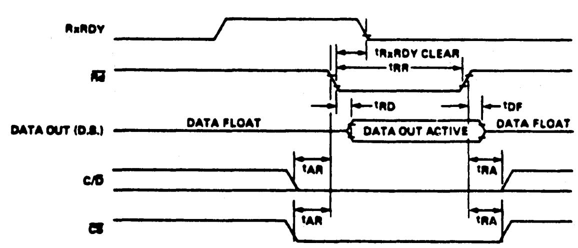
RECEIVER CLOCK AND DATA



WRITE DATA CYCLE (CPU → USART)



READ DATA CYCLE (CPU ← USART)



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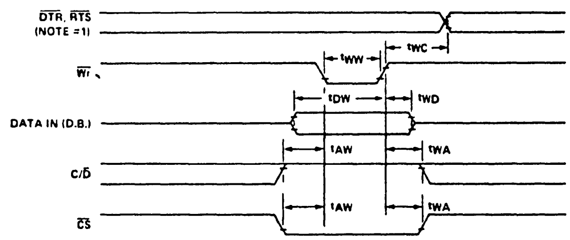
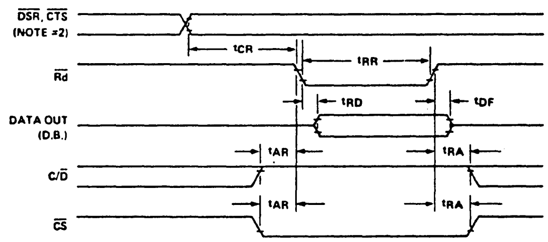
WAVEFORMS (Continued)

WRITE CONTROL OR OUTPUT PORT CYCLE (CPU → USART)

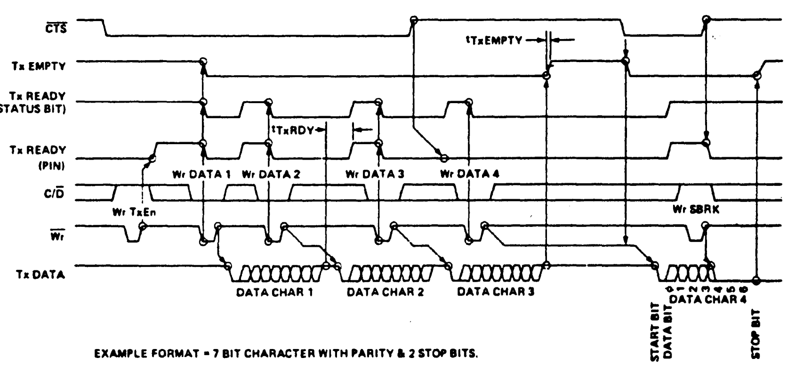


READ CONTROL OR INPUT PORT (CPU ← USART)



NOTE #1: T_{WC} INCLUDES THE RESPONSE TIMING OF A CONTROL BYTE.
NOTE #2: T_{CR} INCLUDES THE EFFECT OF CTS ON THE TxENBL CIRCUITRY.

TRANSMITTER CONTROL AND FLAG TIMING (ASYNC MODE)



EXAMPLE FORMAT = 7 BIT CHARACTER WITH PARITY & 2 STOP BITS.

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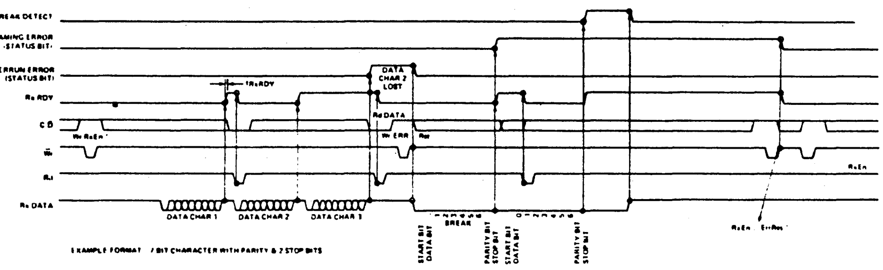
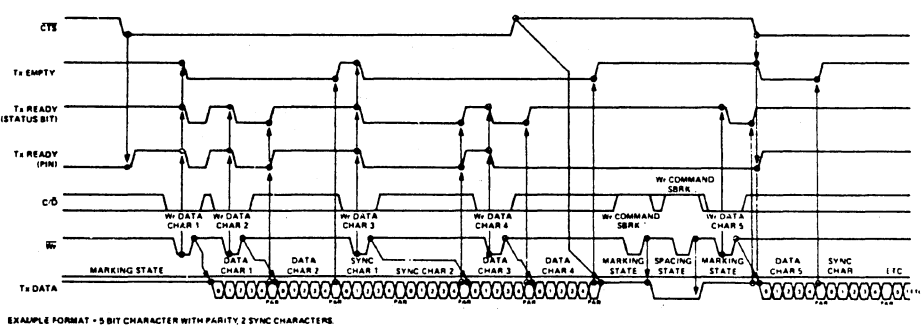
Section 4

WAVEFORMS (Continued)

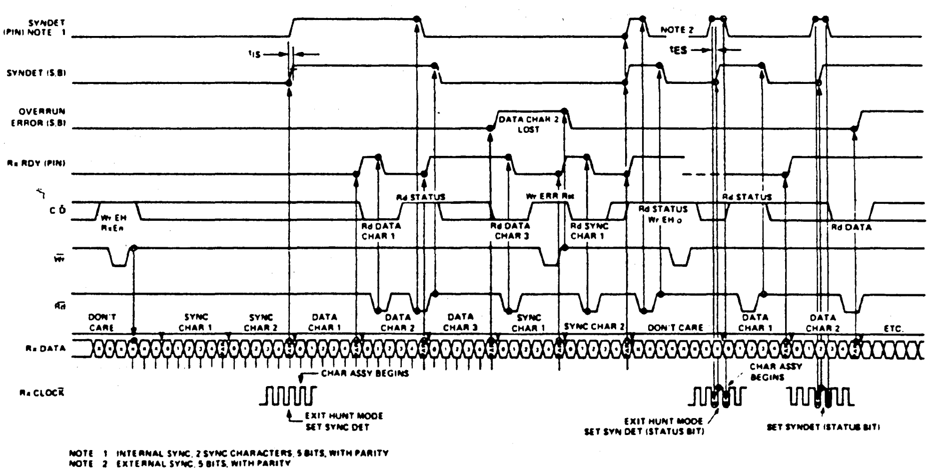
RECEIVER CONTROL AND FLAG TIMING (ASYNC MODE)



TRANSMITTER CONTROL AND FLAG TIMING (SYNC MODE)



RECEIVER CONTROL AND FLAG TIMING (SYNC MODE)



AFN-015738

MASTER RESET FEATURE

A Master Reset of all computer hardware may be accomplished by depressing the solid colored RED keys located on either side of the alphanumeric keyboard.

CURSOR CONTROL KEYS

There are four cursor control keys located on every SuperBrain II. These keys are located on the right-hand side of the numeric keypad. These keys will transmit codes to any program running on the SuperBrain II. These codes may in turn be interpreted by the program to result in cursor movement on the screen. It is important to know that these keys will not produce cursor movement when you are in the operating system mode. The reason for this is that CP/M does not define any use of cursor positioning on the screen. As such, depression of these keys while in the operating system mode will result in the control codes assigned to the individual keys being displayed as control codes on the screen.

ACCESSING TIME/DATE DATA

Accessing the TIME/DATE data is accomplished by reading the appropriate port (31H through 3CH as specified in the Table of I/O Ports in this section). If the real time clock is being updated when the read is attempted, the low order four bits returned will be 1111, indicating a hexadecimal F. The read must be retried if this occurs until a correct value is returned. The subroutine program that follows illustrates one way to do this. It is written in MBASIC.

```
2000 REM SuperBrain II Time of Day Routine
2010 REM
2020 REM This subroutine returns the time-of-day which is currently set in the SuperBrain II TOD
2030 REM clock. The time is returned in the variable T$. It is a string of length 10 where the
2040 REM format is HH:MM:SS:T.
2050 REM
2060 T$ = " "
2070 FOR I = 6 to 0 STEP -1
2080 V = (INP(&H31 + I) AND &HF)
2090 IF V = 15 THEN 2080
2100 T$ = T$ + MID$ (STR$(V),2)
2110 IF I MOD 2 = 1 THEN T$ = T$ + ":"
2120 RETURN
```

INTERFACING INFORMATION

RS232C SERIAL INTERFACE

The following chart illustrates the pinouts for the MAIN and AUXILIARY serial ports and the direction of signal flow.

SUPERBRAIN II SERIAL PORT PIN ASSIGNMENTS

MAIN PORT

PIN #	ASSIGNMENT	DIRECTION
1	GND	–
2	TRANSMITTED DATA	(FROM SB)
3	RECEIVED DATA	(TO SB)
4	REQUEST TO SEND	(FROM SB)
5*	CLEAR TO SEND	(TO SB)
6	DATA SET READY	(TO SB)
7	GND	–
15	TRANSMIT CLOCK	(TO SB)
17	RECEIVE CLOCK	(TO SB)
20	DATA TERMINAL READY	(FROM SB)
22	RING INDICATOR	(TO SB)
24	CLOCK	(FROM SB)

*Pin 5 must be at a high level at the connector in order for successful transmission.

AUXILIARY PORT

PIN #	ASSIGNMENT	DIRECTION
1	GND	--
2	RECEIVED DATA	(TO SB)
3	TRANSMITTED DATA	(FROM SB)
7	GND	--
20	DATA TERMINAL READY	(TO SB)

BUS ADAPTOR INTERFACE

The SuperBrain II contains a Z80 bus interface to the main processor bus. These signals occupy the lower 34 pins of a 50 pin connector and are shown on the following pages.

When using this interface, it is recommended that all signals be buffered so as not to excessively load the main processor bus. The external bus should **ONLY** be utilized for **I/O** devices using addresses 80 to FFH. Memory mapped I/O is **NOT** possible for user applications since the SuperBrain II is internally configured for 64K of RAM.

PIN CONNECTIONS FOR EXTERNAL BUS

PIN NO.	SIGNAL NAME	INPUT OR OUTPUT	DESCRIPTION
1	: OUT*	: OUTPUT	: PERIPHERAL WRITE STROBE OUTPUT
2	: A11	: OUTPUT	: ADDRESS OUTPUT
3	: WR*	: OUTPUT	: MEMORY WRITE STROBE OUTPUT
4	: A14	: OUTPUT	: ADDRESS OUTPUT
5	: RD*	: OUTPUT	: MEMORY READ STROBE OUTPUT
6	: D4	: BOTH	: BIDIRECTIONAL DATA BUS
7	: IN*	: OUTPUT	: PERIPHERAL READ STROBE OUTPUT
8	: D7	: BOTH	: BIDIRECTIONAL DATA BUS

PIN CONNECTIONS FOR EXTERNAL BUS (continued)

PIN NO.	SIGNAL NAME	INPUT OR OUTPUT	DESCRIPTION
9	GND	N/A	SIGNAL GROUND
10	N/A	N/A	N/A
11	A10	OUTPUT	ADDRESS OUTPUT
12	SYSRES	OUTPUT	SYSTEM RESET OUTPUT, LOW DURING POWER UP INITIALIZE OR RESET DEPRESSED
13	A0	OUTPUT	ADDRESS OUTPUT
14	D6	BOTH	BIDIRECTIONAL DATA BUS
15	A12	OUTPUT	ADDRESS OUTPUT
16	A13	OUTPUT	ADDRESS OUTPUT
17	A15	OUTPUT	ADDRESS OUTPUT
18	D3	BOTH	BIDIRECTIONAL DATA BUS
19	D5	BOTH	BIDIRECTIONAL DATA BUS
20	D0	BOTH	BIDIRECTIONAL DATA BUS
21	A8	OUTPUT	ADDRESS OUTPUT
22	A4	OUTPUT	ADDRESS OUTPUT
23	D2	BOTH	BIDIRECTIONAL DATA BUS
24	A1	OUTPUT	ADDRESS OUTPUT
25	A3	OUTPUT	ADDRESS OUTPUT
26	A5	OUTPUT	ADDRESS OUTPUT
27	A9	OUTPUT	ADDRESS OUTPUT
28	A7	OUTPUT	ADDRESS OUTPUT
29	A2	OUTPUT	ADDRESS OUTPUT
30	A6	OUTPUT	ADDRESS OUTPUT
31	D1	BOTH	BIDIRECTIONAL DATA BUS
32	+5V	N/A	POSITIVE 5 VOLTS (LIMITED CURRENT)
33	GND	N/A	SIGNAL GROUND
34	GND	N/A	SIGNAL GROUND
35	GND	N/A	SIGNAL GROUND
36	+12V	N/A	POSITIVE 12 VOLTS (used for RS232 Receiver bias)
37	AUX RX DATA	INPUT	AUXILIARY PORT RECEIVE DATA
38	MAIN TX CLK	INPUT	MAIN PORT TRANSMIT CLOCK
39	MAIN RX CLK	INPUT	MAIN PORT RECEIVE CLOCK
40	MAIN RX DATA	INPUT	MAIN PORT RECEIVE DATA
41	MAIN CTS	INPUT	MAIN PORT CLEAR TO SEND
42	AUX DSR	INPUT	AUXILIARY PORT DATA SET READY
43	MAIN RTS	OUTPUT	MAIN PORT REQUEST TO SEND
44	MAIN DSR	INPUT	MAIN PORT DATA SET READY
45	MAIN CLK	OUTPUT	MAIN PORT CLOCK
46	AUX TX DATA	OUTPUT	AUXILIARY PORT TRANSMIT DATA
47	MAIN RI	INPUT	MAIN PORT RING INDICATOR
48	−12V	N/A	MINUS 12 VOLTS (used for RS232 Receiver bias)
49	MAIN DTR	OUTPUT	MAIN PORT DATA TERMINAL READY
50	MAIN TX DATA	OUTPUT	MAIN PORT DATA TRANSMIT

Section 4

*IMPLIES NEGATIVE (LOGICAL 0) TRUE INPUT OR OUTPUT

TABLE OF I/O PORTS*

DEVICE* NO.	MANUFACTURER	PORT ADDRESS	FUNCTION
KR3600	: STANDARD	: 50H	: KEYBOARD CHARACTER (R/O)
	: MICROSYSTEMS	:	:
	: CORP.	:	:
	:	:	:
BR1941	: WESTERN	: 60H	: BAUD RATE GENERATOR (W/O)
	: DIGITAL	:	:
	:	:	:
8251A	: INTEL	: 40H	: AUXILIARY PORT DATA
	:	: 41H	: AUXILIARY PORT STATUS
	:	: 58H	: MAIN PORT DATA
	:	: 59H	: MAIN PORT STATUS
	:	:	:
8255	: INTEL	: 68H	: 8255 PORT A (W/O)
	:	: 69H	: 8255 PORT B (R/O)
	:	: 6AH	: 8255 PORT C (W/O)
	:	: 6BH	: 8255 CONTROL PORT (W/O)
	:	:	:
MM58174	: NATIONAL	: 31H	: DAY/DATE CLOCK TENTHS DIGIT (R/O)
	: SEMICONDUCTOR	: 32H	: DAY/DATE CLOCK UNITS OF SECONDS (R/O)
	:	: 33H	: DAY/DATE CLOCK TENS OF SECONDS (R/O)
	:	: 34H	: DAY/DATE CLOCK UNITS OF MINUTES (R/W)
	:	: 35H	: DAY/DATE CLOCK TENS OF MINUTES (R/W)
	:	: 36H	: DAY/DATE CLOCK UNITS OF HOURS (R/W)
	:	: 37H	: DAY/DATE CLOCK TENS OF HOURS (R/W)
	:	: 38H	: DAY/DATE CLOCK UNITS OF DAYS (R/W)
	:	: 39H	: DAY/DATE CLOCK TENS OF DAYS (R/W)
	:	: 3AH	: DAY/DATE CLOCK DAY OF THE WEEK (R/W)
	:	: 3BH	: DAY/DATE CLOCK UNITS OF MONTHS (R/W)
	:	: 3CH	: DAY/DATE CLOCK TENS OF MONTHS (R/W)
	:	: 3DH	: DAY/DATE CLOCK LEAP YEAR SETTING (W/O)
	:	: 3EH	: DAY/DATE CLOCK START/STOP PORT (W/O)

*FOR DETAILED DEVICE INFORMATION, CONSULT MANUFACTURER'S DATA SHEETS.

AUTOLOAD FEATURE

Perhaps you wish for your computer to perform the same function upon each operating system restart. This is possible with CP/M version 2.2. The command buffer is the area in computer memory where the next command to be executed is placed. In normal CP/M systems this buffer is empty and, upon operating system restart, the system awaits your command. You may alter this if desired, so that the system will execute any program on the disk upon cold or warm reboot.

In order to implement this autoload feature, you have to change the operating system that is stored on the inner two tracks of your diskette. First, make a copy of the program on your distribution diskette that will generate the operating system. For the SuperBrain II QD, this program is called QDIICPM.COM, for SuperBrain II SD it is called SDIICPM.COM, and for the SuperBrain II Jr, it is called SBIICPM.COM. Using the PIP program, enter the following:

A > **PIP AUTOLOAD.COM = SBIICPM.COM <cr>**

SBIICPM.COM is similar to using the SYSGEN utility, except that no SOURCE DRIVE is specified when using it. After you have made the copy, you will have to alter its command buffer for the autoload capability. The DDT system program will have to be used to do this. It is strongly recommended that you become familiar with the DDT program before attempting to alter the operating system. See the CP/M DYNAMIC DEBUGGING TOOL (DDT) USER'S GUIDE in this manual, for assistance.

Next enter the program 'AUTOLOAD.COM' with the use of DDT. The correct command is:

A > **DDT AUTOLOAD.COM <cr>**

DDT will then load into the computer's memory and read in your 'AUTOLOAD' program. After you have decided on the command you want to be executed upon restart, determine its length. This is done by counting the number of characters in the command. If a file name and/or parameters are included in the command, be sure to include their length(s) in the count. Include any separating spaces. For example, if you wanted the directory display, the command is **DIR**, and its length is 3. If instead you wanted to see a directory display of disk A, the command is **DIR A:** and its length is 6.

The CP/M command buffer begins at location 987H. Use the 'S' command to alter the desired memory locations with your new command. Place the hexadecimal value of the command length in this location. The command itself begins at location 988H, and you may use up to eighty (80) characters from that point for the buffer. Notice that if you go beyond that, you will overwrite the copyright notice in the operating system. At the end of your command, place the null terminator 00H. When inserting the command itself into the memory locations, please note that you must enter hexadecimal numbers for the ASCII values of the letters in the command. When finished, use the DDT command 'D' to display the results of your action. Make any necessary corrections, and then exit to the operating system with CRTL-C. Before you do anything else, you must save the memory contents of the 'AUTOLOAD' program. Using CP/M's 'SAVE' function, enter the following line at the keyboard:

A > **SAVE 48 AUTOLOAD.COM <cr>**

Let's review what we have done so far. First, we made a copy of the operating system, and called it 'AUTOLOAD.COM'. (Incidentally, any other name could have been used as long as the file type is '.COM'). Next, we placed a CP/M command into the CP/M command buffer, starting with the command length in hexadecimal. We ended with a null byte terminator. Then we exited to the operating system and saved the revised program in memory on the disk. Now it is time to generate the new operating system.

Please be sure that the command in the command buffer is what you want your computer to do upon each operating restart, because that is exactly what it will do. Type in the following command at the keyboard:

A > **AUTOLOAD<cr>**

From here the operation will be similar to that of the SYSGEN command. First you will be asked to enter a SOURCE DRIVE. Press the **RETURN** key here; the program itself is carrying the operating system. Next enter the DESTINATION DRIVE. Enter your choice, and press the **RETURN** key when the correct diskette has been inserted in the destination drive. If you are using a new diskette, make certain that it has been formatted with the FORMAT command. When the message FUNCTION COMPLETE is displayed upon the screen, your transfer is done, and you should press the **RETURN** key to reboot the operating system. If you specified Drive A as the destination drive, this reboot will incorporate your new modification. If not, replace the diskette in Drive A with your destination diskette, and press both RED keys simultaneously. You should now have an operating system with an autoload feature. If not, you probably incorrectly entered the command in the command buffer. Repeat the above procedure if this is the case.

WARNING: If you choose drive A as the destination drive and you made an error in altering the command buffer, this diskette will contain an unusable copy of the operating system. You will have to replace its operating system with a valid copy probably using the SYSGEN command. Therefore, it is recommended that you select drive B as your destination drive when altering the command buffer.

Here is a sample session describing the steps needed to alter the command buffer of your operating system. Please carefully read the previous section before attempting to alter this command buffer. Note that all items in bold type are to be typed in by you. Otherwise, the displays are generated by the computer. When you encounter <cr> , press the **RETURN** key.

A > **PIP AUTOLOAD.COM=SBIICPM.COM[V]<cr>**
A > **DDT AUTOLOAD.COM<cr>**
DDT VER 1.4
NEXT PC
3100 0100
–S987<cr>
0987 00 **06<cr>**
0988 20 **44<cr>**
0989 20 **49<cr>**
098A 20 **52<cr>**
098B 20 **20<cr>**
098C 20 **41<cr>**
098D 20 **3A<cr>**
098E 20 **00<cr>**
098F 20 **.<cr>**
-CONTROL-C
A SAVE 48 AUTOLOAD.COM <cr>
A **AUTOLOAD <cr>**
SYSGEN VER 1.X
SOURCE DRIVE NAME (OR RETURN TO SKIP) **<cr>**
DESTINATION DRIVE NAME (OR RETURN TO REBOOT) **B<cr>**
FUNCTION COMPLETE
DESTINATION DRIVE NAME (OR RETURN TO REBOOT) **<cr>**
A>
(Now replace the diskette in drive B into drive A, and depress RED keys.)

KEY CLICK

The key click feature is designed to provide a tone with each key depression. The purpose of the feedback is to allow faster data entry by informing the operator whenever a key is depressed. This feature can be easily selected during terminal operation or can be automatically selected upon system power-up.

To enable the feedback feature, simply type a Control-B (02H). This will 'toggle' the key click feature and turn it on if it is off, or vice versa. The CONFIGUR program will permit you to set the click on or off on system power-up, and hence, relieve you of any further action.

KEY REPEAT

When a key remains depressed for more than 1 second, the key value will repeat at a rate of approximately 30 per second. This will allow faster data entry for applications such as word processing, text editing, and program displays where a 'banner' is required.

TYPE-AHEAD

The input on DOS version 1.X is saved if the operator enters data faster than the computer can accept it. Up to 128 characters are stored when typed, and delivered only when needed. It is now possible to enter commands to an application program as it is being loaded from the disk and not lose any characters. Your input will appear after the program has been loaded, and the program will execute the commands as if you had just entered them. If you type more than 128 characters ahead of the computer system, the bell will ring. This indicates that the buffer is full, and further typing will be ignored by the system.

NOTE: It should be noted that some programs will not work with the type-ahead feature. An example is the DIR command, which displays the directory contents of a diskette. By definition, a directory display is interrupted if a key is depressed during the display. If the DIR command receives a key from the type-ahead feature, it doesn't know if the key was just entered, or if it came from the buffer. In either case, the display is disrupted and a character is lost. Experiment with the system to see which programs will not tolerate type-ahead.

In the event that an error is made, the type ahead buffer can be erased by depressing the **CONTROL** key and the **1** key (on the alphanumeric keyboard only, not the numeric keypad) simultaneously.

CONTROLLING THE VIDEO DISPLAY

The SuperBrain II allows the user a great degree of flexibility in controlling the video display. The user can control where the display is on the screen and the appearance of the displayed information.

Data positioning can be effected either by absolute cursor addressing or memory-mapping. Display appearance is controlled by two factors. First, the SuperBrain II has an optional character set available to the user. Alternating character sets as well as video attributes can be effected on a character by character basis. Second, there are four video attributes. These are:

* Blinking.
* Half-intensity.
* Underlining.
* Reverse Video.

Memory-mapping means that a portion of the memory is devoted to use by the screen display.

The RAM memory location F800H marks the beginning of screen area and this area extends through location FFFFH. This memory area is not available for program or data storage.

The CRT controller performs a direct memory access (DMA) cycle to obtain the screen data, relieving the CPU of most screen related functions. When the CRT controller receives certain inputs, the display is affected.

There are two main types of inputs that are meaningful to the CRT controller: escape sequences and control codes. An escape sequence is noted when the ASCII representation of ESC (27H) is received by the CRT controller and followed by other characters.

A control code is noted when the CTRL key of the keyboard is held down while another key is depressed. The CTRL key functions somewhat like the SHIFT key does.

ESCAPE SEQUENCES

The following is a list of escape sequences that have meaning to the CRT controller.
NOTE: " ~ " is equivalent to ASCII code 7E (Hex) or 126 (decimal).

SEQUENCE	MEANING
ESC Y row column	Absolute cursor addressing. The cursor is positioned to the row and column as shown in the screen layout chart in this section.
ESC ~ K	Erase to end of line. Data is erased from the current cursor position through the end of the current line.
ESC ~ k	Erase to end of screen. Data is erased from the current cursor position through the end of the current screen.
ESC ~ E	Display control characters. The transparent mode of operation is enabled which means that control codes not normally shown on the screen will be displayed.
ESC ~ D	Disable display of control characters.
ESC ~ B	Turns the blinking video attribute on.
ESC ~ b	Turns the blinking video attribute off.
ESC ~ H	Turns the half-intensity attribute on.
ESC ~ h	Turns the half-intensity attribute off.
ESC ~ U	Turns the underlining attribute on.
ESC ~ u	Turns the underlining attribute off.
ESC ~ R	Turns the reverse video attribute on.
ESC ~ r	Turns the reverse video attribute off.
ESC ~ A	Makes the entire screen non-reverse video.
ESC ~ a	Makes the entire screen reverse video.

ESCAPE SEQUENCES (continued)

SEQUENCE	MEANING
ESC ~ N	Normalizes. Turns all attribute indicators (B, H, U, R) off if they are on, beginning with the next character.
ESC ~ g	Displays the entirety of what is on the screen as its corresponding alternate(s) from the secondary character set. This only works if the secondary character EPROM is installed.
ESC ~ G	This reverses the effects of the ESC ~ g escape sequence preceeding.
ESC ~ S	This sequence reverses the primary and secondary assignments of the character sets when an alternate (secondary) character set is installed. If set A is primary and set B is secondary, this sequence will cause B to be primary and A to be secondary.
ESC ~ s	This reverses the effect on the ESC ~ S sequence preceeding.

NOTE: Of the escape sequences discussed, the S, G, a, and A options affect the entire screen including data on the screen entered prior to this sequence.
NOTE: The high order bit of the ASCII character is what controls switching between primary and secondary character sets. A "0" is the high order bit selects primary set. A "1" in the high order bit selects the secondary set.

CONTROL CODES

The following is a list of the control codes that have meaning to the CRT controller.

CODE	MEANING
CTRL-A	Home cursor — The cursor is positioned at row 1, column 1.
CTRL-F	Cursor forward — The cursor is moved one space to the right.
CTRL-G	Ring bell — The audio indicator is activated.
CTRL-H	Cursor back — The cursor is moved one space to the left.
CTRL-K	Cursor up — The cursor is moved up one line.
CTRL-J	Cursor down — The cursor is positioned down one line.
CTRL-I	Tabbing — The cursor is positioned to the next tab (modulo-8) position.
CTRL-L	Clear screen — Erases the data on the screen and the cursor is moved to row 1, column 1, its home position.
CTRL-R	Redisplays current CP/M command line.
CTRL-X	Clears current CP/M command line.
CTRL-@	Page off/on — video display scrolling is enabled or disabled. Valid during operator input only and not subject to user program control.
CTRL-1	Clears type ahead buffer.

VIDEO ATTRIBUTES

Attributes are set by the SuperBrain II when particular escape sequences (see previous list) are received by the Console Out routine of the CP/M BIOS (and subsequently the CRT controller). The escape sequence consists of an ESC(ape), followed by a TILDE, followed by a hexadecimal representation of the attribute desired. The hexadecimal format is 1B 7E NN where NN assumes the following value as desired.

42H - B	61H - a
62H - b	41H - A
48H - H	4EH - N
68H - h	67H - g
55H - U	47H - G
75H - u	53H - S
52H - R	73H - s
72H - r	

The following program written in MBASIC language distributed with your SuperBrain II, shows a technique for attribute manipulation.

```
100  CY = 20
110  CX = 5
120  REM Clear screen and then show some of the SuperBrain II video attributes.
130  REM
140  PRINT CHR$(12)
150  REM first line is normal
160  GOSUB 510
170  PRINT "SuperBrain II Video Attribute Demo"
180  REM
190  REM Now turn on inverse video and reprint line.
200  REM
210  CX = 7:GOSUB 510
220  PRINT CHR$(27); " R";
230  PRINT "SuperBrain II Video Attribute Demo"
240  REM
250  REM Now turn on half intensity and reprint line
260  REM
270  REM
280  CX = 9:GOSUB 510
290  PRINT CHR$(27);" H";
300  PRINT "SuperBrain II Video Attribute Demo"
310  REM
320  REM Turn inverse back off and turn underlining on
330  REM
340  CX = 11:GOSUB 510
350  PRINT CHR$(27); " r"; CHR$(27);" U";
360  PRINT "SuperBrain II Video Attribute Demo"
380  REM
390  REM Turn half intensity off but leave underlining on
420  REM
430  CX = 13:GOSUB 510
450  PRINT CHR$(27);" h";
470  PRINT "SuperBrain II Video Attribute Demo"
471  REM
472  REM Now normalize the video attributes
```

```
473 REM
474 PRINT CHR$(27):" N"
480 PRINT
490 PRINT
500 END
510 Print CHR$(11)
520 PRINT CHR(27);"Y"; CHR$(CX + 31);CHR$ = (CY + 31);
530 RETURN
```

CURSOR POSITIONING FOR DISPLAY CONTROL

Cursor positioning is easily accomplished using the ESC Y row column escape sequence. The proper row, column coordinates can be determined by referencing the SuperBrain II screen layout in this section.

The example program that follows, written in MBASIC, shows one method of accomplishing screen control.

MEMORY MAP/SCREEN INITIALIZATION

This BASIC program fragment will clear the screen and set the "HOME" position to be memory address &HF800. The user can then "POKE" characters into the next 1,920 locations of screen memory.

NOTE: Line number 1110 leaves the cursor at the top of the screen. The cursor can, at this time, be moved where the user wishes with standard escape sequence cursor positioning commands.

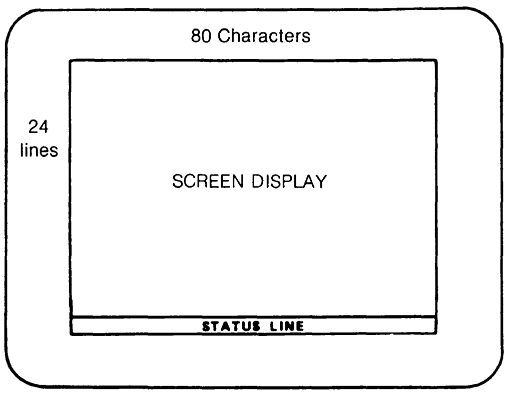
```
1090    PRINT CHR$(12);
1100    FOR I = 1 to 23:PRINT " " :Next I
1110    PRINT " "; CHR$(1);
1120    RETURN
```

The next example program, also written in MBASIC, shows an example of cursor positioning.

```
100     REM Clear the Screen
110     PRINT CHR$(12)
120     REM Position the cursor at row 20 column 30
130     CX = 20
140     CY = 30
150     GOSUB 2000
160     PRINT "* --POSITION 20, 30"
170     REM Position the cursor at row 5 column 20
180     CX = 5
190     CY = 20
200     GOSUB 2000
210     PRINT "* --POSITION 5, 20"
220     REM Home cursor and then end
230     PRINT CHR$(1);
240     END
2000    REM Cursor Positioning Subroutine
2010    REM
2020    REM This subroutine clears the MBASIC line output character counter
2030    REM and then positions the cursor at the locations specified by the
2040    REM variables CX and CY where CX is the line number and CY is the
```

```
2050   REM column number. These variables must be set by the program before
2060   REM entering the subroutine
2070   REM
2080   REM NOTE: Home position on the screen is row 1 column 1
2090   REM
2100   PRINT CHR$(11)
2110   PRINT CHR$(27);"Y";CHR$(CX + 31);CHR$(CY + 31);
2120   RETURN
```

SUPERBRAIN SCREEN LAYOUT



This Screen Format of the SuperBrain display area provides an easy method of locating and addressing specific screen positions.

Using the ESC, Y, r, c command, locate both the row character (r = 1 - 24) and the column (c = 1 - 80) characters. Example:

ROW	COLUMN	COMMAND
1 (Home)	1	ESC Y sp sp
2	5	ESC y ! $
20	50	ESC Y 3 Q

An application programmer may find it helpful to maintain a table of row and column numbers with their respective addressing characters as shown on this Screen Format. This will provide quick and easy access to specific screen positions.

INTERPRETING THE ASCII CODE CHART

The figure below illustrates a conventionally arranged ASCII code chart divided into three sections corresponding to control codes (column 0 to 1) upper case characters (columns 2, 3, 4, and 5), and lower case characters (columns 4 and 5).

$b_7 b_6 b_5$ →					0 0 0	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0	1 1 1
Bits b_4 ↓	b_3 ↓	b_2 ↓	b_1 ↓	column → row ↓	0	1	2	3	4	5	6	7
0	0	0	0	0	NUL	DLE	SP	0	@	P	\	p
0	0	0	1	1	SOH	DC1	!	1	A	Q	a	q
0	0	1	0	2	STX	DC2	"	2	B	R	b	r
0	0	1	1	3	ETX	DC3	#	3	C	S	c	s
0	1	0	0	4	EOT	DC4	$	4	D	T	d	t
0	1	0	1	5	ENQ	NAK	%	5	E	U	e	u
0	1	1	0	6	ACK	SYN	&	6	F	V	f	v
0	1	1	1	7	BEL	ETB	'	7	G	W	g	w
1	0	0	0	8	BS	CAN	(	8	H	X	h	x
1	0	0	1	9	HT	EM	)	9	I	Y	i	y
1	0	1	0	10	LF	SUB	*	:	J	Z	j	z
1	0	1	1	11	VT	ESC	+	;	K	[	k	{
1	1	0	0	12	FF	FS	,	<	L	\	l	¦
1	1	0	1	13	CR	GS	—	=	M	]	m	}
1	1	1	0	14	SO	RS	.	>	N	^	n	~
1	1	1	1	15	SI	US	/	?	O	—	o	DEL

CONTROL CODE CHART

The following is a list of the hexadecimal equivalents of the control codes. The CONFIGUR program accepts only hexadecimal values when reassigning the keypad, so these are listed as a programmer convenience. Use caution when reassigning the values on the keypad, and recall that you may enter 'R' to restore the pad to its original configuration if you desire.

Ctrl-A	01H	Ctrl-J	0AH	Ctrl-S	13H
Ctrl-B	02H	Ctrl-K	0BH	Ctrl-T	14H
Ctrl-C	03H	Ctrl-L	0CH	Ctrl-U	15H
Ctrl-D	04H	Ctrl-M	0DH	Ctrl-V	16H
Ctrl-E	05H	Ctrl-N	0EH	Ctrl-W	17H
Ctrl-F	06H	Ctrl-O	0FH	Ctrl-X	18H
Ctrl-G	07H	Ctrl-P	10H	Ctrl-Y	19H
Ctrl-H	08H	Ctrl-Q	11H	Ctrl-Z	1AH
Ctrl-I	09H	Ctrl-R	12H		

After all corrections have been entered, pressing the 'RETURN' key will save your new parameters on the disk. This must be done at the main menu of selections. Then press both RED keys when instructed to force a 'cold boot' of the Operating System and properly load your new changed parameters.

Control codes are not displayable unless in the transparent mode. Some of these codes affect the state of the terminal when they are received by the display electronics. For example, the code SOH causes the cursor to go to the home position, and code DC2 turns on the printer port. Codes which have no defined function in the SuperBrain II software are ignored if received. The set of 64 upper case alphanumeric characters is sometimes referred to as "compressed ASCII".

CONTROL CODE CHART (continued)

If the terminal is set for upper case operation only (CAPS LOCK), lower case alpha characters from the keyboard are automatically translated and displayed as their upper equivalents (columns 4 and 5). If the DEL code is received, it is ignored. Lower case characters received from the input RS-232C port are displayed as lower case.

The seven bit binary code for each character is divided into two parts in this chart. A four-bit number represents the four least significant bits (B1, B2, B3, B4) and a three-bit number represents the three most significant bits (B5, B6, B7). The chart above also is divided into 8 columns and 16 rows. This offers two ways of indicating a particular character's code. The character code is indicated as either a seven-bit binary number or as a column/row number in decimal notation. For example, the character M is represented by the binary number 1001101 or the alternative 4/13 notation. Similarly, the control code VT is represented by the code 0001011 or the alternative 0/11 notation.

For the SuperBrain II, the high order bit is used to determine switching between the primary and secondary character sets. This eighth (or high order) bit is not shown in this chart but exists and can be manipulated from user programs.

Section 4

WORDSTAR CONSIDERATIONS FOR SUPERBRAIN II

This is to set up a version of WordStar for the SuperBrain II that uses the SuperBrain II in a memory mapped mode. The following variable names are in appendix D of the WordStar manual ("Terminal Patch Area"). The following items need to be set as indicated:

```
0264   UCRPOS   JMP    0304H      ; User cursor positioning
                                  ;      routine for memory map
                                  ;      operation.

02A4   INISUB   JMP    02E0H      ; Jump to the SuperBrain II
                                  ;      initialization routine.

02B0   MEMAPV   DB     0FFH       ; Turn memory map mode on
02B1   MEMADR   DB     0F800H     ; Address of video screen RAM.

02E0   MORPAT   CALL   02E8H      ; Initialize the SuperBrain II
02E3            DEC    A          ;      video memory map.
02E4            CALL   0239H
02E7            RET
02E8            XRA    A
02E9            LXI    H,0E434H
02EC            MVI    B,18H
02EE            MOV    M,A
02EF            INX    H
02F0            DEC    B
02F1            JNZ    02EEH
02F4            LXI    H,0000
02F7            SHLD   0E400H
02FA            SHLD   0E414H
02FD            SHLD   0E416H
0300            SHLD   0E412H
0303            RET
0304            XCHG
0305            JMP    0300H
```

If the user has the reverse video character set EPROM installed in the secondary character set EPROM position, WordStar can also highlight certain items by setting the following value:

```
02B3   HIBIV    DB     0FFH       ; Highlight using the high bit
```

APPENDIX A

INTRODUCTION TO CP/M FEATURES & FACILITIES

DIGITAL RESEARCH

Post Office Box 579, Pacific Grove, California 93950, (408) 649-3896

AN INTRODUCTION TO CP/M FEATURES AND FACILITIES

Append
A

REVISION OF JANUARY 1978

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1. INTRODUCTION.

CP/M is a monitor control program for microcomputer system development which uses IBM-compatible flexible disks for backup storage. Using a computer mainframe based upon Intel's 8080 microcomputer, CP/M provides a general environment for program construction, storage, and editing, along with assembly and program check-out facilities. An important feature of CP/M is that it can be easily altered to execute with any computer configuration which uses an Intel 8080 (or Zilog Z-80) Central Processing Unit, and has at least 16K bytes of main memory with up to four IBM-compatible diskette drives. A detailed discussion of the modifications required for any particular hardware environment is given in the Digital Research document entitled "CP/M System Alteration Guide." Although the standard Digital Research version operates on a single-density Intel MDS 800, several different hardware manufacturers support their own input-output drivers for CP/M.

The CP/M monitor provides rapid access to programs through a comprehensive file management package. The file subsystem supports a named file structure, allowing dynamic allocation of file space as well as sequential and random file access. Using this file system, a large number of distinct programs can be stored in both source and machine executable form.

CP/M also supports a powerful context editor, Intel-compatible assembler, and debugger subsystems. Optional software includes a powerful Intel-compatible macro assembler, symbolic debugger, along with various high-level languages. When coupled with CP/M's Console Command Processor, the resulting facilities equal or excel similar large computer facilities.

CP/M is logically divided into several distinct parts:

BIOS	Basic I/O System (hardware dependent)
BDOS	Basic Disk Operating System
CCP	Console Command Processor
TPA	Transient Program Area

The BIOS provides the primitive operations necessary to access the diskette drives and to interface standard peripherals (teletype, CRT, Paper Tape Reader/Punch, and user-defined peripherals), and can be tailored by the user for any particular hardware environment by "patching" this portion of CP/M. The BDOS provides disk management by controlling one or more disk drives containing independent file directories. The BDOS implements disk allocation strategies which provide fully dynamic file construction while minimizing head movement across the disk during access. Any particular file may contain any number of records, not exceeding the size of any single disk. In a standard CP/M system, each disk can contain up to 64 distinct files. The

BDOS has entry points which include the following primitive operations which can be programmatically accessed:

SEARCH	Look for a particular disk file by name.
OPEN	Open a file for further operations.
CLOSE	Close a file after processing.
RENAME	Change the name of a particular file.
READ	Read a record from a particular file.
WRITE	Write a record onto the disk.
SELECT	Select a particular disk drive for further operations.

The CCP provides symbolic interface between the user´s console and the remainder of the CP/M system. The CCP reads the console device and processes commands which include listing the file directory, printing the contents of files, and controlling the operation of transient programs, such as assemblers, editors, and debuggers. The standard commands which are available in the CCP are listed in a following section.

The last segment of CP/M is the area called the Transient Program Area (TPA). The TPA holds programs which are loaded from the disk under command of the CCP. During program editing, for example, the TPA holds the CP/M text editor machine code and data areas. Similarly, programs created under CP/M can be checked out by loading and executing these programs in the TPA.

It should be mentioned that any or all of the CP/M component subsystems can be "overlayed" by an executing program. That is, once a user´s program is loaded into the TPA, the CCP, BDOS, and BIOS areas can be used as the program´s data area. A "bootstrap" loader is programmatically accessible whenever the BIOS portion is not overlayed; thus, the user program need only branch to the bootstrap loader at the end of execution, and the complete CP/M monitor is reloaded from disk.

It should be reiterated that the CP/M operating system is partitioned into distinct modules, including the BIOS portion which defines the hardware environment in which CP/M is executing. Thus, the standard system can be easily modified to any non-standard environment by changing the peripheral drivers to handle the custom system.

2. FUNCTIONAL DESCRIPTION OF CP/M.

The user interacts with CP/M primarily through the CCP, which reads and interprets commands entered through the console. In general, the CCP addresses one of several disks which are online (the standard system addresses up to four different disk drives). These disk drives are labelled A, B, C, and D. A disk is "logged in" if the CCP is currently addressing the disk. In order to clearly indicate which disk is the currently logged disk, the CCP always prompts the operator with the disk name followed by the symbol ">" indicating that the CCP is ready for another command. Upon initial start up, the CP/M system is brought in from disk A, and the CCP displays the message

xxK CP/M VER m.m

where xx is the memory size (in kilobytes) which this CP/M system manages, and m.m is the CP/M version number. All CP/M systems are initially set to operate in a 16K memory space, but can be easily reconfigured to fit any memory size on the host system (see the MOVCPM transient command). Following system signon, CP/M automatically logs in disk A, prompts the user with the symbol "A>" (indicating that CP/M is currently addressing disk "A"), and waits for a command. The commands are implemented at two levels: built-in commands and transient commands.

Appen A

2.1. GENERAL COMMAND STRUCTURE.

Built-in commands are a part of the CCP program itself, while transient commands are loaded into the TPA from disk and executed. The built-in commands are

ERA	Erase specified files.
DIR	List file names in the directory.
REN	Rename the specified file.
SAVE	Save memory contents in a file.
TYPE	Type the contents of a file on the logged disk.

Nearly all of the commands reference a particular file or group of files. The form of a file reference is specified below.

2.2. FILE REFERENCES.

A file reference identifies a particular file or group of files on a particular disk attached to CP/M. These file references can be either "unambiguous" (ufn) or "ambiguous" (afn). An unambiguous file reference uniquely identifies a single file, while an ambiguous file reference may be satisfied by a number of different files.

File references consist of two parts: the primary name and the secondary name. Although the secondary name is optional, it usually is generic; that is, the secondary name "ASM," for example, is used to denote that the file is an assembly language source file, while the primary name distinguishes each particular source file. The two names are separated by a "." as shown below:

pppppppp.sss

where pppppppp represents the primary name of eight characters or less, and sss is the secondary name of no more than three characters. As mentioned above, the name

pppppppp

is also allowed and is equivalent to a secondary name consisting of three blanks. The characters used in specifying an unambiguous file reference cannot contain any of the special characters

< > . , ; : = ? * [ ]

while all alphanumerics and remaining special characters are allowed.

An ambiguous file reference is used for directory search and pattern matching. The form of an ambiguous file reference is similar to an unambiguous reference, except the symbol "?" may be interspersed throughout the primary and secondary names. In various commands throughout CP/M, the "?" symbol matches any character of a file name in the "?" position. Thus, the ambiguous reference

X?Z.C?M

is satisfied by the unambiguous file names

XYZ.COM

and

X3Z.CAM

Note that the ambiguous reference

.

is equivalent to the ambiguous file reference

????????.???

while

pppppppp.*

and

*.sss

are abbreviations for

pppppppp.???

and

????????.sss

respectively. As an example,

DIR *.*

is interpreted by the CCP as a command to list the names of all disk files in the directory, while

DIR X.Y

searches only for a file by the name X.Y Similarly, the command

DIR X?Y.C?M

causes a search for all (unambiguous) file names on the disk which satisfy this ambiguous reference.

The following file names are valid unambiguous file references:

X	XYZ	GAMMA
X.Y	XYZ.COM	GAMMA.1

As an added convenience, the programmer can generally specify the disk drive name along with the file name. In this case, the drive name is given as a letter A through Z followed by a colon (:). The specified drive is then "logged in" before the file operation occurs. Thus, the following are valid file names with disk name prefixes:

A:X.Y	B:XYZ	C:GAMMA
Z:XYZ.COM	B:X.A?M	C:*.ASM

It should also be noted that all alphabetic lower case letters in file and drive names are always translated to upper case when they are processed by the CCP.

3. SWITCHING DISKS.

The operator can switch the currently logged disk by typing the disk drive name (A, B, C, or D) followed by a colon (:) when the CCP is waiting for console input. Thus, the sequence of prompts and commands shown below might occur after the CP/M system is loaded from disk A:

```
16K CP/M VER 1.4

A>DIR                   List all files on disk A.

SAMPLE   ASM

SAMPLE   PRN

A>B:                    Switch to disk B.

B>DIR *.ASM             List all "ASM" files on B.

DUMP     ASM

FILES    ASM

B>A:                    Switch back to A.
```

4. THE FORM OF BUILT-IN COMMANDS.

The file and device reference forms described above can now be used to fully specify the structure of the built-in commands. In the description below, assume the following abbreviations:

ufn	-	unambiguous file reference
afn	-	ambiguous file reference
cr	-	carriage return

Further, recall that the CCP always translates lower case characters to upper case characters internally. Thus, lower case alphabetics are treated as if they are upper case in command names and file references.

4.1 ERA afn cr

The ERA (erase) command removes files from the currently logged-in disk (i.e., the disk name currently prompted by CP/M preceding the ">"). The files which are erased are those which satisfy the ambiguous file reference afn. The following examples illustrate the use of ERA:

ERA X.Y	The file named X.Y on the currently logged disk is removed from the disk directory, and the space is returned.
ERA X.*	All files with primary name X are removed from the current disk.
ERA *.ASM	All files with secondary name ASM are removed from the current disk.
ERA X?Y.C?M	All files on the current disk which satisfy the ambiguous reference X?Y.C?M are deleted.
ERA *.*	Erase all files on the current disk (in this case the CCP prompts the console with the message "ALL FILES (Y/N)?" which requires a Y response before files are actually removed).
ERA B:*.PRN	All files on drive B which satisfy the ambiguous reference ????????.PRN are deleted, independently of the currently logged disk.

Appen A

4.2. DIR afn cr

The DIR (directory) command causes the names of all files which satisfy the ambiguous file name afn to be listed at the console device. As a special case, the command

DIR

lists the files on the currently logged disk (the command "DIR" is equivalent to the command "DIR *.*"). Valid DIR commands are shown below.

DIR X.Y

DIR X?Z.C?M

DIR ??.Y

Similar to other CCP commands, the afn can be preceded by a drive name. The following DIR commands cause the selected drive to be addressed before the directory search takes place.

DIR B:

DIR B:X.Y

DIR B:*.A?M

If no files can be found on the selected diskette which satisfy the directory request, then the message "NOT FOUND" is typed at the console.

4.3. REN ufn1=ufn2 cr

The REN (rename) command allows the user to change the names of files on disk. The file satisfying ufn2 is changed to ufn1. The currently logged disk is assumed to contain the file to rename (ufn1). The CCP also allows the user to type a left-directed arrow instead of the equal sign, if the user's console supports this graphic character. Examples of the REN command are

REN X.Y=Q.R	The file Q.R is changed to X.Y.
REN XYZ.COM=XYZ.XXX	The file XYZ.XXX is changed to XYZ.COM.

The operator can precede either ufn1 or ufn2 (or both) by an optional drive address. Given that ufn1 is preceded by a drive name, then ufn2 is assumed to exist on the same drive as ufn1. Similarly, if ufn2 is preceded by a drive name, then ufn1 is assumed to reside on that drive as well. If both ufn1 and ufn2 are preceded by drive names, then the same drive must be specified in both cases. The following REN commands illustrate this format.

REN A:X.ASM = Y.ASM	The file Y.ASM is changed to X.ASM on drive A.
REN B:ZAP.BAS=ZOT.BAS	The file ZOT.BAS is changed to ZAP.BAS on drive B.
REN B:A.ASM = B:A.BAK	The file A.BAK is renamed to A.ASM on drive B.

If the file ufn1 is already present, the REN command will respond with the error "FILE EXISTS" and not perform the change. If ufn2 does not exist on the specified diskette, then the message "NOT FOUND" is printed at the console.

4.4. SAVE n ufn cr

The SAVE command places n pages (256-byte blocks) onto disk from the TPA and names this file ufn. In the CP/M distribution system, the TPA starts at 100H (hexadecimal), which is the second page of memory. Thus, if the user's program occupies the area from 100H through 2FFH, the SAVE command must specify 2 pages of memory. The machine code file can be subsequently loaded and executed. Examples are:

SAVE 3 X.COM	Copies 100H through 3FFH to X.COM.
SAVE 40 Q	Copies 100H through 28FFH to Q (note that 28 is the page count in 28FFH, and that 28H = 2*16+8 = 40 decimal).
SAVE 4 X.Y	Copies 100H through 4FFH to X.Y.

The SAVE command can also specify a disk drive in the afn portion of the command, as shown below.

SAVE 10 B:ZOT.COM	Copies 10 pages (100H through 0AFFH) to the file ZOT.COM on drive B.

4.5. TYPE ufn cr

The TYPE command displays the contents of the ASCII source file ufn on the currently logged disk at the console device. Valid TYPE commands are

TYPE X.Y

TYPE X.PLM

TYPE XXX

The TYPE command expands tabs (clt-I characters), assumming tab positions are set at every eighth column. The ufn can also reference a drive name as shown below.

TYPE B:X.PRN   The file X.PRN from drive B is displayed.

5. LINE EDITING AND OUTPUT CONTROL.

The CCP allows certain line editing functions while typing command lines.

rubout	Delete and echo the last character typed at the console.
ctl-U	Delete the entire line typed at the console.
ctl-X	(Same as ctl-U)
ctl-R	Retype current command line: types a "clean line" following character deletion with rubouts.
ctl-E	Physical end of line: carriage is returned, but line is not sent until the carriage return key is depressed.
ctl-C	CP/M system reboot (warm start)
ctl-Z	End input from the console (used in PIP and ED).

The control functions ctl-P and ctl-S affect console output as shown below.

ctl-P	Copy all subsequent console output to the currently assigned list device (see the STAT command). Output is sent to both the list device and the console device until the next ctl-P is typed.
ctl-S	Stop the console output temporarily. Program execution and output continue when the next character is typed at the console (e.g., another ctl-S). This feature is used to stop output on high speed consoles, such as CRT´s, in order to view a segment of output before continuing.

Note that the ctl-key sequences shown above are obtained by depressing the control and letter keys simultaneously. Further, CCP command lines can generally be up to 255 characters in length; they are not acted upon until the carriage return key is typed.

6. TRANSIENT COMMANDS.

Transient commands are loaded from the currently logged disk and executed in the TPA. The transient commands defined for execution under the CCP are shown below. Additional functions can easily be defined by the user (see the LOAD command definition).

STAT	List the number of bytes of storage remaining on the currently logged disk, provide statistical information about particular files, and display or alter device assignment.
ASM	Load the CP/M assembler and assemble the specified program from disk.
LOAD	Load the file in Intel "hex" machine code format and produce a file in machine executable form which can be loaded into the TPA (this loaded program becomes a new command under the CCP).
DDT	Load the CP/M debugger into TPA and start execution.
PIP	Load the Peripheral Interchange Program for subsequent disk file and peripheral transfer operations.
ED	Load and execute the CP/M text editor program.
SYSGEN	Create a new CP/M system diskette.
SUBMIT	Submit a file of commands for batch processing.
DUMP	Dump the contents of a file in hex.
MOVCPM	Regenerate the CP/M system for a particular memory size.

Transient commands are specified in the same manner as built-in commands, and additional commands can be easily defined by the user. As an added convenience, the transient command can be preceded by a drive name, which causes the transient to be loaded from the specified drive into the TPA for execution. Thus, the command

```
B:STAT
```

causes CP/M to temporarily "log in" drive B for the source of the STAT transient, and then return to the original logged disk for subsequent processing.

The basic transient commands are listed in detail below.

6.1. STAT cr

The STAT command provides general statistical information about file storage and device assignment. It is initiated by typing one of the following forms:

```
STAT cr
STAT "command line" cr
```

Special forms of the "command line" allow the current device assignment to be examined and altered as well. The various command lines which can be specified are shown below, with an explanation of each form shown to the right.

STAT cr — If the user types an empty command line, the STAT transient calculates the storage remaining on all active drives, and prints a message

```
x: R/W, SPACE: nnnK
```

or

```
x: R/O, SPACE: nnnK
```

for each active drive x, where R/W indicates the drive may be read or written, and R/O indicates the drive is read only (a drive becomes R/O by explicitly setting it to read only, as shown below, or by inadvertantly changing diskettes without performing a warm start). The space remaining on the diskette in drive x is given in kilobytes by nnn.

STAT x: cr — If a drive name is given, then the drive is selected before the storage is computed. Thus, the command "STAT B:" could be issued while logged into drive A, resulting in the message

```
BYTES REMAINING ON B: nnnK
```

STAT afn cr — The command line can also specify a set of files to be scanned by STAT. The files which satisfy afn are listed in alphabetical order, with storage requirements for each file under the heading

```
RECS BYTS EX D:FILENAME.TYP
rrrr bbbK ee d:pppppppp.sss
```

where rrrr is the number of 128-byte records

Appendix A

allocated to the file, bbb is the number of kilobytes allocated to the file (bbb=rrrr*128/1024), ee is the number of 16K extensions (ee=bbb/16), d is the drive name containing the file (A...Z), pppppppp is the (up to) eight-character primary file name, and sss is the (up to) three-character secondary name. After listing the individual files, the storage usage is summarized.

STAT x:afn cr — As a convenience, the drive name can be given ahead of the afn. In this case, the specified drive is first selected, and the form "STAT afn" is executed.

STAT x:=R/O cr — This form sets the drive given by x to read-only, which remains in effect until the next warm or cold start takes place. When a disk is read-only, the message

BDOS ERR ON x: READ ONLY

will appear if there is an attempt to write to the read-only disk x. CP/M waits until a key is depressed before performing an automatic warm start (at which time the disk becomes R/W).

The STAT command also allows control over the physical to logical device assignment (see the IOBYTE function described in the manuals "CP/M Interface Guide" and "CP/M System Alteration Guide"). In general, there are four logical peripheral devices which are, at any particular instant, each assigned to one of several physical peripheral devices. The four logical devices are named:

CON:	The system console device (used by CCP for communication with the operator)
RDR:	The paper tape reader device
PUN:	The paper tape punch device
LST:	The output list device

The actual devices attached to any particular computer system are driven by subroutines in the BIOS portion of CP/M. Thus, the logical RDR: device, for example, could actually be a high speed reader, Teletype reader, or cassette tape. In order to allow some flexibility in device naming and assignment, several physical devices are defined, as shown below:

TTY:	Teletype device (slow speed console)
CRT:	Cathode ray tube device (high speed console)
BAT:	Batch processing (console is current RDR:, output goes to current LST: device)
UC1:	User-defined console
PTR:	Paper tape reader (high speed reader)
UR1:	User-defined reader #1
UR2:	User-defined reader #2
PTP:	Paper tape punch (high speed punch)
UP1:	User-defined punch #1
UP2:	User-defined punch #2
LPT:	Line printer
UL1:	User-defined list device #1

It must be emphasized that the physical device names may or may not actually correspond to devices which the names imply. That is, the PTP: device may be implemented as a cassette write operation, if the user wishes. The exact correspondence and driving subroutine is defined in the BIOS portion of CP/M. In the standard distribution version of CP/M, these devices correspond to their names on the MDS 800 development system.

The possible logical to physical device assignments can be displayed by typing

STAT VAL: cr

The STAT prints the possible values which can be taken on for each logical device:

```
CON. = TTY:  CRT:  BAT:  UC1:
RDR: = TTY:  PTR:  UR1:  UR2:
PUN: = TTY:  PTP:  UP1:  UP2:
LST: = TTY:  CRT:  LPT:  UL1:
```

In each case, the logical device shown to the left can take any of the four physical assignments shown to the right on each line. The current logical to physical mapping is displayed by typing the command

STAT DEV: cr

which produces a listing of each logical device to the left, and the current corresponding physical device to the right. For example, the list might appear as follows:

```
CON: = CRT:
RDR: = UR1:
PUN: = PTP:
LST: = TTY:
```

The current logical to physical device assignment can be changed by typing a STAT command of the form

```
STAT ld1 = pd1, ld2 = pd2 , ... , ldn = pdn cr
```

where ld1 through ldn are logical device names, and pd1 through pdn are compatible physical device names (i.e., ldi and pdi appear on the same line in the "VAL:" command shown above). The following are valid STAT commands which change the current logical to physical device assignments:

```
STAT CON:=CRT: cr
STAT PUN: = TTY:,LST:=LPT:, RDR:=TTY: cr
```

6.2. ASM ufn cr

The ASM command loads and executes the CP/M 8080 assembler. The ufn specifies a source file containing assembly language statements where the secondary name is assumed to be ASM, and thus is not specified. The following ASM commands are valid:

```
ASM X

ASM GAMMA
```

The two-pass assembler is automatically executed. If assembly errors occur during the second pass, the errors are printed at the console.

The assembler produces a file

```
x.PRN
```

where x is the primary name specified in the ASM command. The PRN file contains a listing of the source program (with imbedded tab characters if present in the source program), along with the machine code generated for each statement and diagnostic error messages, if any. The PRN file can be listed at the console using the TYPE command, or sent to a peripheral device using PIP (see the PIP command structure below). Note also that the PRN file contains the original source program, augmented by miscellaneous assembly information in the leftmost 16 columns (program addresses and hexadecimal machine code, for example). Thus, the PRN file can serve as a backup for the original source file: if the source file is accidently removed or destroyed, the PRN file can be edited (see the ED operator's guide) by removing the leftmost 16 characters of each line (this can be done by issuing a single editor "macro" command). The resulting file is identical to the original source file and can be renamed (REN) from PRN to ASM for subsequent editing and assembly. The file

x.HEX

is also produced which contains 8080 machine language in Intel "hex" format suitable for subsequent loading and execution (see the LOAD command). For complete details of CP/M's assembly language program, see the "CP/M Assembler Language (ASM) User's Guide."

Similar to other transient commands, the source file for assembly can be taken from an alternate disk by prefixing the assembly language file name by a disk drive name. Thus, the command

ASM B:ALPHA cr

loads the assembler from the currently logged drive and operates upon the source program ALPHA.ASM on drive B. The HEX and PRN files are also placed on drive B in this case.

Appendix A

6.3. LOAD ufn cr

The LOAD command reads the file ufn, which is assumed to contain "hex" format machine code, and produces a memory image file which can be subsequently executed. The file name ufn is assumed to be of the form

x.HEX

and thus only the name x need be specified in the command. The LOAD command creates a file named

x.COM

which marks it as containing machine executable code. The file is actually loaded into memory and executed when the user types the file name x immediately after the prompting character ">" printed by the CCP.

In general, the CCP reads the name x following the prompting character and looks for a built-in function name. If no function name is found, the CCP searches the system disk directory for a file by the name x.COM

If found, the machine code is loaded into the TPA, and the program executes. Thus, the user need only LOAD a hex file once; it can be subsequently executed any number of times by simply typing the primary name. In this way, the user can "invent" new commands in the CCP. (Initialized disks contain the transient commands as COM files, which can be deleted at the user's option.) The operation can take place on an alternate drive if the file name is prefixed by a drive name. Thus,

LOAD B:BETA

brings the LOAD program into the TPA from the currently logged disk and operates upon drive B after execution begins.

It must be noted that the BETA.HEX file must contain valid Intel format hexadecimal machine code records (as produced by the ASM program, for example) which begin at 100H, the beginning of the TPA. Further, the addresses in the hex records must be in ascending order; gaps in unfilled memory regions are filled with zeroes by the LOAD command as the hex records are read. Thus, LOAD must be used only for creating CP/M standard "COM" files which operate in the TPA. Programs which occupy regions of memory other than the TPA can be loaded under DDT.

6.4. PIP cr

PIP is the CP/M Peripheral Interchange Program which implements the basic media conversion operations necessary to load, print, punch, copy, and combine disk files. The PIP program is initiated by typing one of the following forms

(1) PIP cr
(2) PIP "command line" cr

In both cases, PIP is loaded into the TPA and executed. In case (1), PIP reads command lines directly from the console, prompted with the "*" character, until an empty command line is typed (i.e., a single carriage return is issued by the operator). Each successive command line causes some media conversion to take place according to the rules shown below. Form (2) of the PIP command is equivalent to the first, except that the single command line given with the PIP command is automatically executed, and PIP terminates immediately with no further prompting of the console for input command lines. The form of each command line is

destination = source#1, source#2, ... , source#n cr

where "destination" is the file or peripheral device to receive the data, and "source#1, ..., source#n" represents a series of one or more files or devices which are copied from left to right to the destination.

When multiple files are given in the command line (i.e, n > 1), the individual files are assumed to contain ASCII characters, with an assumed CP/M end-of-file character (ctl-Z) at the end of each file (see the O parameter to override this assumption). The equal symbol (=) can be replaced by a left-oriented arrow, if your console supports this ASCII character, to improve readability. Lower case ASCII alphabetics are internally translated to upper case to be consistent with CP/M file and device name conventions. Finally, the total command line length cannot exceed 255 characters (ctl-E can be used to force a physical carriage return for lines which exceed the console width).

The destination and source elements can be unambiguous references to CP/M source files, with or without a preceding disk drive name. That is, any file can be referenced with a preceding drive name (A:, B:, C:, or D:) which defines the particular drive where the file may be obtained or stored. When the drive name is not included, the currently logged disk is assumed. Further, the destination file can also appear as one or more of the source files, in which case the source file is not altered until the entire concatenation is complete. If the destination file already exists, it is removed if the command line is properly formed (it is not removed if an error condition arises). The following command lines (with explanations to the right) are valid as input to PIP:

X = Y cr	Copy to file X from file Y, where X and Y are unambiguous file names; Y remains unchanged.
X = Y,Z cr	Concatenate files Y and Z and copy to file X, with Y and Z unchanged.
X.ASM=Y.ASM,Z.ASM,FIN.ASM cr	Create the file X.ASM from the concatenation of the Y, Z, and FIN files with type ASM.
NEW.ZOT = B:OLD.ZAP cr	Move a copy of OLD.ZAP from drive B to the currently logged disk; name the file NEW.ZOT.
B:A.U = B:B.V,A:C.W,D.X cr	Concatenate file B.V from drive B with C.W from drive A and D.X. from the logged disk; create the file A.U on drive B.

For more convenient use, PIP allows abbreviated commands for transferring files between disk drives. The abbreviated forms are

Appendi
A

PIP x:=afn cr

PIP x:=y:afn cr

PIP ufn = y: cr

PIP x:ufn = y: cr

The first form copies all files from the currently logged disk which satisfy the afn to the same file names on drive x (x = A...Z). The second form is equivalent to the first, where the source for the copy is drive y (y = A... Z). The third form is equivalent to the command "PIP ufn=y:ufn cr" which copies the file given by ufn from drive y to the file ufn on drive x. The fourth form is equivalent to the third, where the source disk is explicitly given by y.

Note that the source and destination disks must be different in all of these cases. If an afn is specified, PIP lists each ufn which satisfies the afn as it is being copied. If a file exists by the same name as the destination file, it is removed upon successful completion of the copy, and replaced by the copied file.

The following PIP commands give examples of valid disk-to-disk copy operations:

B:=*.COM cr	Copy all files which have the secondary name "COM" to drive B from the current drive.
A:=B:ZAP.* cr	Copy all files which have the primary name "ZAP" to drive A from drive B.
ZAP.ASM=B: cr	Equivalent to ZAP.ASM=B:ZAP.ASM
B:ZOT.COM=A: cr	Equivalent to B:ZOT.COM=A:ZOT.COM
B:=GAMMA.BAS cr	Same as B:GAMMA.BAS=GAMMA.BAS
B:=A:GAMMA.BAS cr	Same as B:GAMMA.BAS=A:GAMMA.BAS

PIP also allows reference to physical and logical devices which are attached to the CP/M system. The device names are the same as given under the STAT command, along with a number of specially named devices. The logical devices given in the STAT command are

CON: (console), RDR: (reader), PUN: (punch), and LST: (list)

while the physical devices are

TTY: (console, reader, punch, or list)
CRT: (console, or list), UC1: (console)
PTR: (reader), UR1: (reader), UR2: (reader)
PTP: (punch), UP1: (punch), UP2: (punch)
LPT: (list), UL1: (list)

(Note that the "BAT:" physical device is not included, since this assignment is used only to indicate that the RDR: and LST: devices are to be used for console input/output.)

The RDR, LST, PUN, and CON devices are all defined within the BIOS portion of CP/M, and thus are easily altered for any particular I/O system. (The current physical device mapping is defined by IOBYTE; see the "CP/M Interface Guide" for a discussion of this function). The destination device must be capable of receiving data (i.e., data cannot be sent to the punch), and the source devices must be capable of generating data (i.e., the LST: device cannot be read).

The additional device names which can be used in PIP commands are

NUL: Send 40 "nulls" (ASCII 0's) to the device (this can be issued at the end of punched output).

EOF: Send a CP/M end-of-file (ASCII ctl-Z) to the destination device (sent automatically at the end of all ASCII data transfers through PIP).

INP: Special PIP input source which can be "patched" into the PIP program itself: PIP gets the input data character-by-character by CALLing location 103H, with data returned in location 109H (parity bit must be zero).

OUT: Special PIP output destination which can be patched into the PIP program: PIP CALLs location 106H with data in register C for each character to transmit. Note that locations 109H through 1FFH of the PIP memory image are not used and can be replaced by special purpose drivers using DDT (see the DDT operator's manual).

PRN: Same as LST:, except that tabs are expanded at every eighth character position, lines are numbered, and page ejects are inserted every 60 lines, with an initial eject (same as [t8np]).

File and device names can be interspersed in the PIP commands. In each case, the specific device is read until end-of-file (ctl-Z for ASCII files, and a real end of file for non-ASCII disk files). Data from each device or file is concatenated from left to right until the last data source has been read. The destination device or file is written using the data from the source files, and an end-of-file character (ctl-Z) is appended to the result for ASCII files. Note if the destination is a disk file, then a temporary file is created ($$$ secondary name) which is changed to the actual file name only upon successful completion of the copy. Files with the extension "COM" are always assumed to be non-ASCII.

The copy operation can be aborted at any time by depressing any key on the keyboard (a rubout suffices). PIP will respond with the message "ABORTED" to indicate that the operation was not completed. Note that if any operation is aborted, or if an error occurs during processing, PIP removes any pending commands which were set up while using the SUBMIT command.

It should also be noted that PIP performs a special function if the destination is a disk file with type "HEX" (an Intel hex formatted machine code file), and the source is an external peripheral device, such as a paper tape reader. In this case, the PIP program checks to ensure that the source file contains a properly formed hex file, with legal hexadecimal values and checksum records. When an invalid input record is found, PIP reports an error message at the console and waits for corrective action. It is usually sufficient to open the reader and rerun a section of the tape (pull the tape back about 20 inches). When the tape is ready for the re-read, type a single carriage return at the console, and PIP will attempt another read. If the tape position cannot be properly read, simply continue the read (by typing a return following the error message), and enter the record manually with the ED program after the disk file is constructed. For convenience, PIP allows the end-of-file to be entered from the console if the source file is a RDR: device. In this case, the PIP program reads the device and monitors the keyboard. If ctl-Z is typed at the keyboard, then the read operation is terminated normally.

Valid PIP commands are shown below.

PIP LST: = X.PRN cr	Copy X.PRN to the LST device and terminate the PIP program.
PIP cr	Start PIP for a sequence of commands (PIP prompts with "*").
*CON:=X.ASM,Y.ASM,Z.ASM cr	Concatenate three ASM files and copy to the CON device.
*X.HEX=CON:,Y.HEX,PTR: cr	Create a HEX file by reading the CON (until a ctl-Z is typed), followed by data from Y.HEX, followed by data from PTR until a ctl-Z is encountered.
*cr	Single carriage return stops PIP.

PIP PUN:=NUL:,X.ASM,EOF:,NUL: cr — Send 40 nulls to the punch device; then copy the X.ASM file to the punch, followed by an end-of-file (ctl-Z) and 40 more null characters.

The user can also specify one or more PIP parameters, enclosed in left and right square brackets, separated by zero or more blanks. Each parameter affects the copy operation, and the enclosed list of parameters must immediately follow the affected file or device. Generally, each parameter can be followed by an optional decimal integer value (the S and Q parameters are exceptions). The valid PIP parameters are listed below.

B — Block mode transfer: data is buffered by PIP until an ASCII x-off character (ctl-S) is received from the source device. This allows transfer of data to a disk file from a continuous reading device, such as a cassette reader. Upon receipt of the x-off, PIP clears the disk buffers and returns for more input data. The amount of data which can be buffered is dependent upon the memory size of the host system (PIP will issue an error message if the buffers overflow).

Dn — Delete characters which extend past column n in the transfer of data to the destination from the character source. This parameter is used most often to truncate long lines which are sent to a (narrow) printer or console device.

E — Echo all transfer operations to the console as they are being performed.

F — Filter form feeds from the file. All imbedded form feeds are removed. The P parameter can be used simultaneously to insert new form feeds.

H — Hex data transfer: all data is checked for proper Intel hex file format. Non-essential characters between hex records are removed during the copy operation. The console will be prompted for corrective action in case errors occur.

I — Ignore ":00" records in the transfer of Intel hex format file (the I parameter automatically sets the H parameter).

L — Translate upper case alphabetics to lower case.

N — Add line numbers to each line transferred to the destination starting at one, and incrementing by 1. Leading zeroes are suppressed, and the number is followed by a colon. If N2 is specified, then leading zeroes are included, and a tab is inserted following the number. The tab is expanded if T is set.

O	Object file (non-ASCII) transfer: the normal CP/M end of file is ignored.

Pn	Include page ejects at every n lines (with an initial page eject). If n = 1 or is excluded altogether, page ejects occur every 60 lines. If the F parameter is used, form feed suppression takes place before the new page ejects are inserted.

Qs↑z	Quit copying from the source device or file when the string s (terminated by ctl-Z) is encountered.

Ss↑z	Start copying from the source device when the string s is encountered (terminated by ctl-Z). The S and Q parameters can be used to "abstract" a particular section of a file (such as a subroutine). The start and quit strings are always included in the copy operation.

NOTE - the strings following the s and q parameters are translated to upper case by the CCP if form (2) of the PIP command is used. Form (1) of the PIP invocation, however, does not perform the automatic upper case translation.

(1) PIP cr
(2) PIP "command line" cr

Tn	Expand tabs (ctl-I characters) to every nth column during the transfer of characters to the destination from the source.

U	Translate lower case alphabetics to upper case during the the copy operation.

V	Verify that data has been copied correctly by rereading after the write operation (the destination must be a disk file).

Z	Zero the parity bit on input for each ASCII character.

The following are valid PIP commands which specify parameters in the file transfer:

PIP X.ASM=B:[v] cr	Copy X.ASM from drive B to the current drive and verify that the data was properly copied.

PIP LPT:=X.ASM[nt8u] cr	Copy X.ASM to the LPT: device; number each line, expand tabs to every eighth column, and translate lower case alphabetics to upper case.

PIP PUN:=X.HEX[i],Y.ZOT[h] cr   First copy X.HEX to the PUN: device and ignore the trailing ":00" record in X.HEX; then continue the transfer of data by reading Y.ZOT, which contains hex records, including any ":00" records which it contains.

PIP X.LIB = Y.ASM [sSUBR1:↑z qJMP L3↑z] cr   Copy from the file Y.ASM into the file X.LIB. Start the copy when the string "SUBR1:" has been found, and quit copying after the string "JMP L3" is encountered.

PIP PRN:=X.ASM[p50]   Send X.ASM to the LST: device, with line numbers, tabs expanded to every eighth column, and page ejects at every 50th line. Note that nt8p60 is the assumed parameter list for a PRN file; p50 overrides the default value.

6.5. ED ufn cr

The ED program is the CP/M system context editor, which allows creation and alteration of ASCII files in the CP/M environment. Complete details of operation are given the ED user's manual, "ED: a Context Editor for the CP/M Disk System." In general, ED allows the operator to create and operate upon source files which are organized as a sequence of ASCII characters, separated by end-of-line characters (a carriage-return line-feed sequence). There is no practical restriction on line length (no single line can exceed the size of the working memory), which is instead defined by the number of characters typed between cr's. The ED program has a number of commands for character string searching, replacement, and insertion, which are useful in the creation and correction of programs or text files under CP/M. Although the CP/M has a limited memory work space area (approximately 5000 characters in a 16K CP/M system), the file size which can be edited is not limited, since data is easily "paged" through this work area.

Upon initiation, ED creates the specified source file, if it does not exist, and opens the file for access. The programmer then "appends" data from the source file into the work area, if the source file already exists (see the A command), for editing. The appended data can then be displayed, altered, and written from the work area back to the disk (see the W command). Particular points in the program can be automatically paged and located by context (see the N command), allowing easy access to particular portions of a large file.

Given that the operator has typed

ED X.ASM cr

the ED program creates an intermediate work file with the name

X.$$$

to hold the edited data during the ED run. Upon completion of ED, the X.ASM file (original file) is renamed to X.BAK, and the edited work file is renamed to X.ASM. Thus, the X.BAK file contains the original (unedited) file, and the X.ASM file contains the newly edited file. The operator can always return to the previous version of a file by removing the most recent version, and renaming the previous version. Suppose, for example, that the current X.ASM file was improperly edited; the sequence of CCP command shown below would reclaim the backup file.

DIR X.*	Check to see that BAK file is available.
ERA X.ASM	Erase most recent version.
REN X.ASM=X.BAK	Rename the BAK file to ASM.

Note that the operator can abort the edit at any point (reboot, power failure, ctl-C, or Q command) without destroying the original file. In this case, the BAK file is not created, and the original file is always intact.

The ED program also allows the user to "ping-pong" the source and create backup files between two disks. The form of the ED command in this case is

ED ufn d:

where ufn is the name of a file to edit on the currently logged disk, and d is the name of an alternate drive. The ED program reads and processes the source file, and writes the new file to drive d, using the name ufn. Upon completion of processing, the original file becomes the backup file. Thus, if the operator is addressing disk A, the following command is valid:

ED X.ASM B:

which edits the file X.ASM on drive A, creating the new file X.$$$ on drive B. Upon completion of a successful edit, A:X.ASM is renamed to A:X.BAK, and B:X.$$$ is renamed to B:X.ASM. For user convenience, the currently logged disk becomes drive B at the end of the edit. Note that if a file by the name B:X.ASM exists before the editing begins, the message

FILE EXISTS

is printed at the console as a precaution against accidently destroying a source file. In this case, the operator must first ERAse the existing file and then restart the edit operation.

Similar to other transient commands, editing can take place on a drive different from the currently logged disk by preceding the source file name by a drive name. Examples of valid edit requests are shown below

ED A:X.ASM	Edit the file X.ASM on drive A, with new file and backup on drive A.
ED B:X.ASM A:	Edit the file X.ASM on drive B to the temporary file X.$$$ on drive A. On termination of editing, change X.ASM on drive B to X.BAK, and change X.$$$ on drive A to X.ASM.

6.6. SYSGEN cr

The SYSGEN transient command allows generation of an initialized diskette containing the CP/M operating system. The SYSGEN program prompts the console for commands, with interaction as shown below.

SYSGEN cr	Initiate the SYSGEN program.
SYSGEN VERSION m.m	SYSGEN sign-on message.
SOURCE DRIVE NAME (OR RETURN TO SKIP)	Respond with the drive name (one of the letters A, B, C, or D) of the disk containing a CP/M system; usually A. If a copy of CP/M already exists in memory, due to a MOVCPM command, type a cr only. Typing a drive name x will cause the response:
SOURCE ON x THEN TYPE RETURN	Place a diskette containing the CP/M operating system on drive x (x is one of A, B, C, or D). Answer with cr when ready.
FUNCTION COMPLETE	System is copied to memory. SYSGEN will then prompt with:
DESTINATION DRIVE NAME (OR RETURN TO REBOOT)	If a diskette is being initialized, place the new disk into a drive and answer with the drive name. Otherwise, type a cr and the system will reboot from drive A. Typing drive name x will cause SYSGEN to prompt

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	with:
DESTINATION ON x THEN TYPE RETURN	Place new diskette into drive x; type return when ready.
FUNCTION COMPLETE	New diskette is initialized in drive x.

The "DESTINATION" prompt will be repeated until a single carriage return is typed at the console, so that more than one disk can be initialized.

Upon completion of a successful system generation, the new diskette contains the operating system, and only the built-in commands are available. A factory-fresh IBM-compatible diskette appears to CP/M as a diskette with an empty directory; therefore, the operator must copy the appropriate COM files from an existing CP/M diskette to the newly constructed diskette using the PIP transient.

The user can copy all files from an existing diskette by typing the PIP command

PIP B: = A: *.*[v] cr

which copies all files from disk drive A to disk drive B, and verifies that each file has been copied correctly. The name of each file is displayed at the console as the copy operation proceeds.

It should be noted that a SYSGEN does not destroy the files which already exist on a diskette; it results only in construction of a new operating system. Further, if a diskette is being used only on drives B through D, and will never be the source of a bootstrap operation on drive A, the SYSGEN need not take place. In fact, a new diskette needs absolutely no initialization to be used with CP/M.

6.7. SUBMIT ufn parm#1 ... parm#n cr

The SUBMIT command allows CP/M commands to be batched together for automatic processing. The ufn given in the SUBMIT command must be the filename of a file which exists on the currently logged disk, with an assumed file type of "SUB." The SUB file contains CP/M prototype commands, with possible parameter substitution. The actual parameters parm#1 ... parm#n are substituted into the prototype commands, and, if no errors occur, the file of substituted commands are processed sequentially by CP/M.

The prototype command file is created using the ED program, with interspersed "$" parameters of the form

$1 $2 $3 ... $n

corresponding to the number of actual parameters which will be included when the file is submitted for execution. When the SUBMIT transient is executed, the actual parameters parm#1 ... parm#n are paired with the formal parameters $1 ... $n in the prototype commands. If the number of formal and actual parameters does not correspond, then the submit function is aborted with an error message at the console. The SUBMIT function creates a file of substituted commands with the name

$$$.SUB

on the logged disk. When the system reboots (at the termination of the SUBMIT), this command file is read by the CCP as a source of input, rather than the console. If the SUBMIT function is performed on any disk other than drive A, the commands are not processed until the disk is inserted into drive A and the system reboots. Further, the user can abort command processing at any time by typing a rubout when the command is read and echoed. In this case, the $$$.SUB file is removed, and the subsequent commands come from the console. Command processing is also aborted if the CCP detects an error in any of the commands. Programs which execute under CP/M can abort processing of command files when error conditions occur by simply erasing any existing $$$.SUB file.

In order to introduce dollar signs into a SUBMIT file, the user may type a "$$" which reduces to a single "$" within the command file. Further, an up-arrow symbol "↑" may precede an alphabetic character x, which produces a single ctl-x character within the file.

The last command in a SUB file can initiate another SUB file, thus allowing chained batch commands.

Suppose the file ASMBL.SUB exists on disk and contains the prototype commands

```
ASM $1
DIR $1.*
ERA *.BAK
PIP $2:=$1.PRN
ERA $1.PRN
```

and the command

```
SUBMIT ASMBL X PRN cr
```

is issued by the operator. The SUBMIT program reads the ASMBL.SUB file, substituting "X" for all occurrences of $1 and "PRN" for all occurrences of $2, resulting in a $$$.SUB file containing the commands

```
ASM X
DIR X.*
ERA *.BAK
PIP PRN:=X.PRN
ERA X.PRN
```

which are executed in sequence by the CCP.

The SUBMIT function can access a SUB file which is on an alternate drive by preceding the file name by a drive name. Submitted files are only acted upon, however, when they appear on drive A. Thus, it is possible to create a submitted file on drive B which is executed at a later time when it is inserted in drive A.

6.8. DUMP ufn cr

The DUMP program types the contents of the disk file (ufn) at the console in hexadecimal form. The file contents are listed sixteen bytes at a time, with the absolute byte address listed to the left of each line in hexadecimal. Long typeouts can be aborted by pushing the rubout key during printout. (The source listing of the DUMP program is given in the "CP/M Interface Guide" as an example of a program written for the CP/M environment.)

6.9. MOVCPM cr

The MOVCPM program allows the user to reconfigure the CP/M system for any particular memory size. Two optional parameters may be used to indicate (1) the desired size of the new system and (2) the disposition of the new system at program termination. If the first parameter is omitted or a "*" is given, the MOVCPM program will reconfigure the system to its maximum size, based upon the kilobytes of contiguous RAM in the host system (starting aat 0000H). If the second parameter is omitted, the system is executed, but not permanently recorded; if "*" is given, the system is left in memory, ready for a SYSGEN operation. The MOVCPM program relocates a memory image of CP/M and places this image in memory in preparation for a system generation operation. The command forms are:

MOVCPM cr	Relocate and execute CP/M for management of the current memory configuration (memory is examined for contiguous RAM, starting at 100H). Upon completion of the relocation, the new system is executed but not permanently recorded on the diskette. The system which is constructed contains a BIOS for the Intel MDS 800.

MOVCPM n cr	Create a relocated CP/M system for management of an n kilobyte system (n must be in the range 16 to 64), and execute the system, as described above.
MOVCPM * * cr	Construct a relocated memory image for the current memory configuration, but leave the memory image in memory, in preparation for a SYSGEN operation.
MOVCPM n * cr	Construct a relocated memory image for an n kilobyte memory system, and leave the memory image in preparation for a SYSGEN operation.

The command

    MOVCPM * *

for example, constructs a new version of the CP/M system and leaves it in memory, ready for a SYSGEN operation. The message

    READY FOR "SYSGEN" OR
    "SAVE 32 CPMxx.COM"

is printed at the console upon completion, where xx is the current memory size in kilobytes. The operator can then type

SYSGEN cr — Start the system generation.

SOURCE DRIVE NAME (OR RETURN TO SKIP) — Respond with a cr to skip the CP/M read operation since the system is already in memory as a result of the previous MOVCPM operation.

DESTINATION DRIVE NAME (OR RETURN TØ REBOOT)
Respond with B to write new system to the diskette in drive B. SYSGEN will prompt with:

DESTINATION ON B, THEN TYPE RETURN
Ready the fresh diskette on drive B and type a return when ready.

Note that if you respond with "A" rather than "B" above, the system will be written to drive A rather than B. SYSGEN will continue to type the prompt:

    DESTINATION DRIVE NAME (OR RETURN TO REBOOT)

until the operator responds with a single carriage return, which stops the

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SYSGEN program with a system reboot.

The user can then go through the reboot process with the old or new diskette. Instead of performing the SYSGEN operation, the user could have typed

    SAVE 32 CPMxx.COM

at the completion of the MOVCPM function, which would place the CP/M memory image on the currently logged disk in a form which can be "patched." This is necessary when operating in a non-standard environment where the BIOS must be altered for a particular peripheral device configuration, as described in the"CP/M System Alteration Guide."

Valid MOVCPM commands are given below:

MOVCPM 48 cr	Construct a 48K verskon of CP/M and start execution.
MOVCPM 48 * cr	Construct a 48K version of CP/M in preparation for permanent recording; response is READY FOR "SYSGEN" OR "SAVE 32CPM48.COM"
MOVCPM * * cr	Construct a maximum memory version of CP/M and start execution.

It is important to note that the newly created system is serialized with the number attached to the original diskette and is subject to the conditions of the Digital Research Software Licensing Agreement.

7. BDOS ERROR MESSAGES.

There are three error situations which the Basic Disk Operating System intercepts during file processsing. When one of these conditions is detected, the BDOS prints the message:

BDOS ERR ON x: error

where x is the drive name, and "error" is one of the three error messages:

BAD SECTOR
SELECT
READ ONLY

The "BAD SECTOR" message indicates that the disk controller electronics has detected an error condition in reading or writing the diskette. This condition is generally due to a malfunctioning disk controller, or an extremely worn diskette. If you find that your system reports this error more than once a month, you should check the state of your controller electronics, and the condition of your media. You may also encounter this condition in reading files generated by a controller produced by a different manufacturer. Even though controllers are claimed to be IBM-compatible, one often finds small differences in recording formats. The MDS-800 controller, for example, requires two bytes of one's following the data CRC byte, which is not required in the IBM format. As a result, diskettes generated by the Intel MDS can be read by almost all other IBM-compatible systems, while disk files generated on other manufacturer's equipment will produce the "BAD SECTOR" message when read by the MDS. In any case, recovery from this condition is accomplished by typing a ctl-C to reboot (this is the safest!), or a return, which simply ignores the bad sector in the file operation. Note, however, that typing a return may destroy your diskette integrity if the operation is a directory write, so make sure you have adequate backups in this case.

The "SELECT" error occurs when there is an attempt to address a drive beyond the A through D range. In this case, the value of x in the error message gives the selected drive. The system reboots following any input from the console.

The "READ ONLY" message occurs when there is an attempt to write to a diskette which has been designated as read-only in a STAT command, or has been set to read-only by the BDOS. In general, the operator should reboot CP/M either by using the warm start procedure (ctl-C) or by performing a cold start whenever the diskettes are changed. If a changed diskette is to be read but not written, BDOS allows the diskette to be changed without the warm or cold start, but internally marks the drive as read-only. The status of the drive is subsequently changed to read/write if a warm or cold start occurs. Upon issuing this message, CP/M waits for input from the console. An automatic warm start takes place following any input.

8. OPERATION OF CP/M ON THE MDS.

This section gives operating procedures for using CP/M on the Intel MDS microcomputer development system. A basic knowledge of the MDS hardware and software systems is assumed.

CP/M is initiated in essentially the same manner as Intel's ISIS operating system. The disk drives are labelled Ø through 3 on the MDS, corresponding to CP/M drives A through D, respectively. The CP/M system diskette is inserted into drive Ø, and the BOOT and RESET switches are depressed in sequence. The interrupt 2 light should go on at this point. The space bar is then depressed on the device which is to be taken as the system console, and the light should go out (if it does not, then check connections and baud rates). The BOOT switch is then turned off, and the CP/M signon message should appear at the selected console device, followed by the "A>" system prompt. The user can then issue the various resident and transient commands

The CP/M system can be restarted (warm start) at any time by pushing the INT Ø switch on the front panel. The built-in Intel ROM monitor can be initiated by pushing the INT 7 switch (which generates a RST 7), except when operating under DDT, in which case the DDT program gets control instead.

Diskettes can be removed from the drives at any time, and the system can be shut down during operation without affecting data integrity. Note, however, that the user must not remove a diskette and replace it with another without rebooting the system (cold or warm start), unless the inserted diskette is "read only."

Due to hardware hang-ups or malfunctions, CP/M may type the message

```
BDOS ERR ON x: BAD SECTOR
```

where x is the drive which has a permanent error. This error may occur when drive doors are opened and closed randomly, followed by disk operations, or may be due to a diskette, drive, or controller failure. The user can optionally elect to ignore the error by typing a single return at the console. The error may produce a bad data record, requiring re-initialization of up to 128 bytes of data. The operator can reboot the CP/M system and try the operation again.

Termination of a CP/M session requires no special action, except that it is necessary to remove the diskettes before turning the power off, to avoid random transients which often make their way to the drive electronics.

It should be noted that factory-fresh IBM-compatible diskettes should be used rather than diskettes which have previously been used with any ISIS version. In particular, the ISIS "FORMAT" operation produces non-standard sector numbering throughout the diskette. This non-standard numbering seriously degrades the performance of CP/M, and will operate noticeably slower than the distribution version. If it becomes necessary to reformat a diskette (which should not be the case for standard diskettes), a program can be written under CP/M which causes the MDS 800 controller to reformat with sequential sector numbering (1-26) on each track.

Note: "MDS 800" and "ISIS" are registered trademarks of Intel Corporation.

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A

APPENDIX B

OPERATION OF THE CP/M CONTEXT EDITOR

DIGITAL RESEARCH

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ED: A CONTEXT EDITOR FOR THE CP/M DISK SYSTEM

USER'S MANUAL

Appendix B

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ED USER'S MANUAL

1. ED TUTORIAL

1.1. Introduction to ED.

ED is the context editor for CP/M, and is used to create and alter CP/M source files. ED is initiated in CP/M by typing

ED { <filename> }
ED { <filename>.<filetype> }

In general, ED reads segments of the source file given by <filename> or <filename> . <filetype> into central memory, where the file is manipulated by the operator, and subsequently written back to disk after alterations. If the source file does not exist before editing, it is created by ED and initialized to empty. The overall operation of ED is shown in Figure 1.

1.2. ED Operation

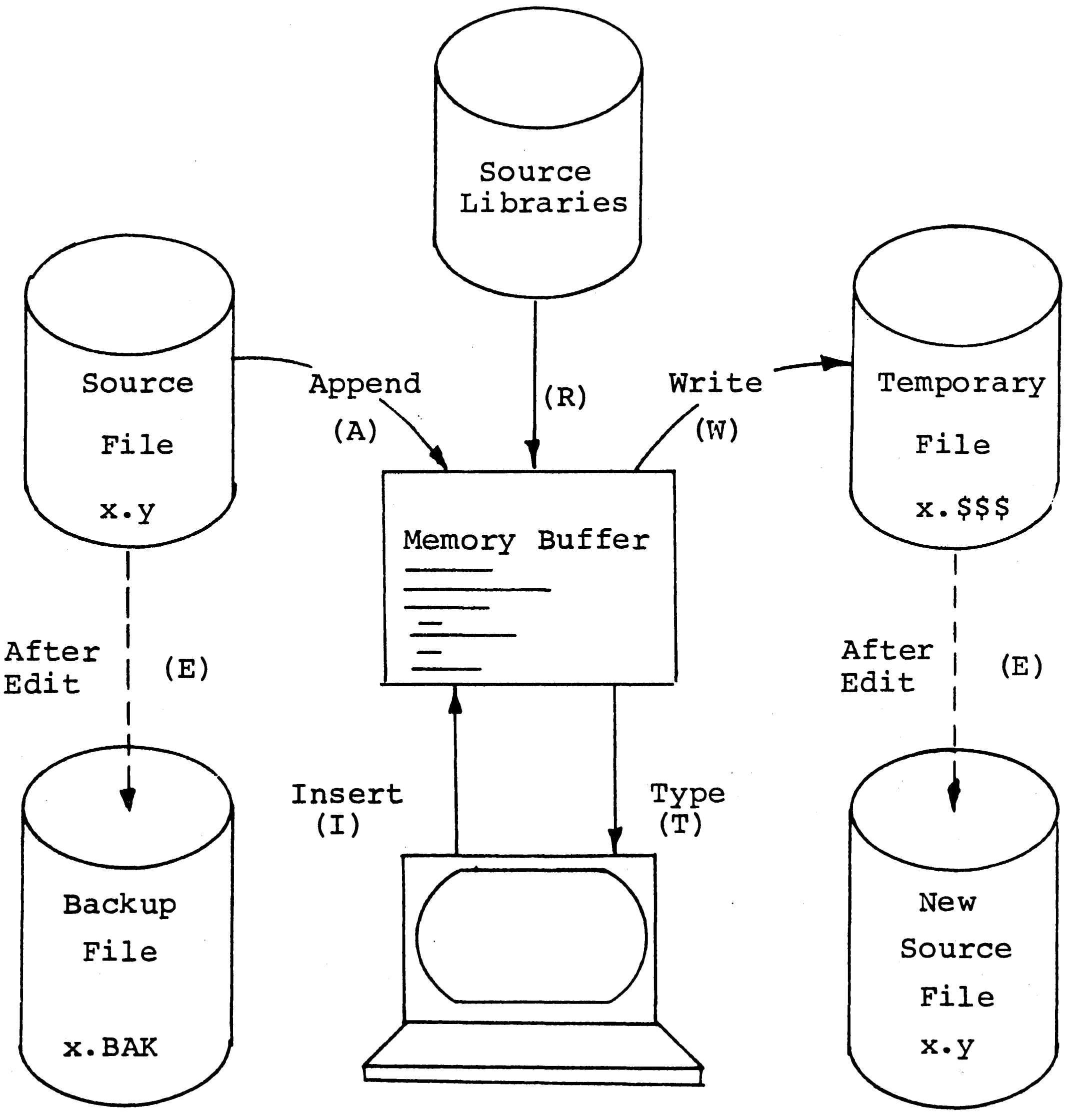
ED operates upon the source file, denoted in Figure 1 by x.y, and passes all text through a memory buffer where the text can be viewed or altered (the number of lines which can be maintained in the memory buffer varies with the line length, but has a total capacity of about 6000 characters in a 16K CP/M system). Text material which has been edited is written onto a temporary work file under command of the operator. Upon termination of the edit, the memory buffer is written to the temporary file, followed by any remaining (unread) text in the source file. The name of the original file is changed from x.y to x.BAK so that the most recent previously edited source file can be reclaimed if necessary (see the CP/M commands ERASE and RENAME). The temporary file is then changed from x.$$$ to x.y which becomes the resulting edited file.

The memory buffer is logically between the source file and working file as shown in Figure 2.

1.3. Text Transfer Functions

Given that n is an integer value in the range 0 through 65535, the following ED commands transfer lines of text from the source file through the memory buffer to the temporary (and eventually final) file:

Figure 1. Overall ED Operation



Note: the ED program accepts both lower and upper case ASCII characters as input from the console. Single letter commands can be typed in either case. The U command can be issued to cause ED to translate lower case alphabetics to upper case as characters are filled to the memory buffer from the console. Characters are echoed as typed without translation, however. The -U command causes ED to revert to "no translation" mode. ED starts with an assumed -U in effect.

Figure 2. Memory Buffer Organization

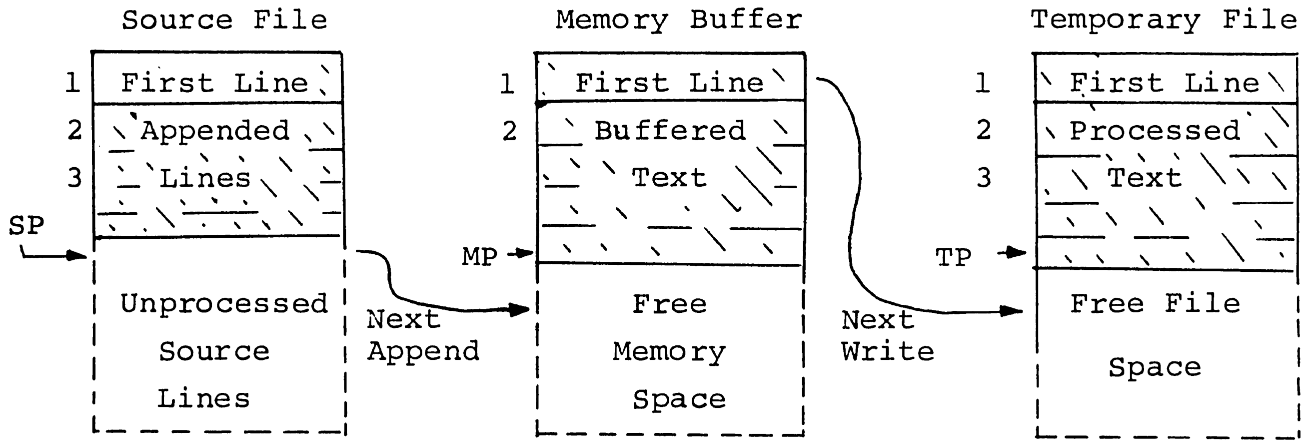
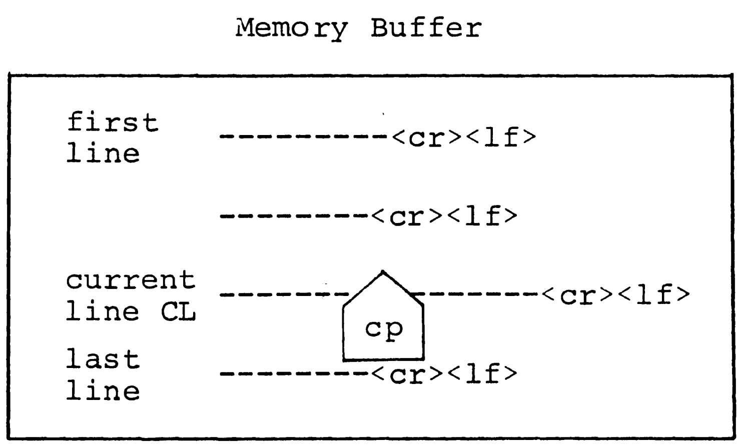


Figure 3. Logical Organization of Memory Buffer



nA<cr>* - append the next n unprocessed source lines from the source file at SP to the end of the memory buffer at MP. Increment SP and MP by n.

nW<cr> - write the first n lines of the memory buffer to the temporary file free space. Shift the remaining lines n+1 through MP to the top of the memory buffer. Increment TP by n.

E<cr> - end the edit. Copy all buffered text to temporary file, and copy all unprocessed source lines to the temporary file. Rename files as described previously.

H<cr> - move to head of new file by performing automatic E command. Temporary file becomes the new source file, the memory buffer is emptied, and a new temporary file is created (equivalent to issuing an E command, followed by a reinvocation of ED using x.y as the file to edit).

O<cr> - return to original file. The memory buffer is emptied, the temporary file id deleted, and the SP is returned to position 1 of the source file. The effects of the previous editing commands are thus nullified.

Q<cr> - quit edit with <u>no</u> file alterations, return to CP/M.

There are a number of special cases to consider. If the integer n is omitted in any ED command where an integer is allowed, then 1 is assumed. Thus, the commands A and W append one line and write 1 line, respectively. In addition, if a pound sign (#) is given in the place of n, then the integer 65535 is assumed (the largest value for n which is allowed). Since most reasonably sized source files can be contained entirely in the memory buffer, the command #A is often issued at the beginning of the edit to read the entire source file to memory. Similarly, the command #W writes the entire buffer to the temporary file. Two special forms of the A and W

---

*<cr> represents the carriage-return key

commands are provided as a convenience. The command 0A fills the current memory buffer to at least half-full, while 0W writes lines until the buffer is at least half empty. It should also be noted that an error is issued if the memory buffer size is exceded. The operator may then enter any command (such as W) which does not increase memory requirements. The remainder of any partial line read during the overflow will be brought into memory on the next successful append.

1.4. Memory Buffer Organization

The memory buffer can be considered a sequence of source lines brought in with the A command from a source file. The memory buffer has an associated (imaginary) character pointer CP which moves throughout the memory buffer under command of the operator. The memory buffer appears logically as shown in Figure 3 where the dashes represent characters of the source line of indefinite length, terminated by carriage-return (<cr>) and line-feed (<lf>) characters, and cp represents the imaginary character pointer. Note that the CP is always located ahead of the first character of the first line, behind the last character of the last line, or between two characters. The current line CL is the source line which contains the CP.

1.5. Memory Buffer Operation

Upon initiation of ED, the memory buffer is empty (ie, CP is both ahead and behind the first and last character). The operator may either append lines (A command) from the source file, or enter the lines directly from the console with the insert command

```
I<cr>
```

ED then accepts any number of input lines, where each line terminates with a <cr> (the <lf> is supplied automatically), until a control-z (denoted by ↑z is typed by the operator. The CP is positioned after the last character entered. The sequence

```
I<cr>
NOW IS THE<cr>
TIME FOR<cr>
ALL GOOD MEN<cr>
↑z
```

leaves the memory buffer as shown below

Apper
B

```
NOW IS THE<cr><lf>
TIME FOR<cr><lf>
ALL GOOD MEN<cr><lf>
                  cp
```

Various commands can then be issued which manipulate the CP or display source text in the vicinity of the CP. The commands shown below with a preceding n indicate that an optional unsigned value can be specified. When preceded by ±, the command can be unsigned, or have an optional preceding plus or minus sign. As before, the pound sign (#) is replaced by 65535. If an integer n is optional, but not supplied, then n=1 is assumed. Finally, if a plus sign is optional, but none is specified, then + is assumed.

±B<cr> - move CP to beginning of memory buffer if +, and to bottom if -.

±nC<cr> - move CP by ±n characters (toward front of buffer if +), counting <cr><lf> as two distinct characters

±nD<cr> - delete n characters ahead of CP if plus and behind CP if minus.

±nK<cr> - kill (ie remove) ±n lines of source text using CP as the current reference. If CP is not at the beginning of the current line when K is issued, then the characters <u>before</u> CP remain if + is specified, while the characters <u>after</u> CP remain if - is given in the command.

±nL<cr> - if n=0 then move CP to the beginning of the current line (if it is not already there) if n≠0 then first move the CP to the beginning of the current line, and then move it to the beginning of the line which is n lines down (if +) or up (if -). The CP will stop at the top or bottom of the memory buffer if too large a value of n is specified.

±nT<cr> - If n=0 then type the contents of the current line up to CP. If n=1 then type the contents of the current line from CP to the end of the line. If n>1 then type the current line along with n-1 lines which follow, if + is specified. Similarly, if n>1 and - is given, type the previous n lines, up to the CP. The break key can be depressed to abort long type-outs.

±n<cr> - equivalent to ±nLT, which moves up or down and types a single line

1.6. Command Strings

Any number of commands can be typed contiguously (up to the capacity of the CP/M console buffer), and are executed only after the <cr> is typed. Thus, the operator may use the CP/M console command functions to manipulate the input command:

Rubout	remove the last character
Control-U	delete the entire line
Control-C	re-initialize the CP/M System
Control-E	return carriage for long lines without transmitting buffer (max 128 chars)

Suppose the memory buffer contains the characters shown in the previous section, with the CP following the last character of the buffer. The command strings shown below produce the results shown to the right

Command String	Effect	Resulting Memory Buffer
1. B2T<cr>	move to beginning of buffer and type 2 lines: "NOW IS THE TIME FOR"	cp NOW IS THE<cr><lf> TIME FOR<cr><lf> ALL GOOD MEN<cr><lf>
2. 5C0T<cr>	move CP 5 characters and type the beginning of the line "NOW I"	NOW I cp S THE<cr><lf>

3.	2L-T<cr>	move two lines down and type previous line "TIME FOR"	NOW IS THE<cr><lf> TIME FOR<cr><lf> ALL GOOD MEN<cr><lf>
4.	-L#K<cr>	move up one line, delte 65535 lines which follow	NOW IS THE<cr><lf>
5.	I<cr> TIME TO<cr> INSERT<cr> ↑z	insert two lines of text	NOW IS THE<cr><lf> TIME TO<cr><lf> INSERT<cr><lf>
6.	-2L#T<cr>	move up two lines, and type 65535 lines ahead of CP "NOW IS THE"	NOW IS THE<cr><lf> TIME TO<cr><lf> INSERT<cr><lf>
7.	<cr>	move down one line and type one line "INSERT"	NOW IS THE<cr><lf> TIME TO<cr><lf> INSERT<cr><lf>

1.7. Text Search and Alteration

ED also has a command which locates strings within the memory buffer. The command takes the form

$$nF\ c_1 c_2 \ldots c_k \begin{Bmatrix} \langle cr \rangle \\ \uparrow z \end{Bmatrix}$$

where c_1 through c_k represent the characters to match followed by either a <cr> or control -z*. ED starts at the current position of CP and attempts to match all k characters. The match is attempted n times, and if successful, the CP is moved directly after the character c_k. If the n matches are not successful, the CP is not moved from its initial position. Search strings can include ↑l (control-l), which is replaced by the pair of symbols <cr><lf>.

*The control-z is used if additional commands will be typed following the ↑z.

The following commands illustrate the use of the F command:

Command String	Effect	Resulting Memory Buffer
1. B#T<cr>	move to beginning and type entire buffer	cp NOW IS THE<cr><lf> TIME FOR<cr><lf> ALL GOOD MEN<cr><lf>
2. FS T<cr>	find the end of the string "S T"	NOW IS T cp HE<cr><lf>
3. FI↑z0TT	find the next "I" and type to the CP then type the remainder of the current line: "TIME FOR"	NOW IS THE<cr><lf> TI cp ME FOR<cr><lf> ALL GOOD MEN<cr><lf>

An abbreviated form of the insert command is also allowed, which is often used in conjunction with the F command to make simple textual changes. The form is:

I $c_1 c_2 \ldots c_n$↑z   or

I $c_1 c_2 \ldots c_n$<cr>

where c_1 through c_n are characters to insert. If the insertion string is terminated by a ↑z, the characters c_1 through c_n are inserted directly following the CP, and the CP is moved directly after character c_n. The action is the same if the command is followed by a <cr> except that a <cr><lf> is automatically inserted into the text following character c_n. Consider the following command sequences as examples of the F and I commands:

Command String	Effect	Resulting Memory Buffer
BITHIS IS ↑z<cr>	Insert "THIS IS " at the beginning of the text	THIS IS cp NOW THE <cr><lf> TIME FOR<cr><lf> ALL GOOD MEN<cr><lf>

FTIME↑z-4DIPLACE↑z<cr>	find "TIME" and delete it; then insert "PLACE"	THIS IS NOW THE<cr><lf> PLACE cp FOR<cr><lf> ALL GOOD MEN<cr><lf>
3FO↑z-3D5DICHANGES↑<cr>	find third occurrence of "O" (ie the second "O" in GOOD), delete previous 3 characters; then insert "CHANGES"	THIS IS NOW THE <cr><lf> PLACE FOR<cr><lf> ALL CHANGES cp <cr><lf>
-8CISOURCE<cr>	move back 8 characters and insert the line "SOURCE<cr><lf>"	THIS IS NOW THE<cr><lf> PLACE FOR<cr><lf> ALL SOURCE<cr><lf> cp CHANGES<cr><lf>

ED also provides a single command which combines the F and I commands to perform simple string substitutions. The command takes the form

$$n\ S\ c_1c_2\ldots c_k{\uparrow}z\ d_1d_2\ldots d_m \left\{\begin{matrix}\text{<cr>}\\ {\uparrow}z\end{matrix}\right\}$$

and has exactly the same effect as applying the command string

$$F\ c_1c_2\ldots c_k{\uparrow}z\text{-}k\text{DI}d_1d_2\ldots d_m \left\{\begin{matrix}\text{<cr>}\\ {\uparrow}z\end{matrix}\right\}$$

a total of n times. That is, ED searches the memory buffer starting at the current position of CP and successively substitutes the second string for the first string until the end of buffer, or until the substitution has been performed n times.

As a convenience, a command similar to F is provided by ED which automatically appends and writes lines as the search proceeds. The form is

$$n\ N\ c_1c_2\ldots c_k \left\{\begin{matrix}\text{cr}\\ {\uparrow}z\end{matrix}\right\}$$

which searches the entire source file for the nth occurrence of the string $c_1c_2\ldots c_k$ (recall that F fails if the string cannot be found in the current buffer). The operation of the

N command is precisely the same as F except in the case that the string cannot be found within the current memory buffer. In this case, the entire memory contents is written (ie, an automatic #W is issued). Input lines are then read until the buffer is at least half full, or the entire source file is exhausted. The search continues in this manner until the string has been found n times, or until the source file has been completely transferred to the temporary file.

A final line editing function, called the juxtaposition command takes the form

$$n\ J\ c_1c_2\ldots c_k\uparrow z\ \ d_1d_2\ldots d_m\uparrow z\ \ e_1e_2\ldots e_q \left\{\begin{matrix}\text{<cr>}\\ \uparrow z\end{matrix}\right\}$$

with the following action applied n times to the memory buffer: search from the current CP for the next occurrence of the string $c_1c_2\ldots c_k$. If found, insert the string $d_1,d_2,\ldots,d_m$, and move CP to follow d_m. Then delete all characters following CP up to (but not including) the string $e_1,e_2,\ldots e_q$, leaving CP directly after d_m. If $e_1,e_2,\ldots e_q$ cannot be found, then no deletion is made. If the current line is

cp NOW IS THE TIME<cr><lf>

Then the command

JW ↑zWHAT↑z↑l<cr>

Results in

NOW WHAT cp <cr><lf>

(Recall that ↑l represents the pair <cr><lf> in search and substitute strings).

It should be noted that the number of characters allowed by ED in the F,S,N, and J commands is limited to 100 symbols.

1.8. Source Libraries

ED also allows the inclusion of source libraries during the editing process with the R command. The form of this command is

Appen B

$$R\ f_1f_2..f_n{\uparrow}z \qquad \text{or}$$

$$R\ f_1f_2..f_n\text{<cr>}$$

where $f_1f_2..f_n$ is the name of a source file on the disk with as assumed filetype of 'LIB'. ED reads the specified file, and places the characters into the memory buffer after CP, in a manner similar to the I command. Thus, if the command

RMACRO<cr>

is issued by the operator, ED reads from the file MACRO.LIB until the end-of-file, and automatically inserts the characters into the memory buffer.

1.9. Repetitive Command Execution

The macro command M allows the ED user to group ED commands together for repeated evaluation. The M command takes the form:

$$n\ M\ c_1c_2\ldots c_k \begin{Bmatrix}\text{<cr>} \\ \uparrow z\end{Bmatrix}$$

where $c_1c_2\ldots c_k$ represent a string of ED commands, not including another M command. ED executes the command string n times if n>1. If n=0 or 1, the command string is executed repetitively until an error condition is encountered (e.g., the end of the memory buffer is reached with an F command).

As an example, the following macro changes all occurrences of GAMMA to DELTA within the current buffer, and types each line which is changed:

MFGAMMA↑z-5DIDELTA↑z0TT<cr>

or equivalently

MSGAMMA↑zDELTA↑z0TT<cr>

2. ED ERROR CONDITIONS

On error conditions, ED prints the last character read before the error, along with an error indicator:

?	unrecognized command
>	memory buffer full (use one of the commands D,K,N,S, or W to remove characters), F,N, or S strings too long.
#	cannot apply command the number of times specified (e.g., in F command)
O	cannot open LIB file in R command

Cyclic redundancy check (CRC) information is written with each output record under CP/M in order to detect errors on subsequent read operations. If a CRC error is detected, CP/M will type

PERM ERR DISK d

where d is the currently selected drive (A,B,...). The operator can choose to ignore the error by typing any character at the console (in this case, the memory buffer data should be examined to see if it was incorrectly read), or the user can reset the system and reclaim the backup file, if it exists. The file can be reclaimed by first typing the contents of the BAK file to ensure that it contains the proper information:

TYPE x.BAK<cr>

where x is the file being edited. Then remove the primary file:

ERA x.y<cr>

and rename the BAK file:

REN x.y=x.BAK<cr>

The file can then be re-edited, starting with the previous version.

3. CONTROL CHARACTERS AND COMMANDS

The following table summarizes the control characters and commands available in ED:

Control Character	Function
↑c	system reboot
↑e	physical <cr><lf> (not actually entered in command)
↑i	logical tab (cols 1,8, 15,...)
↑l	logical <cr><lf> in search and substitute strings
↑u	line delete
↑z	string terminator
rubout	character delete
break	discontinue command (e.g., stop typing)

Command	Function
nA	append lines
±B	begin bottom of buffer
±nC	move character positions
±nD	delete characters
E	end edit and close files (normal end)
nF	find string
H	end edit, close and reopen files
I	insert characters
nJ	place strings in juxtaposition
±nK	kill lines
±nL	move down/up lines
nM	macro definition
nN	find next occurrence with autoscan
O	return to original file
±nP	move and print pages
Q	quit with no file changes
R	read library file
nS	substitute strings
±nT	type lines
± U	translate lower to upper case if U, no translation if -U
nW	write lines
nZ	sleep
±n<cr>	move and type (±nLT)

Appendix A: ED 1.4 Enhancements

The ED context editor contains a number of commands which enhance its usefulness in text editing. The improvements are found in the addition of line numbers, free space interrogation, and improved error reporting.

The context editor issued with CP/M 1.4 produces absolute line number prefixes when the "V" (Verify Line Numbers) command is issued. Following the V command, the line number is displayed ahead of each line in the format:

nnnnn:

where nnnnn is an absolute line number in the range 1 to 65535. If the memory buffer is empty, or if the current line is at the end of the memory buffer, then nnnnn appears as 5 blanks.

The user may reference an absolute line number by preceding any command by a number followed by a colon, in the same format as the line number display. In this case, the ED program moves the current line reference to the absolute line number, if the line exists in the current memory buffer. Thus, the command

345:T

is interpreted as "move to absolute line 345, and type the line." Note that absolute line numbers are produced only during the editing process, and are not recorded with the file. In particular, the line numbers will change following a deleted or expanded section of text.

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The user may also reference an absolute line number as a backward or forward distance from the current line by preceding the absolute line number by a colon. Thus, the command

:4ØØT

is interpreted as "type from the current line number through the line whose absolute number is 4ØØ." Combining the two line reference forms, the command

345::4ØØT

for example, is interpreted as "move to absolute line 345, then type through absolute line 4ØØ." Note that absolute line references of this sort can precede any of the standard ED commands.

A special case of the V command, "ØV", prints the memory buffer statistics in the form:

free/total

where "free" is the number of free bytes in the memory buffer (in decimal), and "total" is the size of the memory buffer.

ED 1.4 also includes a "block move" facility implemented through the "X" (Xfer) command. The form

nX

transfers the next n lines from the current line to a temporary file called

X$$$$$$$.LIB

which is active only during the editing process. In general, the user can reposition the current line reference to any portion of the source file and transfer lines to the temporary file. The transferred line accumulate one after another in this file, and can be retrieved by simply typing:

R

which is the trivial case of the library read command. In this case, the entire transferred set of lines is read into the memory buffer. Note that the X command does not remove the transferred lines from the memory buffer, although a K command can be used directly after the X, and the R command does not empty the transferred line file. That is, given that a set of lines has been transferred with the X command, they can be re-read any number of times back into the source file. The command

ØX

is provided, however, to empty the transferred line file.

Note that upon normal completion of the ED program through Q or E, the temporary LIB file is removed. If ED is aborted through ctl-C, the LIB file will exist if lines have been transferred, but will generally be empty (a subsequent ED invocation will erase the temporary file).

Due to common typographical errors, ED 1.4 requires several potentially disasterous commands to be typed as single letters, rather than in composite commands. The commands

E (end), H (head), O (original), Q (quit)

must be typed as single letter commands.

ED 1.4 also prints error messages in the form

BREAK "x" AT c

where x is the error character, and c is the command where the error occurred.

APPENDIX C

CP/M 2.0 USER'S GUIDE FOR CP/M 1.4 OWNERS

DIGITAL RESEARCH

Post Office Box 579, Pacific Grove, California 93950, (408) 649-3896

CP/M 2.0 USER'S GUIDE

FOR CP/M 1.4 OWNERS

Appendix C

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CP/M 2.0 USER'S GUIDE FOR CP/M 1.4 OWNERS

Appendix C

1. AN OVERVIEW OF CP/M 2.0 FACILITIES.

CP/M 2.0 is a high-performance single-console operating system which uses table driven techniques to allow field reconfiguration to match a wide variety of disk capacities. All of the fundamental file restrictions are removed, while maintaining upward compatibility from previous versions of release 1. Features of CP/M 2.0 include field specification of one to sixteen logical drives, each containing up to eight megabytes. Any particular file can reach the full drive size with the capability to expand to thirty-two megabytes in future releases. The directory size can be field configured to contain any reasonable number of entries, and each file is optionally tagged with read/only and system attributes. Users of CP/M 2.0 are physically separated by user numbers, with facilities for file copy operations from one user area to another. Powerful relative-record random access functions are present in CP/M 2.0 which provide direct access to any of the 65536 records of an eight megabyte file.

All disk-dependent portions of CP/M 2.0 are placed into a BIOS-resident "disk parameter block" which is either hand coded or produced automatically using the disk definition macro library provided with CP/M 2.0. The end user need only specify the maximum number of active disks, the starting and ending sector numbers, the data allocation size, the maximum extent of the logical disk, directory size information, and reserved track values. The macros use this information to generate the appropriate tables and table references for use during CP/M 2.0 operation. Deblocking information is also provided which aids in assembly or disassembly of sector sizes which are multiples of the fundamental 128 byte data unit, and the system alteration manual includes general-purpose subroutines which use the this deblocking information to take advantage of larger sector sizes. Use of these subroutines, together with the table driven data access algorithms, make CP/M 2.0 truly a universal data management system.

File expansion is achieved by providing up to 512 logical file extents, where each logical extent contains 16K bytes of data. CP/M 2.0 is structured, however, so that as much as 128K bytes of data is addressed by a single physical extent (corresponding to a single directory entry), thus maintaining compatibility with previous versions while taking full advantage of directory space.

Random access facilities are present in CP/M 2.0 which allow immediate reference to any record of an eight megabyte file. Using CP/M's unique data organization, data blocks are only allocated when actually required and movement to a record position requires little search time. Sequential file access is upward compatible from earlier versions to the full eight megabytes, while random access compatibility stops at 512K byte files. Due to CP/M 2.0's simpler and faster random access, application programmers are encouraged to alter their programs to take full advantage of the 2.0 facilities.

Several CP/M 2.0 modules and utilities have improvements which correspond to the enhanced file system. STAT and PIP both account for file attributes and user areas, while the CCP provides a "login"

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function to change from one user area to another. The CCP also formats directory displays in a more convenient manner and accounts for both CRT and hard-copy devices in its enhanced line editing functions.

The sections below point out the individual differences between CP/M 1.4 and CP/M 2.0, with the understanding that the reader is either familiar with CP/M 1.4, or has access to the 1.4 manuals. Additional information dealing with CP/M 2.0 I/O system alteration is presented in the Digital Research manual "CP/M 2.0 Alteration Guide."

!. USER INTERFACE.

Console line processing takes CRT-type devices into account with three new control characters, shown with an asterisk in the list below (the symbol "ctl" below indicates that the control key is simultaneously depressed):

```
rub/del removes and echoes last character
 ctl-C  reboot when at beginning of line
 ctl-E  physical end of line
 ctl-H  backspace one character position*
 ctl-J  (line feed) terminates current input*
 ctl-M  (carriage return) terminates input
 ctl-R  retype current line after new line
 ctl-U  remove current line after new line
 ctl-X  backspace to beginning of current line*
```

In particular, note that ctl-H produces the proper backspace overwrite function (ctl-H can be changed internally to another character, such as delete, through a simple single byte change). Further, the line editor keeps track of the current prompt column position so that the operator can properly align data input following a ctl-U, ctl-R, or ctl-X command.

Appendix C

3. CONSOLE COMMAND PROCESSOR (CCP) INTERFACE.

There are four functional differences between CP/M 1.4 and CP/M 2.0 at the console command processor (CCP) level. The CCP now displays directory information across the screen (four elements per line), the USER command is present to allow maintenance of separate files in the same directory, and the actions of the "ERA *.*" and "SAVE" commands have changed. The altered DIR format is self-explanatory, while the USER command takes the form:

USER n

where n is an integer value in the range 0 to 15. Upon cold start, the operator is automatically "logged" into user area number 0, which is compatible with standard CP/M 1.4 directories. The operator may issue the USER command at any time to move to another logical area within the same directory. Drives which are logged-in while addressing one user number are automatically active when the operator moves to another user number since a user number is simply a prefix which accesses particular directory entries on the active disks.

The active user number is maintained until changed by a subsequent USER command, or until a cold start operation when user 0 is again assumed.

Due to the fact that user numbers now tag individual directory entries, the ERA *.* command has a different effect. In version 1.4, this command can be used to erase a directory which has "garbage" information, perhaps resulting from use of a diskette under another operating system (heaven forbid!). In 2.0, however, the ERA *.* command affects only the current user number. Thus, it is necessary to write a simple utility to erase a nonsense disk (the program simply writes the hexadecimal pattern E5 throughout the disk).

The SAVE command in version 1.4 allows only a single memory save operation, with the potential of destroying the memory image due to directory operations following extent boundary changes. Version 2.0, however, does not perform directory operations in user data areas after disk writes, and thus the SAVE operation can be used any number of times without altering the memory image.

4. STAT ENHANCEMENTS.

The STAT program has a number of additional functions which allow disk parameter display, user number display, and file indicator manipulation. The command:

```
STAT VAL:
```

produces a summary of the available status commands, resulting in the output:

```
Temp R/O Disk: d:=R/O
Set Indicator: d:filename.typ $R/O $R/W $SYS $DIR
Disk Status  : DSK: d:DSK:
User Status  : USR:
Iobyte Assign:
(list of possible assignments)
```

which gives an instant summary of the possible STAT commands. The command form:

```
STAT d:filename.typ $S
```

where "d:" is an optional drive name, and "filename.typ" is an unambiguous or ambiguous file name, produces the output display format:

```
 Size  Recs  Bytes  Ext Acc
   48    48     6k    1 R/O A:ED.COM
   55    55    12k    1 R/O (A:PIP.COM)
65536   128     2k    2 R/W A:X.DAT
```

where the $S parameter causes the "Size" field to be displayed (without the $S, the Size field is skipped, but the remaining fields are displayed). The Size field lists the virtual file size in records, while the "Recs" field sums the number of virtual records in each extent. For files constructed sequentially, the Size and Recs fields are identical. The "Bytes" field lists the actual number of bytes allocated to the corresponding file. The minimum allocation unit is determined at configuration time, and thus the number of bytes corresponds to the record count plus the remaining unused space in the last allocated block for sequential files. Random access files are given data areas only when written, so the Bytes field contains the only accurate allocation figure. In the case of random access, the Size field gives the logical end-of-file record position and the Recs field counts the logical records of each extent (each of these extents, however, may contain unallocated "holes" even though they are added into the record count). The "Ext" field counts the number of logical 16K extents allocated to the file. Unlike version 1.4, the Ext count does not necessarily correspond to the number of directory entries given to the file, since there can be up to 128K bytes (8 logical extents) directly addressed by a single directory entry, depending upon allocation size (in a special case, there are actually 256K bytes which can be directly addressed by a physical extent).

The "Acc" field gives the R/O or R/W access mode, which is changed using the commands shown below. Similarly, the parentheses

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shown around the PIP.COM file name indicate that it has the "system" indicator set, so that it will not be listed in DIR commands. The four command forms

```
STAT d:filename.typ $R/O
STAT d:filename.typ $R/W
STAT d:filename.typ $SYS
STAT d:filename.typ $DIR
```

set or reset various permanent file indicators. The R/O indicator places the file (or set of files) in a read-only status until changed by a subsequent STAT command. The R/O status is recorded in the directory with the file so that it remains R/O through intervening cold start operations. The R/W indicator places the file in a permanent read/write status. The SYS indicator attaches the system indicator to the file, while the DIR command removes the system indicator. The "filename.typ" may be ambiguous or unambiguous, but in either case, the files whose attributes are changed are listed at the console when the change occurs. The drive name denoted by "d:" is optional.

When a file is marked R/O, subsequent attempts to erase or write into the file result in a terminal BDOS message

```
Bdos Err on d: File R/O
```

The BDOS then waits for a console input before performing a subsequent warm start (a "return" is sufficient to continue). The command form

```
STAT d:DSK:
```

lists the drive characteristics of the disk named by "d:" which is in the range A:, B:, ..., P:. The drive characteristics are listed in the format:

```
    d: Drive Characteristics
65536: 128 Byte record Capacity
 8192: Kilobyte Drive Capacity
  128: 32  Byte Directory Entries
    0: Checked  Directory Entries
 1024: Records/ Extent
  128: Records/ Block
   58: Sectors/ Track
    2: Reserved Tracks
```

where "d:" is the selected drive, followed by the total record capacity (65536 is an 8 megabyte drive), followed by the total capacity listed in Kilobytes. The directory size is listed next, followed by the "checked" entries. The number of checked entries is usually identical to the directory size for removable media, since this mechanism is used to detect changed media during CP/M operation without an intervening warm start. For fixed media, the number is usually zero, since the media is not changed without at least a cold or warm start. The number of records per extent determines the addressing capacity of each directory entry (1024 times 128 bytes, or

128K in the example above). The number of records per block shows the basic allocation size (in the example, 128 records/block times 128 bytes per record, or 16K bytes per block). The listing is then followed by the number of physical sectors per track and the number of reserved tracks. For logical drives which share the same physical disk, the number of reserved tracks may be quite large, since this mechanism is used to skip lower-numbered disk areas allocated to other logical disks. The command form

STAT DSK:

produces a drive characteristics table for all currently active drives. The final STAT command form is

STAT USR:

which produces a list of the user numbers which have files on the currently addressed disk. The display format is:

```
Active User : Ø
Active Files: Ø 1 3
```

where the first line lists the currently addressed user number, as set by the last CCP USER command, followed by a list of user numbers scanned from the current directory. In the above case, the active user number is Ø (default at cold start), with three user numbers which have active files on the current disk. The operator can subsequently examine the directories of the other user numbers by logging-in with USER 1, USER 2, or USER 3 commands, followed by a DIR command at the CCP level.

Append
C

5. PIP ENHANCEMENTS.

PIP provides three new functions which account for the features of CP/M 2.Ø. All three functions take the form of file parameters which are enclosed in square brackets following the appropriate file names. The commands are:

Gn	Get File from User number n (n in the range Ø - 15)
W	Write over R/O files without console interrogation
R	Read system files

The G command allows one user area to receive data files from another. Assuming the operator has issued the USER 4 command at the CCP level, the PIP statement

```
PIP X.Y = X.Y[G2]
```

reads file X.Y from user number 2 into user area number 4. The command

```
PIP A:=A:*.*[G2]
```

copies all of the files from the A drive directory for user number 2 into the A drive directory of the currently logged user number. Note that to ensure file security, one cannot copy files into a different area than the one which is currently addressed by the USER command.

Note also that the PIP program itself is initially copied to a user area (so that subsequent files can be copied) using the SAVE command. The sequence of operations shown below effectively moves PIP from one user area to the next.

```
USER Ø              login user Ø
DDT PIP.COM         load PIP to memory
(note PIP size s)
GØ                  return to CCP
USER 3              login user 3
SAVE s PIP.COM
```

where s is the integral number of memory "pages" (256 byte segments) occupied by PIP. The number s can be determined when PIP.COM is loaded under DDT, by referring to the value under the "NEXT" display. If for example, the next available address is 1DØØ, then PIP.COM requires 1C hexadecimal pages (or 1 times 16 + 12 = 28 pages), and thus the value of s is 28 in the subsequent save. Once PIP is copied in this manner, it can then be copied to another disk belonging to the same user number through normal pip transfers.

Under normal operation, PIP will not overwrite a file which is set to a permanent R/O status. If attempt is made to overwrite a R/O file, the prompt

DESTINATION FILE IS R/O, DELETE (Y/N)?

is issued. If the operator responds with the character "y" then the file is overwritten. Otherwise, the response

** NOT DELETED **

is issued, the file transfer is skippped, and PIP continues with the next operation in sequence. In order to avoid the prompt and response in the case of R/O file overwrite, the command line can include the W parameter, as shown below

PIP A:=B:*.COM[W]

which copies all non-system files to the A drive from the B drive, and overwrites any R/O files in the process. If the operation involves several concatenated files, the W parameter need only be included with the last file in the list, as shown in the following example

PIP A.DAT = B.DAT,F:NEW.DAT,G:OLD.DAT[W]

Files with the system attribute can be included in PIP transfers if the R parameter is included, otherwise system files are not recognized. The command line

PIP ED.COM = B:ED.COM[R]

for example, reads the ED.COM file from the B drive, even if it has been marked as a R/O and system file. The system file attributes are copied, if present.

It should be noted that downward compatibility with previous versions of CP/M is only maintained if the file does not exceed one megabyte, no file attributes are set, and the file is created by user 0. If compatibility is required with non-standard (e.g., "double density") versions of 1.4, it may be necessary to select 1.4 compatibility mode when constructing the internal disk parameter block (see the "CP/M 2.0 Alteration Guide," and refer to Section 10 which describes BIOS differences).

6. ED ENHANCEMENTS.

The CP/M standard program editor provides several new facilities in the 2.0 release. Experience has shown that most operators use the relative line numbering feature of ED, and thus the editor has the "v" (Verify Line) option set as an initial value. The operator can, of course, disable line numbering by typing the "-v" command. If you are not familiar with the ED line number mode, you may wish to refer to the Appendix in the ED user's guide, where the "v" command is described.

ED also takes file attributes into account. If the operator attempts to edit a read/only file, the message

** FILE IS READ/ONLY **

appears at the console. The file can be loaded and examined, but cannot be altered in any way. Normally, the operator simply ends the edit session, and uses STAT to change the file attribute to R/W. If the edited file has the "system" attribute set, the message

"SYSTEM" FILE NOT ACCESSIBLE

is displayed at the console, and the edit session is aborted. Again, the STAT program can be used to change the system attribute, if desired.

Finally, the insert mode ("i") command allows CRT line editing functions, as described in Section 2, above.

7. THE XSUB FUNCTION.

An additional utility program is supplied with version 2.0 of CP/M, called XSUB, which extends the power of the SUBMIT facility to include line input to programs as well as the console command processor. The XSUB command is included as the first line of your submit file and, when executed, self-relocates directly below the CCP. All subsequent submit command lines are processed by XSUB, so that programs which read buffered console input (BDOS function 10) receive their input directly from the submit file. For example, the file SAVER.SUB could contain the submit lines:

```
XSUB
DDT
I$1.HEX
R
G0
SAVE 1 $2.COM
```

with a subsequent SUBMIT command:

```
SUBMIT SAVER X Y
```

which substitutes X for $1 and Y for $2 in the command stream. The XSUB program loads, followed by DDT which is sent the command lines "IX.HEX" "R" and "G0" thus returning to the CCP. The final command "SAVE 1 Y.COM" is processed by the CCP.

The XSUB program remains in memory, and prints the message

```
(xsub active)
```

on each warm start operation to indicate its presence. Subsequent submit command streams do not require the XSUB, unless an intervening cold start has occurred. Note that XSUB must be loaded after DESPOOL, if both are to run simultaneously.

Append
C

8. BDOS INTERFACE CONVENTIONS.

CP/M 2.Ø system calls take place in exactly the same manner as earlier versions, with a call to location ØØØ5H, function number in register C, and information address in register pair DE. Single byte values are returned in register A, with double byte values returned in HL (for reasons of compatibility, register A = L and register B = H upon return in all cases). A list of CP/M 2.Ø calls is given below, with an asterisk following functions which are either new or revised from version 1.4 to 2.Ø. Note that a zero value is returned for out-of range function numbers.

Ø	System Reset	19*	Delete File
1	Console Input	2Ø	Read Sequential
2	Console Output	21	Write Sequential
3	Reader Input	22*	Make File
4	Punch Output	23*	Rename File
5	List Output	24*	Return Login Vector
6*	Direct Console I/O	25	Return Current Disk
7	Get I/O Byte	26	Set DMA Address
8	Set I/O Byte	27	Get Addr(Alloc)
9	Print String	28*	Write Protect Disk
1Ø*	Read Console Buffer	29*	Get Addr(R/O Vector)
11	Get Console Status	3Ø*	Set File Attributes
12*	Return Version Number	31*	Get Addr(Disk Parms)
13	Reset Disk System	32*	Set/Get User Code
14	Select Disk	33*	Read Random
15*	Open File	34*	Write Random
16	Close File	35*	Compute File Size
17*	Search for First	36*	Set Random Record
18*	Search for Next		

(Functions 28, 29, and 32 should be avoided in application programs to maintain upward compatibility with MP/M.) The new or revised functions are described below.

Function 6: Direct Console I/O.

Direct Console I/O is supported under CP/M 2.Ø for those applications where it is necessary to avoid the BDOS console I/O operations. Programs which currently perform direct I/O through the BIOS should be changed to use direct I/O under BDOS so that they can be fully supported under future releases of MP/M and CP/M.

Upon entry to function 6, register E either contains hexadecimal FF, denoting a console input request, or register E contains an ASCII character. If the input value is FF, then function 6 returns A = ØØ if no character is ready, otherwise A contains the next console input character.

If the input value in E is not FF, then function 6 assumes that E contains a valid ASCII character which is sent to the console.

Function 10: Read Console Buffer.

The console buffer read operation remains unchanged except that console line editing is supported, as described in Section 2. Note also that certain functions which return the carriage to the leftmost position (e.g., ctl-X) do so only to the column position where the prompt ended (previously, the carriage returned to the extreme left margin). This new convention makes operator data input and line correction more legible.

Function 12: Return Version Number.

Function 12 has been redefined to provide information which allows version-independent programming (this was previously the "lift head" function which returned HL=0000 in version 1.4, but performed no operation). The value returned by function 12 is a two-byte value, with H = 00 for the CP/M release (H = 01 for MP/M), and L = 00 for all releases previous to 2.0. CP/M 2.0 returns a hexadecimal 20 in register L, with subsequent version 2 releases in the hexadecimal range 21, 22, through 2F. Using function 12, for example, you can write application programs which provide both sequential and random access functions, with random access disabled when operating under early releases of CP/M.

In the file operations described below, DE addresses a file control block (FCB). Further, all directory operations take place in a reserved area which does not affect write buffers as was the case in version 1.4, with the exception of Search First and Search Next, where compatibility is required.

The File Control Block (FCB) data area consists of a sequence of 33 bytes for sequential access, and a series of 36 bytes in the case that the file is accessed randomly. The default file control block normally located at 005CH can be used for random access files, since bytes 007DH, 007EH, and 007FH are available for this purpose. For notational purposes, the FCB format is shown with the following fields:

```
-----------------------------------------------------------
|dr|f1|f2|/ /|f8|t1|t2|t3|ex|s1|s2|rc|d0|/ /|dn|cr|r0|r1|r2|
-----------------------------------------------------------
 00 01 02 ... 08 09 10 11 12 13 14 15 16 ... 31 32 33 34 35
```

where

```
   dr         drive code (0 - 16)
              0 => use default drive for file
              1 => auto disk select drive A,
              2 => auto disk select drive B,
              ...
              16=> auto disk select drive P.

   f1...f8    contain the file name in ASCII
              upper case, with high bit = 0

   t1,t2,t3   contain the file type in ASCII
              upper case, with high bit = 0
              t1', t2', and t3' denote the
              bit of these positions,
              t1' = 1 => Read/Only file,
              t2' = 1 => SYS file, no DIR list

    ex        contains the current extent number,
              normally set to 00 by the user, but
              in range 0 - 31 during file I/O

    s1        reserved for internal system use

    s2        reserved for internal system use, set
              to zero on call to OPEN, MAKE, SEARCH

    rc        record count for extent "ex,"
              takes on values from 0 - 128

    d0...dn   filled-in by CP/M, reserved for
              system use

    cr        current record to read or write in
              a sequential file operation, normally
              set to zero by user

    r0,r1,r2  optional random record number in the
              range 0-65535, with overflow to r2,
              r0,r1 constitute a 16-bit value with
              low byte r0, and high byte r1
```

Function 15: Open File.

The Open File operation is identical to previous definitions, with the exception that byte s2 is automatically zeroed. Note that previous versions of CP/M defined this byte as zero, but made nc checks to assure compliance. Thus, the byte is cleared to ensure upward compatibility with the latest version, where it is required.

Function 17: Search for First.

Search First scans the directory for a match with the file given by the FCB addressed by DE. The value 255 (hexadecimal FF) is returned if the file is not found, otherwise a value of A equal to 0, 1, 2, or 3 is returned indicating the file is present. In the case that the file is found, the current DMA address is filled with the record containing the directory entry, and the relative starting position is A * 32 (i.e., rotate the A register left 5 bits, or ADD A five times). Although not normally required for application programs, the directory information can be extracted from the buffer at this position.

An ASCII question mark (63 decimal, 3F hexadecimal) in any position from f1 through ex matches the corresponding field of any directory entry on the default or auto-selected disk drive. If the dr field contains an ASCII question mark, then the auto disk select function is disabled, the default disk is searched, with the search function returning any matched entry, allocated or free, belonging to any user number. This latter function is not normally used by application programs, but does allow complete flexibility to scan all current directory values. If the dr field is not a question mark, the s2 byte is automatically zeroed.

Function 18: Search for Next.

The Search Next function is similar to the Search First function, except that the directory scan continues from the last matched entry. Similar to function 17, function 18 returns the decimal value 255 in A when no more directory items match.

Function 19: Delete File.

The Delete File function removes files which match the FCB addressed by DE. The filename and type may contain ambiguous references (i.e., question marks in various positions), but the drive select code cannot be ambiguous, as in the Search and Search Next functions.

Function 19 returns a decimal 255 if the reference file or files could not be found, otherwise a value in the range 0 to 3 is returned.

Function 22: Make File.

The Make File operation is identical to previous versions of CP/M, except that byte s2 is zeroed upon entry to the BDOS.

Function 23: Rename File.

The Actions of the file rename functions are the same as previous releases except that the value 255 is returned if the rename function is unsuccessful (the file to rename could not be found), otherwise a value in the range 0 to 3 is returned.

Function 24: Return Login Vector.

The login vector value returned by CP/M 2.0 is a 16-bit value in HL, where the least significant bit of L corresponds to the first drive A, and the high order bit of H corresponds to the sixteenth drive, labelled P. Note that compatibility is maintained with earlier releases, since registers A and L contain the same values upon return.

Function 28: Write Protect Current Disk.

The disk write protect function provides temporary write protection for the currently selected disk. Any attempt to write to the disk, before the next cold or warm start operation produces the message

Bdos Err on d: R/O

Function 29: Get R/O Vector.

Function 29 returns a bit vector in register pair HL which indicates drives which have the temporary read/only bit set. Similar to function 24, the least significant bit corresponds to drive A, while the most significant bit corresponds to drive P. The R/O bit is set either by an explicit call to function 28, or by the automatic software mechanisms within CP/M which detect changed disks.

Function 30: Set File Attributes.

The Set File Attributes function allows programmatic manipulation of permanent indicators attached to files. In particular, the R/O and System attributes (t1' and t2' above) can be set or reset. The DE pair addresses an unambiguous file name with the appropriate attributes set or reset. Function 30 searches for a atch, and changes the matched directory entry to contain the selected ndicators. Indicators f1' through f4' are not presently used, but ay be useful for applications programs, since they are not involved n the matching process during file open and close operations. ndicators f5' through f8' and t3' are reserved for future system xpansion.

Function 31: Get Disk Parameter Block Address.

The address of the BIOS resident disk parameter block is eturned in HL as a result of this function call. This address can be sed for either of two purposes. First, the disk parameter values can e extracted for display and space computation purposes, or transient rograms can dynamically change the values of current disk parameters hen the disk environment changes, if required. Normally, application rograms will not require this facility.

Function 32: Set or Get User Code.

An application program can change or interrogate the currently ctive user number by calling function 32. If register E = FF exadecimal, then the value of the current user number is returned in egister A, where the value is in the range 0 to 31. If register E is ot FF, then the current user number is changed to the value of E modulo 32).

Function 33: Read Random.

The Read Random function is similar to the sequential file read peration of previous releases, except that the read operation takes lace at a particular record number, selected by the 24-bit value onstructed from the three byte field following the FCB (byte ositions r0 at 33, r1 at 34, and r2 at 35). Note that the sequence f 24 bits is stored with least significant byte first (r0), middle yte next (r1), and high byte last (r2). CP/M release 2.0 does not eference byte r2, except in computing the size of a file (function 5). Byte r2 must be zero, however, since a non-zero value indicates verflow past the end of file.

Thus, in version 2.0, the r0,r1 byte pair is treated as a ouble-byte, or "word" value, which contains the record to read. This alue ranges from 0 to 65535, providing access to any particular ecord of the 8 megabyte file. In order to process a file using andom access, the base extent (extent 0) must first be opened. lthough the base extent may or may not contain any allocated data, his ensures that the file is properly recorded in the directory, and s visible in DIR requests. The selected record number is then stored nto the random record field (r0,r1), and the BDOS is called to read he record. Upon return from the call, register A either contains an error code, as listed below, or the value 00 indicating the operation was successful. In the latter case, the current DMA address contains the randomly accessed record. Note that contrary to the sequential read operation, the record number is not advanced. Thus, subsequent random read operations continue to read the same record.

Upon each random read operation, the logical extent and current record values are automatically set. Thus, the file can be sequentially read or written, starting from the current randomly accessed position. Note, however, that in this case, the last randomly read record will be re-read as you switch from random mode to sequential read, and the last record will be re-written as you switch to a sequential write operation. You can, of course, simply advance the random record position following each random read or write to obtain the effect of a sequential I/O operation.

Error codes returned in register A following a random read are listed below.

- 01 reading unwritten data
- 02 (not returned in random mode)
- 03 cannot close current extent
- 04 seek to unwritten extent
- 05 (not returned in read mode)
- 06 seek past physical end of disk

Error code 01 and 04 occur when a random read operation accesses a data block which has not been previously written, or an extent which has not been created, which are equivalent conditions. Error 3 does not normally occur under proper system operation, but can be cleared by simply re-reading, or re-opening extent zero as long as the disk is not physically write protected. Error code 06 occurs whenever byte r2 is non-zero under the current 2.0 release. Normally, non-zero return codes can be treated as missing data, with zero return codes indicating operation complete.

Function 34: Write Random.

The Write Random operation is initiated similar to the Read Random call, except that data is written to the disk from the current DMA address. Further, if the disk extent or data block which is the target of the write has not yet been allocated, the allocation is performed before the write operation continues. As in the Read Random operation, the random record number is not changed as a result of the write. The logical extent number and current record positions of the file control block are set to correspond to the random record which is being written. Again, sequential read or write operations can commence following a random write, with the notation that the currently addressed record is either read or rewritten again as the sequential operation begins. You can also simply advance the random record position following each write to get the effect of a sequential write operation. Note that in particular, reading or writing the last record of an extent in random mode does not cause an automatic extent vitch as it does in sequential mode under either CP/M 1.4 or CP/M .0.

The error codes returned by a random write are identical to the andom read operation with the addition of error code 05, which ndicates that a new extent cannot be created due to directory verflow.

Function 35: Compute File Size.

When computing the size of a file, the DE register pair ldresses an FCB in random mode format (bytes r0, r1, and r2 are :esent). The FCB contains an unambiguous file name which is used in ne directory scan. Upon return, the random record bytes contain the virtual" file size which is, in effect, the record address of the ecord following the end of the file. if, following a call to inction 35, the high record byte r2 is 01, then the file contains the iximum record count 65536 in version 2.0. Otherwise, bytes r0 and r1 onstitute a 16-bit value (r0 is the least significant byte, as efore) which is the file size.

Data can be appended to the end of an existing file by simply alling function 35 to set the random record position to the end of ile, then performing a sequence of random writes starting at the :eset record address.

The virtual size of a file corresponds to the physical size when ne file is written sequentially. If, instead, the file was created random mode and "holes" exist in the allocation, then the file may fact contain fewer records than the size indicates. If, for ample, only the last record of an eight megabyte file is written in ndom mode (i.e., record number 65535), then the virtual size is 536 records, although only one block of data is actually allocated.

Appendix C

Function 36: Set Random Record.

The Set Random Record function causes the BDOS to automatically oduce the random record position from a file which has been read or itten sequentially to a particular point. The function can be seful in two ways.

First, it is often necessary to initially read and scan a quential file to extract the positions of various "key" fields. As ich key is encountered, function 36 is called to compute the random cord position for the data corresponding to this key. If the data it size is 128 bytes, the resulting record position is placed into a ble with the key for later retrieval. After scanning the entire le and tabularizing the keys and their record numbers, you can move stantly to a particular keyed record by performing a random read ing the corresponding random record number which was saved earlier. e scheme is easily generalized when variable record lengths are involved since the program need only store the buffer-relative byte position along with the key and record number in order to find the exact starting position of the keyed data at a later time.

A second use of function 36 occurs when switching from a sequential read or write over to random read or write. A file is sequentially accessed to a particular point in the file, function 36 is called which sets the record number, and subsequent random read and write operations continue from the selected point in the file.

This section is concluded with a rather extensive, but complete example of random access operation. The program listed below performs the simple function of reading or writing random records upon command from the terminal. Given that the program has been created, assembled, and placed into a file labelled RANDOM.COM, the CCP level command:

RANDOM X.DAT

starts the test program. The program looks for a file by the name X.DAT (in this particular case) and, if found, proceeds to prompt the console for input. If not found, the file is created before the prompt is given. Each prompt takes the form

next command?

and is followed by operator input, terminated by a carriage return. The input commands take the form

nW nR Q

where n is an integer value in the range Ø to 65535, and W, R, and Q are simple command characters corresponding to random write, random read, and quit processing, respectively. If the W command is issued, the RANDOM program issues the prompt

type data:

The operator then responds by typing up to 127 characters, followed by a carriage return. RANDOM then writes the character string into the X.DAT file at record n. If the R command is issued, RANDOM reads record number n and displays the string value at the console. If the Q command is issued, the X.DAT file is closed, and the program returns to the console command processor. In the interest of brevity (ok, so the program's not so brief), the only error message is

error, try again

The program begins with an initialization section where the input file is opened or created, followed by a continuous loop at the label "ready" where the individual commands are interpreted. The default file control block at ØØ5CH and the default buffer at ØØ8ØH are used in all disk operations. The utility subroutines then follow, which contain the principal input line processor, called "readc." This particular program shows the elements of random access processing, and can be used as the basis for further program development.

```
                ;**************************************************
                ;*                                                *
                ;* sample random access program for cp/m 2.0      *
                ;*                                                *
                ;**************************************************
0100                    org     100h    ;base of tpa
                ;
0000 =          reboot  equ     0000h   ;system reboot
0005 =          bdos    equ     0005h   ;bdos entry point
                ;
0001 =          coninp  equ     1       ;console input function
0002 =          conout  equ     2       ;console output function
0009 =          pstring equ     9       ;print string until '$'
000a =          rstring equ     10      ;read console buffer
000c =          version equ     12      ;return version number
000f =          openf   equ     15      ;file open function
0010 =          closef  equ     16      ;close function
0016 =          makef   equ     22      ;make file function
0021 =          readr   equ     33      ;read random
0022 =          writer  equ     34      ;write random
                ;
005c =          fcb     equ     005ch   ;default file control block
007d =          ranrec  equ     fcb+33  ;random record position
007f =          ranovf  equ     fcb+35  ;high order (overflow) byte
0080 =          buff    equ     0080h   ;buffer address
                ;
000d =          cr      equ     0dh     ;carriage return
000a =          lf      equ     0ah     ;line feed
                ;
                ;**************************************************
                ;*                                                *
                ;* load SP, set-up file for random access         *
                ;*                                                *
                ;**************************************************
0100 31bc0              lxi     sp,stack
                ;
                ;       version 2.0?
0103 0e0c               mvi     c,version
0105 cd050              call    bdos
0108 fe20               cpi     20h     ;version 2.0 or better?
010a d2160              jnc     versok
                ;       bad version, message and go back
010d 111b0              lxi     d,badver
0110 cdda0              call    print
0113 c3000              jmp     reboot
                ;
                versok:
                ;       correct version for random access
```

```
0116 0e0f           mvi     c,openf ;open default fcb
0118 115c0          lxi     d,fcb
011b cd050          call    bdos
011e 3c             inr     a       ;err 255 becomes zero
011f c2370          jnz     ready
               ;
               ;        cannot open file, so create it
0122 0e16           mvi     c,makef
0124 115c0          lxi     d,fcb
0127 cd050          call    bdos
012a 3c             inr     a       ;err 255 becomes zero
012b c2370          jnz     ready
               ;
               ;        cannot create file, directory full
012e 113a0          lxi     d,nospace
0131 cdda0          call    print
0134 c3000          jmp     reboot  ;back to ccp
               ;
               ;*************************************************
               ;*                                               *
               ;*   loop back to "ready" after each command     *
               ;*                                               *
               ;*************************************************
               ;
               ready:
               ;        file is ready for processing
               ;
0137 cde50          call    readcom ;read next command
013a 227d0          shld    ranrec  ;store input record#
013d 217f0          lxi     h,ranovf
0140 3600           mvi     m,0     ;clear high byte if set
0142 fe51           cpi     'Q'     ;quit?
0144 c2560          jnz     notq
               ;
               ;        quit processing, close file
0147 0e10           mvi     c,closef
0149 115c0          lxi     d,fcb
014c cd050          call    bdos
014f 3c             inr     a       ;err 255 becomes 0
0150 cab90          jz      error   ;error message, retry
0153 c3000          jmp     reboot  ;back to ccp
               ;
               ;*************************************************
               ;*                                               *
               ;* end of quit command, process write            *
               ;*                                               *
               ;*************************************************
               notq:
               ;        not the quit command, random write?
0156 fe57           cpi     'W'
0158 c2890          jnz     notw
               ;
               ;        this is a random write, fill buffer until cr
015b 114d0          lxi     d,datmsg
015e cdda0          call    print   ;data prompt
```

```
Ø161 Øe7f             mvi     c,127    ;up to 127 characters
Ø163 218ØØ            lxi     h,buff   ;destination
            rloop:   ;read next character to buff
Ø166 c5               push    b        ;save counter
Ø167 e5               push    h        ;next destination
Ø168 cdc2Ø            call    getchr   ;character to a
Ø16b e1               pop     h        ;restore counter
Ø16c c1               pop     b        ;restore next to fill
Ø16d feØd             cpi     cr       ;end of line?
Ø16f ca78Ø            jz      erloop
            ;        not end, store character
Ø172 77               mov     m,a
Ø173 23               inx     h        ;next to fill
Ø174 Ød               dcr     c        ;counter goes down
Ø175 c266Ø            jnz     rloop    ;end of buffer?
            erloop:
            ;        end of read loop, store ØØ
Ø178 36ØØ             mvi     m,Ø
            ;
            ;        write the record to selected record number
Ø17a Øe22             mvi     c,writer
Ø17c 115cØ            lxi     d,fcb
Ø17f cdØ5Ø            call    bdos
Ø182 b7               ora     a        ;error code zero?
Ø183 c2b9Ø            jnz     error    ;message if not
Ø186 c337Ø            jmp     ready    ;for another record
            ;
            ;*********************************************************
            ;*                                                       *
            ;* end of write command, process read                    *
            ;*                                                       *
            ;*********************************************************
            notw:
            ;        not a write command, read record?
Ø189 fe52             cpi     'R'
Ø18b c2b9Ø            jnz     error    ;skip if not
            ;
            ;        read random record
Ø18e Øe21             mvi     c,readr
Ø19Ø 115cØ            lxi     d,fcb
Ø193 cdØ5Ø            call    bdos
Ø196 b7               ora     a        ;return code ØØ?
Ø197 c2b9Ø            jnz     error
            ;
            ;        read was successful, write to console
Ø19a cdcfØ            call    crlf     ;new line
Ø19d Øe8Ø             mvi     c,128    ;max 128 characters
Ø19f 218ØØ            lxi     h,buff   ;next to get
            wloop:
Ø1a2 7e               mov     a,m      ;next character
Ø1a3 23               inx     h        ;next to get
Ø1a4 e67f             ani     7fh      ;mask parity
Ø1a6 ca37Ø            jz      ready    ;for another command if ØØ
Ø1a9 c5               push    b        ;save counter
Ø1aa e5               push    h        ;save next to get
```

```
01ab fe20           cpi              ;graphic?
01ad d4c80          cnc     putchr   ;skip output if not
01b0 e1             pop     h
01b1 c1             pop     b
01b2 0d             dcr     c        ;count=count-1
01b3 c2a20          jnz     wloop
01b6 c3370          jmp     ready
          ;
          ;*********************************************************
          ;*                                                       *
          ;* end of read command, all errors end-up here           *
          ;*                                                       *
          ;*********************************************************
          ;
          error:
01b9 11590          lxi     d,errmsg
01bc cdda0          call    print
01bf c3370          jmp     ready
          ;
          ;*********************************************************
          ;*                                                       *
          ;* utility subroutines for console i/o                   *
          ;*                                                       *
          ;*********************************************************
          getchr:
                    ;read next console character to a
01c2 0e01           mvi     c,coninp
01c4 cd050          call    bdos
01c7 c9             ret
          ;
          putchr:
                    ;write character from a to console
01c8 0e02           mvi     c,conout
01ca 5f             mov     e,a      ;character to send
01cb cd050          call    bdos     ;send character
01ce c9             ret
          ;
          crlf:
                    ;send carriage return line feed
01cf 3e0d           mvi     a,cr     ;carriage return
01d1 cdc80          call    putchr
01d4 3e0a           mvi     a,lf     ;line feed
01d6 cdc80          call    putchr
01d9 c9             ret
          ;
          print:
                    ;print the buffer addressed by de until $
01da d5             push    d
01db cdcf0          call    crlf
01de d1             pop     d        ;new line
01df 0e09           mvi     c,pstring
01e1 cd050          call    bdos     ;print the string
01e4 c9             ret
          ;
          readcom:
```

```
                        ;read the next command line to the conbuf
Ø1e5 116bØ              lxi     d,prompt
Ø1e8 cddaØ              call    print   ;command?
Ø1eb ØeØa               mvi     c,rstring
Ø1ed 117aØ              lxi     d,conbuf
Ø1fØ cdØ5Ø              call    bdos    ;read command line
                ;       command line is present, scan it
Ø1f3 21ØØØ              lxi     h,Ø     ;start with ØØØØ
Ø1f6 117cØ              lxi     d,conlin;command line
Ø1f9 1a         readc:  ldax    d       ;next command character
Ø1fa 13                 inx     d       ;to next command position
Ø1fb b7                 ora     a       ;cannot be end of command
Ø1fc c8                 rz
                ;       not zero, numeric?
Ø1fd d63Ø               sui     'Ø'
Ø1ff feØa               cpi     1Ø      ;carry if numeric
Ø2Ø1 d213Ø              jnc     endrd
                ;       add-in next digit
Ø2Ø4 29                 dad     h       ;*2
Ø2Ø5 4d                 mov     c,l
Ø2Ø6 44                 mov     b,h     ;bc = value * 2
Ø2Ø7 29                 dad     h       ;*4
Ø2Ø8 29                 dad     h       ;*8
Ø2Ø9 Ø9                 dad     b       ;*2 + *8 = *1Ø
Ø2Øa 85                 add     l       ;+digit
Ø2Øb 6f                 mov     l,a
Ø2Øc d2f9Ø              jnc     readc   ;for another char
Ø2Øf 24                 inr     h       ;overflow
Ø21Ø c3f9Ø              jmp     readc   ;for another char
                endrd:
                ;       end of read, restore value in a
Ø213 c63Ø               adi     'Ø'     ;command
Ø215 fe61               cpi     'a'     ;translate case?
Ø217 d8                 rc
                ;       lower case, mask lower case bits
Ø218 e65f               ani     1Ø1$1111b
Ø21a c9                 ret
                ;
                ;*****************************************************
                ;*                                                   *
                ;* string data area for console messages             *
                ;*                                                   *
                ;*****************************************************
                badver:
Ø21b 536f79             db      'sorry, you need cp/m version 2$'
                nospace:
Ø23a 4e6f29             db      'no directory space$'
                datmsg:
Ø24d 54797Ø             db      'type data: $'
                errmsg:
Ø259 457272             db      'error, try again.$'
                prompt:
Ø26b 4e657Ø             db      'next command? $'
                ;
```

```
                ;***************************************************
                ;*                                                 *
                ;* fixed and variable data area                    *
                ;*                                                 *
                ;***************************************************
Ø27a 21         conbuf: db      conlen  ;length of console buffer
Ø27b            consiz: ds      1       ;resulting size after read
Ø27c            conlin: ds      32      ;length 32 buffer
ØØ21 =          conlen  equ     $-consiz
                ;
Ø29c                    ds      32      ;16 level stack
                stack:
Ø2bc                    end
```

9. CP/M 2.0 MEMORY ORGANIZATION.

Similar to earlier versions, CP/M 2.0 is field-altered to fit various memory sizes, depending upon the host computer memory configuration. Typical base addresses for popular memory sizes are shown in the table below.

Module	20k	24k	32k	48k	64k
CCP	3400H	4400H	6400H	A400H	E400H
BDOS	3C00H	4C00H	6C00H	AC00H	EC00H
BIOS	4A00H	5A00H	7A00H	BA00H	FA00H
Top of Ram	4FFFH	5FFFH	7FFFH	BFFFH	FFFFH

The distribution disk contains a CP/M 2.0 system configured for a 20k Intel MDS-800 with standard IBM 8" floppy disk drives. The disk layout is shown below:

Sector	Track 00	Module	Track 01	Module
1	(Bootstrap Loader)		4080H	BDOS + 480H
2	3400H	CCP + 000H	4100H	BDOS + 500H
3	3480H	CCP + 080H	4180H	BDOS + 580H
4	3500H	CCP + 100H	4200H	BDOS + 600H
5	3580H	CCP + 180H	4280H	BDOS + 680H
6	3600H	CCP + 200H	4300H	BDOS + 700H
7	3680H	CCP + 280H	4380H	BDOS + 780H
8	3700H	CCP + 300H	4400H	BDOS + 800H
9	3780H	CCP + 380H	4480H	BDOS + 880H
10	3800H	CCP + 400H	4500H	BDOS + 900H
11	3880H	CCP + 480H	4580H	BDOS + 980H
12	3900H	CCP + 500H	4600H	BDOS + A00H
13	3980H	CCP + 580H	4680H	BDOS + A80H
14	3A00H	CCP + 600H	4700H	BDOS + B00H
15	3A80H	CCP + 680H	4780H	BDOS + B80H
16	3B00H	CCP + 700H	4800H	BDOS + C00H
17	3B80H	CCP + 780H	4880H	BDOS + C80H
18	3C00H	BDOS + 000H	4900H	BDOS + D00H
19	3C80H	BDOS + 080H	4980H	BDOS + D80H
20	3D00H	BDOS + 100H	4A00H	BIOS + 000H
21	3D80H	BDOS + 180H	4A80H	BIOS + 080H
22	3E00H	BDOS + 200H	4B00H	BIOS + 100H
23	3E80H	BDOS + 280H	4B80H	BIOS + 180H
24	3F00H	BDOS + 300H	4C00H	BIOS + 200H
25	3F80H	BDOS + 380H	4C80H	BIOS + 280H
26	4000H	BDOS + 400H	4D00H	BIOS + 300H

In particular, note that the CCP is at the same position on the disk, and occupies the same space as version 1.4. The BDOS portion, however, occupies one more 256-byte page and the BIOS portion extends through the remainder of track 01. Thus, the CCP is 800H (2048 decimal) bytes in length, the BDOS is E00H (3584 decimal) bytes in length, and the BIOS is up to 380H (898 decimal) bytes in length. In version 2.0, the BIOS portion contains the standard subroutines of 1.4, along with some initialized table space, as described in the following section.

Appen
C

10. BIOS DIFFERENCES.

The CP/M 2.0 Basic I/O System differs only slightly in concept from its predecesssors. Two new jump vector entry points are defined, a new sector translation subroutine is included, and a disk characteristics table must be defined. The skeletal form of these changes are found in the program shown below.

```
        org     4000h
        maclib  diskdef
        jmp     boot
;       ...
        jmp     listst  ;list status
        jmp     sectran ;sector translate
        disks   4
;       large capacity drive
bpb     equ     16*1024 ;bytes per block
rpb     equ     bpb/128 ;records per block
maxb    equ     65535/rpb ;max block number
        diskdef 0,1,58,3,bpb,maxb+1,128,0,2
        diskdef 1,1,58,,bpb,maxb+1,128,0,2
        diskdef 2,0
        diskdef 3,1
;
boot:   ret     ;nop
;
listst: xra     a       ;nop
        ret
;
seldsk:
        ;drive number in c
        lxi     h,0     ;0000 in hl produces select error
        mov     a,c     ;a is disk number 0 ... ndisks-1
        cpi     ndisks  ;less than ndisks?
        rnc             ;return with HL = 0000 if not
;       proper disk number, return dpb element address
        mov     l,c
        dad     h       ;*2
        dad     h       ;*4
        dad     h       ;*8
        dad     h       ;*16
        lxi     d,dpbase
        dad     d       ;HL=.dpb
        ret
;
selsec:
        ;sector number in c
        lxi     h,sector
        mov     m,c
        ret
;
sectran:
        ;translate sector BC using table at DE
        xchg            ;HL = .tran
        dad     b       ;single precision tran
```

```
48: ;         dad b again if double precision tran
49:           mov     l,m     ;only low byte necessary here
5Ø: ;         fill both H and L if double precision tran
51:           ret             ;HL = ??ss
52: ;
53: sector:   ds      1
54:           endef
55:           end
```

Referring to the program shown above, lines 3-6 represent the BIOS entry vector of 17 elements (version 1.4 defines only 15 jump vector elements). The last two elements provide access to the "LISTST" (List Status) entry point for DESPOOL. The use of this particular entry point is defined in the DESPOOL documentation, and is no different than the previous 1.4 release. It should be noted that the 1.4 DESPOOL program will not operate under version 2.Ø, but an update version will be available from Digital Research in the near future.

The "SECTRAN" (Sector Number Translate) entry shown in the jump vector at line 6 provides access to a BIOS-resident sector translation subroutine. This mechanism allows the user to specify the sector skew factor and translation for a particular disk system, and is described below.

A macro library is shown in the listing,. called DISKDEF, included on line 2, and referenced in 12-15. Although it is not necessary to use the macro library, it greatly simplifies the disk definition process. You must have access to the MAC macro assembler, of course, to use the DISKDEF facility, while the macro library is included with all CP/M 2.Ø distribution disks. (See the CP/M 2.Ø Alteration Guide for formulas which you can use to hand-code the tables produced by the DISKDEF library).

A BIOS disk definition consists of the following sequence of macro statements:

```
MACLIB   DISKDEF
......
DISKS    n
DISKDEF  Ø,...
DISKDEF  1,...
......
DISKDEF  n-1
......
ENDEF
```

where the MACLIB statement loads the DISKDEF.LIB file (on the same disk as your BIOS) into MAC's internal tables. The DISKS macro call follows, which specifies the number of drives to be configured with your system, where n is an integer in the range 1 to 16. A series of DISKDEF macro calls then follow which define the characteristics of each logical disk, Ø through n-1 (corresponding to logical drives A through P). Note that the DISKS and DISKDEF macros generate in-line fixed data tables, and thus must be placed in a non-executable portion of your BIOS, typically directly following the BIOS jump vector.

The remaining portion of your BIOS is defined following the DISKDEF macros, with the ENDEF macro call immediately preceding the END statement. The ENDEF (End of Diskdef) macro generates the necessary uninitialized RAM areas which are located above your BIOS.

The form of the DISKDEF macro call is

```
DISKDEF  dn,fsc,lsc,[skf],bls,dks,dir,cks,ofs,[0]
```

where

```
dn      is the logical disk number, 0 to n-1
fsc     is the first physical sector number (0 or 1)
lsc     is the last sector number
skf     is the optional sector skew factor
bls     is the data allocation block size
dir     is the number of directory entries
cks     is the number of "checked" directory entries
ofs     is the track offset to logical track 00
[0]     is an optional 1.4 compatibility flag
```

The value "dn" is the drive number being defined with this DISKDEF macro invocation. The "fsc" parameter accounts for differing sector numbering systems, and is usually 0 or 1. The "lsc" is the last numbered sector on a track. When present, the "skf" parameter defines the sector skew factor which is used to create a sector translation table according to the skew. If the number of sectors is less than 256, a single-byte table is created, otherwise each translation table element occupies two bytes. No translation table is created if the skf parameter is omitted (or equal to 0). The "bls" parameter specifies the number of bytes allocated to each data block, and takes on the values 1024, 2048, 4096, 8192, or 16384. Generally, performance increases with larger data block sizes since there are fewer directory references and logically connected data records are physically close on the disk. Further, each directory entry addresses more data and the BIOS-resident ram space is reduced. The "dks" specifies the total disk size in "bls" units. That is, if the bls = 2048 and dks = 1000, then the total disk capacity is 2,048,000 bytes. If dks is greater than 255, then the block size parameter bls must be greater than 1024. The value of "dir" is the total number of directory entries which may exceed 255, if desired. The "cks" parameter determines the number of directory items to check on each directory scan, and is used internally to detect changed disks during system operation, where an intervening cold or warm start has not occurred (when this situation is detected, CP/M automatically marks the disk read/only so that data is not subsequently destroyed). Normally the value of cks = dir when the media is easily changed, as is the case with a floppy disk subsystem. If the disk is permanently mounted, then the value of cks is typically 0, since the probability of changing disks without a restart is quite low. The "ofs" value determines the number of tracks to skip when this particular drive is addressed, which can be used to reserve additional operating system space or to simulate several logical drives on a single large capacity physical drive. Finally, the [Ø] parameter is included when file compatibility is required with versions of 1.4 which have been modified for higher density disks. This parameter ensures that only 16K is allocated for each directory record, as was the case for previous versions. Normally, this parameter is not included.

For convenience and economy of table space, the special form

```
DISKDEF    i,j
```

gives disk i the same characteristics as a previously defined drive j. A standard four-drive single density system, which is compatible with version 1.4, is defined using the following macro invocations:

```
DISKS      4
 DISKDEF   Ø,1,26,6,1Ø24,243,64,64,2
 DISKDEF   1,Ø
 DISKDEF   2,Ø
 DISKDEF   3,Ø

 ....
 ENDEF
```

with all disks having the same parameter values of 26 sectors per track (numbered 1 through 26), with 6 sectors skipped between each access, 1Ø24 bytes per data block, 243 data blocks for a total of 243k byte disk capacity, 64 checked directory entries, and two operating system tracks.

The definitions given in the program shown above (lines 12 through 15) provide access to the largest disks addressable by CP/M 2.Ø. All disks have identical parameters, except that drives Ø and 2 skip three sectors on every data access, while disks 1 and 3 access each sector in sequence as the disk revolves (there may, however, be a transparent hardware skew factor on these drives).

Appendix C

The DISKS macro generates n "disk header blocks," starting at address DPBASE which is a label generated by the macro. Each disk header block contains sixteen bytes, and correspond, in sequence, to each of the defined drives. In the four drive standard system, for example, the DISKS macro generates a table of the form:

```
DPBASE  EQU  $
DPEØ:   DW   XLTØ,ØØØØH,ØØØØH,ØØØØH,DIRBUF,DPBØ,CSVØ,ALVØ
DPE1:   DW   XLTØ,ØØØØH,ØØØØH,ØØØØH,DIRBUF,DPBØ,CSV1,ALV1
DPE2:   DW   XLTØ,ØØØØH,ØØØØH,ØØØØH,DIRBUF,DPBØ,CSV2,ALV2
DPE3:   DW   XLTØ,ØØØØH,ØØØØH,ØØØØH,DIRBUF,DPBØ,CSV3,ALV3
```

where the DPE (disk parameter entry) labels are included for reference purposes to show the beginning table addresses for each drive Ø through 3. The values contained within the disk parameter header are described in detail in the CP/M 2.Ø Alteration Guide, but basically address the translation vector for the drive (all reference XLTØ, which is the translation vector for drive Ø in the above example), followed by three 16-bit "scratch" addresses, followed by the directory buffer address, disk parameter block address, check vector address, and allocation vector address. The check and allocation vector addresses are generated by the ENDEF macro in the ram area following the BIOS code and tables.

The SELDSK function is extended somewhat in version 2.0. In particular, the selected disk number is passed to the BIOS in register C, as before, and the SELDSK subroutine performs the appropriate software or hardware actions to select the disk. Version 2.0, however, also requires the SELDSK subroutine to return the address of the selected disk parameter header (DPE0, DPE1, DPE2, or DPE3, in the above example) in register HL. If SELDSK returns the value HL = 0000H, then the BDOS assumes the disk does not exist, and prints a select error mesage at the terminal. Program lines 22 through 36 give a sample CP/M 2.0 SELDSK subroutine, showing only the disk parameter header address calculation.

The subroutine SECTRAN is also included in version 2.0 which performs the actual logical to physical sector translation. In earlier versions of CP/M, the sector translation process was a part of the BDOS, and set to skip six sectors between each read. Due differing rotational speeds of various disks, the translation function has become a part of the BIOS in version 2.0. Thus, the BDOS sends sequential sector numbers to SECTRAN, starting at sector number 0. The SECTRAN subroutine uses the sequential sector number to produce a translated sector number which is returned to the BDOS. The BDOS subsequently sends the translated sector number to SELSEC before the actual read or write is performed. Note that many controllers have the capability to record the sector skew on the disk itself, and thus there is no translation necessary. In this case, the "skf" parameter is omitted in the macro call, and SECTRAN simply returns the same value which it receives. The table shown below, for example, is constructed when the standard skew factor skf = 6 is specified in the DISKDEF macro call:

```
XLT0:  DB    1,7,13,19,25,5,11,17,23,3,9,15,21
       DB    2,8,14,20,26,6,12,18,24,4,10,16,22
```

If SECTRAN is required to translate a sector, then the following process takes place. The sector to translate is received in register pair BC. Only the C register is significant if the sector value does not exceed 255 (B = 00 in this case). Register pair DE addresses the sector translate table for this drive, determined by a previous call on SELDSK, corresponding to the first element of a disk parameter header (XLT0 in the case shown above). The SECTRAN subroutine then fetches the translated sector number by adding the input sector number to the base of the translate table, to get the indexed translate table address (see lines 46, 47, and 48 in the above program). The value at this location is then returned in register L. Note that if the number of sectors exceeds 255, the translate table contains 16-bit elements whose value must be returned in HL.

Following the ENDEF macro call, a number of uninitialized data areas are defined. These data areas need not be a part of the BIOS which is loaded upon cold start, but must be available between the BIOS and the end of memory. The size of the uninitialized RAM area is determined by EQU statements generated by the ENDEF macro. For a standard four-drive system, the ENDEF macro might produce

```
4C72 =          BEGDAT EQU $
                (data areas)
4DB0 =          ENDDAT EQU $
013C =          DATSIZ EQU $-BEGDAT
```

which indicates that uninitialized RAM begins at location 4C72H, ends at 4DB0H-1, and occupies 013CH bytes. You must ensure that these addresses are free for use after the system is loaded.

CP/M 2.0 is also easily adapated to disk subsystems whose sector size is a multiple of 128 bytes. Information is provided by the BDOS on sector write operations which eliminates the need for pre-read operations, thus allowing blocking and deblocking to take place at the BIOS level.

See the "CP/M 2.0 Alteration Guide" for additional details concerning tailoring your CP/M system to your particular hardware.

APPENDIX D

OPERATION OF THE CP/M DEBUGGER

DIGITAL RESEARCH

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CP/M DYNAMIC DEBUGGING TOOL (DDT)

USER'S GUIDE

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D

Disclaimer

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CP/M Dynamic Debugging Tool (DDT)

User's Guide

I. Introduction.

The DDT program allows dynamic interactive testing and debugging of programs generated in the CP/M environment. The debugger is initiated by typing one of the following commands at the CP/M Console Command level

```
DDT
DDT filename.HEX
DDT filename.COM
```

where "filename" is the name of the program to be loaded and tested. In both cases, the DDT program is brought into main memory in the place of the Console Command Processor (refer to the CP/M Interface Guide for standard memory organization), and thus resides directly below the Basic Disk Operating System portion of CP/M. The BDOS starting address, which is located in the address field of the JMP instruction at location 5H, is altered to reflect the reduced Transient Program Area size.

The second and third forms of the DDT command shown above perform the same actions as the first, except there is a subsequent automatic load of the specified HEX or COM file. The action is identical to the sequence of commands

```
DDT
Ifilename.HEX or Ifilename.COM
R
```

where the I and R commands set up and read the specified program to test (see the explanation of the I and R commands below for exact details).

Upon initiation, DDT prints a sign-on message in the format

```
nnK DDT-s VER m.m
```

where nn is the memory size (which must match the CP/M system being used), s is the hardware system which is assumed, corresponding to the codes

```
D   -   Digital Research standard version
M   -   MDS version
I   -   IMSAI standard version
O   -   Omron systems
S   -   Digital Systems standard version
```

and m.m is the revision number.

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Following the sign on message, DDT prompts the operator with the character "-" and waits for input commands from the console. The operator can type any of several single character commands, terminated by a carriage return to execute the command. Each line of input can be line-edited using the standard CP/M controls

rubout	remove the last character typed
ctl-U	remove the entire line, ready for re-typing
ctl-C	system reboot

Any command can be up to 32 characters in length (an automatic carriage return is inserted as the 33rd character), where the first character determines the command type

A	enter assembly language mnemonics with operands
D	display memory in hexadecimal and ASCII
F	fill memory with constant data
G	begin execution with optional breakpoints
I	set up a standard input file control block
L	list memory using assembler mnemonics
M	move a memory segment from source to destination
R	read program for subsequent testing
S	substitute memory values
T	trace program execution
U	untraced program monitoring
X	examine and optionally alter the CPU state

The command character, in some cases, is followed by zero, one, two, or three hexadecimal values which are separated by commas or single blank characters. All DDT numeric output is in hexadecimal form. In all cases, the commands are not executed until the carriage return is typed at the end of the command.

At any point in the debug run, the operator can stop execution of DDT using either a ctl-C or G0 (jmp to location 0000H), and save the current memory image using a SAVE command of the form

```
SAVE n filename.COM
```

where n is the number of pages (256 byte blocks) to be saved on disk. The number of blocks can be determined by taking the high order byte of the top load address and converting this number to decimal. For example, if the highest address in the Transient Program Area is 1234H then the number of pages is 12H, or 18 in decimal. Thus the operator could type a ctl-C during the debug run, returning to the Console Processor level, followed by

```
SAVE 18 X.COM
```

The memory image is saved as X.COM on the diskette, and can be directly executed by simply typing the name X. If further testing is required, the memory image can be recalled by typing

DDT X.COM

which reloads previously saved program from loaction 100H through page 18 (12FFH). The machine state is not a part of the COM file, and thus the program must be restarted from the beginning in order to properly test it.

II. DDT COMMANDS.

The individual commands are given below in some detail. In each case, the operator must wait for the prompt character (-) before entering the command. If control is passed to a program under test, and the program has not reached a breakpoint, control can be returned to DDT by executing a RST 7 from the front panel (note that the rubout key should be used instead if the program is executing a T or U command). In the explanation of each command, the command letter is shown in some cases with numbers separated by commas, where the numbers are represented by lower case letters. These numbers are always assumed to be in a hexadecimal radix, and from one to four digits in length (longer numbers will be automatically truncated on the right).

Many of the commands operate upon a "CPU state" which corresponds to the program under test. The CPU state holds the registers of the program being debugged, and initially contains zeroes for all registers and flags except for the program counter (P) and stack pointer (S), which default to 100H. The program counter is subsequently set to the starting address given in the last record of a HEX file if a file of this form is loaded (see the I and R commands).

1. The A (Assemble) Command. DDT allows inline assembly language to be inserted into the current memory image using the A command which takes the form

As

where s is the hexadecimal starting address for the inline assembly. DDT prompts the console with the address of the next instruction to fill, and reads the console, looking for assembly language mnemonics (see the Intel 8080 Assembly Language Reference Card for a list of mnemonics), followed by register references and operands in absolute hexadecimal form. Each sucessive load address is printed before reading the console. The A command terminates when the first empty line is input from the console.

Upon completion of assembly language input, the operator can review the memory segment using the DDT disassembler (see the L command).

Note that the assembler/disassembler portion of DDT can be overlayed by the transient program being tested, in which case the DDT program responds with an error condition when the A and L commands are used (refer to Section IV).

2. The D (Display) Command. The D command allows the operator to view the contents of memory in hexadecimal and ASCII formats. The forms are

D
Ds
Ds,f

In the first case, memory is displayed from the current display address (initially 1ØØH), and continues for 16 display lines. Each display line takes the form shown below

aaaa bb bb bb bb bb bb bb bb bb bb bb bb bb bb bb bb cccccccccccccccc

where aaaa is the display address in hexadecimal, and bb represents data present in memory starting at aaaa. The ASCII characters starting at aaaa are given to the right (represented by the sequence of c´s), where non-graphic characters are printed as a period (.) symbol. Note that both upper and lower case alphabetics are displayed, and thus will appear as upper case symbols on a console device that supports only upper case. Each display line gives the values of 16 bytes of data, except that the first line displayed is truncated so that the next line begins at an address which is a multiple of 16.

The second form of the D command shown above is similar to the first, except that the display address is first set to address s. The third form causes the display to continue from address s through address f. In all cases, the display address is set to the first address not displayed in this command, so that a continuing display can be accomplished by issuing successive D commands with no explicit addresses.

Excessively long displays can be aborted by pushing the rubout key.

3. The F (Fill) Command. The F command takes the form

Fs,f,c

where s is the starting address, f is the final address, and c is a hexadecimal byte constant. The effect is as follows: DDT stores the constant c at address s, increments the value of s and tests against f. If s exceeds f then the operation terminates, otherwise the operation is repeated. Thus, the fill command can be used to set a memory block to a specific constant value.

4. The G (Go) Command. Program execution is started using the G comand, with up to two optional breakpoint addresses. The G command takes one ot the forms

G
Gs
Gs,b

Gs,b,c
G,b
G,b,c

The first form starts execution of the program under test at the current value of the program counter in the current machine state, with no breakpoints set (the only way to regain control in DDT is through a RST 7 execution). The current program counter can be viewed by typing an X or XP command. The second form is similar to the first except that the program counter in the current machine state is set to address s before execution begins. The third form is the same as the second, except that program execution stops when address b is encountered (b must be in the area of the program under test). The instruction at location b is not executed when the breakpoint is encountered. The fourth form is identical to the third, except that two breakpoints are specified, one at b and the other at c. Encountering either breakpoint causes execution to stop, and both breakpoints are subsequently cleared. The last two forms take the program counter from the current machine state, and set one and two breakpoints, respectively.

Execution continues from the starting address in real-time to the next breakpoint. That is, there is no intervention between the starting address and the break address by DDT. Thus, if the program under test does not reach a breakpoint, control cannot return to DDT without executing a RST 7 instruction. Upon encountering a breakpoint, DDT stops execution and types

*d

where d is the stop address. The machine state can be examined at this point using the X (Examine) command. The operator must specify breakpoints which differ from the program counter address at the beginning of the G command. Thus, if the current program counter is 1234H, then the commands

G,1234

and

G4ØØ,4ØØ

both produce an immediate breakpoint, without executing any instructions whatsoever.

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5. The I (Input) Command. The I command allows the operator to insert a file name into the default file control block at 5CH (the file control block created by CP/M for transient programs is placed at this location; see the CP/M Interface Guide). The default FCB can be used by the program under test as if it had been passed by the CP/M Console Processor. Note that this file name is also used by DDT for reading additional HEX and COM files. The form of the I command is

Ifilename

or

Ifilename.filetype

If the second form is used, and the filetype is either HEX or COM, then subsequent R commands can be used to read the pure binary or hex format machine code (see the R command for further details).

6. The L (List) Command. The L command is used to list assembly language mnemonics in a particular program region. The forms are

L
Ls
Ls,f

The first command lists twelve lines of disassembled machine code from the current list address. The second form sets the list address to s, and then lists twelve lines of code. The last form lists disassembled code from s through address f. In all three cases, the list address is set to the next unlisted location in preparation for a subsequent L command. Upon encountering an execution breakpoint, the list address is set to the current value of the program counter (see the G and T commands). Again, long typeouts can be aborted using the rubout key during the list process.

7. The M (Move) Command. The M command allows block movement of program or data areas from one location to another in memory. The form is

Ms,f,d

where s is the start address of the move, f is the final address of the move, and d is the destination address. Data is first moved from s to d, and both addresses are incremented. If s exceeds f then the move operation stops, otherwise the move operation is repeated.

8. The R (Read) Command. The R command is used in conjunction with the I command to read COM and HEX files from the diskette into the transient program area in preparation for the debug run. The forms are

R
Rb

where b is an optional bias address which is added to each program or data address as it is loaded. The load operation must not overwrite any of the system parameters from 000H through 0FFH (i.e., the first page of memory). If b is omitted, then b=0000 is assumed. The R command requires a previous I command, specifying the name of a HEX or COM file. The load address for each record is obtained from each individual HEX record, while an assumed load address of 100H is taken for COM files. Note that any number of R commands can be issued following the I command to re-read the program under test, assuming the tested program does not destroy the default area at 5CH. Further, any file specified with the filetype "COM" is assumed to contain machine code in pure binary form (created with the LOAD or SAVE command), and all others are assumed to contain machine code in Intel hex format (produced, for example, with the ASM command).

Recall that the command

```
DDT filename.filetype
```

which initiates the DDT program is equivalent to the commands

```
DDT
-Ifilename.filetype
-R
```

Whenever the R command is issued, DDT responds with either the error indicator "?" (file cannot be opened, or a checksum error occurred in a HEX file), or with a load message taking the form

```
NEXT  PC
nnnn pppp
```

where nnnn is the next address following the loaded program, and pppp is the assumed program counter (1ØØH for COM files, or taken from the last record if a HEX file is specified).

9. The S (Set) Command. The S command allows memory locations to be examined and optionally altered. The form of the command is

```
Ss
```

where s is the hexadecimal starting address for examination and alteration of memory. DDT responds with a numeric prompt, giving the memory location, along with the data currently held in the memory location. If the operator types a carriage return, then the data is not altered. If a byte value is typed, then the value is stored at the prompted address. In either case, DDT continues to prompt with successive addresses and values until either a period (.) is typed by the operator, or an invalid input value is detected.

Appen
D

1Ø. The T (Trace) Command. The T command allows selective tracing of program execution for 1 to 65535 program steps. The forms are

```
T
Tn
```

In the first case, the CPU state is displayed, and the next program step is executed. The program terminates immediately, with the termination address displayed as

*hhhh

where hhhh is the next address to execute. The display address (used in the D command) is set to the value of H and L, and the list address (used in the L command) is set to hhhh. The CPU state at program termination can then be examined using the X command.

The second form of the T command is similar to the first, except that execution is traced for n steps (n is a hexadecimal value) before a program breakpoint is occurs. A breakpoint can be forced in the trace mode by typing a rubout character. The CPU state is displayed before each program step is taken in trace mode. The format of the display is the same as described in the X command.

Note that program tracing is discontinued at the interface to CP/M, and resumes after return from CP/M to the program under test. Thus, CP/M functions which access I/O devices, such as the diskette drive, run in real-time, avoiding I/O timing problems. Programs running in trace mode execute approximately 500 times slower than real time since DDT gets control after each user instruction is executed. Interrupt processing routines can be traced, but it must be noted that commands which use the breakpoint facility (G, T, and U) accomplish the break using a RST 7 instruction, which means that the tested program cannot use this interrupt location. Further, the trace mode always runs the tested program with interrupts enabled, which may cause problems if asynchronous interrupts are received during tracing.

Note also that the operator should use the rubout key to get control back to DDT during trace, rather than executing a RST 7, in order to ensure that the trace for the current instruction is completed before interruption.

11. The U (Untrace) Command. The U command is identical to the T command except that intermediate program steps are not displayed. The untrace mode allows from 1 to 65535 (0FFFFH) steps to be executed in monitored mode, and is used principally to retain control of an executing program while it reaches steady state conditions. All conditions of the T command apply to the U command.

12. The X (Examine) Command. The X command allows selective display and alteration of the current CPU state for the program under test. The forms are

X
Xr

where r is one of the 8080 CPU registers

C	Carry Flag	(0/1)
Z	Zero Flag	(0/1)

M	Minus Flag	(0/1)
E	Even Parity Flag	(0/1)
I	Interdigit Carry	(0/1)
A	Accumulator	(0-FF)
B	BC register pair	(0-FFFF)
D	DE register pair	(0-FFFF)
H	HL register pair	(0-FFFF)
S	Stack Pointer	(0-FFFF)
P	Program Counter	(0-FFFF)

In the first case, the CPU register state is displayed in the format

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

where f is a 0 or 1 flag value, bb is a byte value, and dddd is a double byte quantity corresponding to the register pair. The "inst" field contains the disassembled instruction which occurs at the location addressed by the CPU state's program counter.

The second form allows display and optional alteration of register values, where r is one of the registers given above (C, Z, M, E, I, A, B, D, H, S, or P). In each case, the flag or register value is first displayed at the console. The DDT program then accepts input from the console. If a carriage return is typed, then the flag or register value is not altered. If a value in the proper range is typed, then the flag or register value is altered. Note that BC, DE, and HL are displayed as register pairs. Thus, the operator types the entire register pair when B, C, or the BC pair is altered.

III. IMPLEMENTATION NOTES.

The organization of DDT allows certain non-essential portions to be overlayed in order to gain a larger transient program area for debugging large programs. The DDT program consists of two parts: the DDT nucleus and the assembler/disassembler module. The DDT nucleus is loaded over the Console Command Processor, and, although loaded with the DDT nucleus, the assembler/disassembler is overlayable unless used to assemble or disassemble.

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In particular, the BDOS address at location 6H (address field of the JMP instruction at location 5H) is modified by DDT to address the base location of the DDT nucleus which, in turn, contains a JMP instruction to the BDOS. Thus, programs which use this address field to size memory see the logical end of memory at the base of the DDT nucleus rather than the base of the BDOS.

The assembler/disassembler module resides directly below the DDT nucleus in the transient program area. If the A, L, T, or X commands are used during the debugging process then the DDT program again alters the address field at 6H to include this module, thus further reducing the logical end of memory. If a program loads beyond the beginning of the assembler/disassembler module, the A and L commands are lost (their use produces a "?" in response), and the trace and display (T and X) commands list the "inst" field of the display in hexadecimal, rather than as a decoded instruction.

IV. AN EXAMPLE.

The following example shows an edit, assemble, and debug for a simple program which reads a set of data values and determines the largest value in the set. The largest value is taken from the vector, and stored into "LARGE" at the termination of the program

tab character

rubout

rubout echo

```
ED SCAN.ASM
*I
      ORG     100H        L̲L;START OF TRANSIENT AREA
      MVI     B,LEN       ;LENGTH OF VECTOR TO SCAN
      MVI     C,0         ;LARGER_RST VALUE SO FAR
LOOP__P_O_O_L LXI H,VECT  ;BASE OF VECTOR
LOOP: MOV     A,M         ;GET VALUE
      SUB     C           ;LARGER VALUE IN C?
      JNC     NFOUND      ;JUMP IF LARGER VALUE NOT FOUND
;     NEW LARGEST VALUE, STORE IT TO C
      MOV     C,A
NFOUND: INX   H           ;TO NEXT ELEMENT
      DCR     B           ;MORE TO SCAN?
      JNZ     LOOP        ;FOR ANOTHER
;
;     END OF SCAN, STORE C
      MOV     A,C         ;GET LARGEST VALUE
      STA     LARGE
      JMP     0           ;REBOOT
;
;     TEST DATA
VECT: DB      2,0,4,3,5,6,1,5
LEN   EQU     $-VECT      ;LENGTH
LARGE: DS     1           ;LARGEST VALUE ON EXIT
      END
*B0P
      ORG     100H        ;START OF TRANSIENT AREA
      MVI     B,LEN       ;LENGTH OF VECTOR TO SCAN
      MVI     C,0         ;LARGEST VALUE SO FAR
      LXI     H,VECT      ;BASE OF VECTOR
LOOP: MOV     A,M         ;GET VALUE
      SUB     C           ;LARGER VALUE IN C?
      JNC     NFOUND      ;JUMP IF LARGER VALUE NOT FOUND
;     NEW LARGEST VALUE, STORE IT TO C
      MOV     C,A
NFOUND: INX   H           ;TO NEXT ELEMENT
      DCR     B           ;MORE TO SCAN?
      JNZ     LOOP        ;FOR ANOTHER
```

Rubout deletes character

Create Source Program - underlined characters typed by programmer. "↵" represents carriage return.

```
;         END OF SCAN, STORE C
          MOV      A,C       ;GET LARGEST VALUE
          STA      LARGE
          JMP      0         ;REBOOT
;
;         TEST DATA
VECT:     DB       2,0,4,3,5,6,1,5
LEN       EQU      $-VECT    ;LENGTH
LARGE:    DS       1         ;LARGEST VALUE ON EXIT
          END
*E        <- End of Edit


ASM SCAN      Start Assembler
CP/M ASSEMBLER - VER 1.0

0122
002H USE FACTOR
END OF ASSEMBLY     Assembly Complete - Look at Program Listing

TYPE SCAN.PRN

ode Address        Source Program
 0100   Machine Code          ORG      100H      ;START OF TRANSIENT AREA
 0100 0608                    MVI      B,LEN     ;LENGTH OF VECTOR TO SCAN
 0102 0E00                    MVI      C,0       ;LARGEST VALUE SO FAR
 0104 211901                  LXI      H,VECT    ;BASE OF VECTOR
 0107 7E            LOOP:     MOV      A,M       ;GET VALUE
 0108 91                      SUB      C         ;LARGER VALUE IN C?
 0109 D20D01                  JNC      NFOUND    ;JUMP IF LARGER VALUE NOT FOUND
                    ;         NEW LARGEST VALUE, STORE IT TO C
 010C 4F                      MOV      C,A
 010D 23            NFOUND:   INX      H         ;TO NEXT ELEMENT
 010E 05                      DCR      B         ;MORE TO SCAN?
 010F C20701                  JNZ      LOOP      ;FOR ANOTHER
                    ;
                    ;         END OF SCAN, STORE C
 0112 79                      MOV      A,C       ;GET LARGEST VALUE
 0113 322101                  STA      LARGE
 0116 C30000                  JMP      0         ;REBOOT
      Code/data listing ;
      truncated         ;     TEST DATA
 0119 0200040305VECT:         DB       2,0,4,3,5,6,1,5
 0008 =             LEN       EQU      $-VECT    ;LENGTH
 0121 Value of      LARGE:    DS       1         ;LARGEST VALUE ON EXIT
 0122  Equate                 END
A>
```

Appendix D

```
DDT SCAN.HEX        Start Debugger using hex format machine code
16K DDT VER 1.0
NEXT  PC
0121  0000
-X                  last load address +1
                                                                      next instruction
                                                                      to execute at
C0Z0M0E0I0 A=00 B=0000 D=0000 H=0000 S=0100 P=0000 OUT  7F            PC=0
-XP                 Examine registers before debug run
P=0000 100          Change PC to 100
-X                  Look at registers again
                                                              PC changed.
C0Z0M0E0I0 A=00 B=0000 D=0000 H=0000 S=0100 P=0100 MVI  B,08
-L100                                                          Next instruction
                                                               to execute at PC=100
0100  MVI   B,08
0102  MVI   C,00
0104  LXI   H,0119
0107  MOV   A,M
0108  SUB   C
0109  JNC   010D     Disassembled Machine
010C  MOV   C,A      Code at 100H
010D  INX   H        (See Source Listing
010E  DCR   B        for comparison)
010F  JNZ   0107
0112  MOV   A,C
-L
0113  STA   0121
0116  JMP   0000
0119  STAX  B
011A  NOP
011B  INR   B        A litte more
011C  INX   B        machine code
011D  DCR   B        (note that Program
011E  MVI   B,01     ends at location 116
0120  DCR   B        with a JMP to 0000)
0121  LXI   D,2200
0124  LXI   H,0200
-A116     enter inline assembly mode to change the JMP to 0000 into a RST 7, which
          will cause the program under test to return to DDT if 116H
0116  RST 7         is ever executed.
0117      (single carriage return stops assemble mode)
-L113     List code at 113H to check that RST 7 was properly inserted
0113  STA   0121    in place of JMP
0116  RST   07
```

```
0117   NOP
0118   NOP
0119   STAX  B
011A   NOP
011B   INR   B
011C   INX   B
-
```

-X, Look at registers

```
C0Z0M0E0I0 A=00 B=0000 D=0000 H=0000 S=0100 P=0100 MVI   B,08
```

-I, Execute Program for one step. initial CPU state, before , is executed

```
C0Z0M0E0I0 A=00 B=0000 D=0000 H=0000 S=0100 P=0100 MVI   B,08*0102
```

-I, Trace one step again (note 08H in B) automatic breakpoint

```
C0Z0M0E0I0 A=00 B=0800 D=0000 H=0000 S=0100 P=0102 MVI   C,00*0104
```

-I, Trace again (Register C is cleared)

```
C0Z0M0E0I0 A=00 B=0800 D=0000 H=0000 S=0100 P=0104 LXI   H,0119*0107
```

-T3, Trace three steps

```
C0Z0M0E0I0 A=00 B=0800 D=0000 H=0119 S=0100 P=0107 MOV   A,M
C0Z0M0E0I0 A=02 B=0800 D=0000 H=0119 S=0100 P=0108 SUB   C
C0Z0M0E0I1 A=02 B=0800 D=0000 H=0119 S=0100 P=0109 JNC   010D*010D
```

-D119, Display memory starting at 119H. automatic breakpoint at 10DH

Program data

Lower case x

```
0119 02 00 04 03 05 06 01                         .......
0120 05 11 00 22 21 00 02 7E EB 77 13 23 EB 0B 78 B1 ..."!..^.W.#..x.
0130 C2 27 01 C3 03 29 00 00 00 00 00 00 00 00 00 00 .'...)..........
0140 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ................
0150 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ................
0160 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ................
0170 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ................
0180 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ................
0190 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ................
01A0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ................
01B0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ................
01C0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ................
```

Data is displayed in ASCII with a "." in the position of non-graphic characters

-X, Current CPU state

```
C0Z0M0E0I1 A=02 B=0800 D=0000 H=0119 S=0100 P=010D INX   H
```

-T5, Trace 5 steps from current CPU state

```
C0Z0M0E0I1 A=02 B=0800 D=0000 H=0119 S=0100 P=010D INX   H
C0Z0M0E0I1 A=02 B=0800 D=0000 H=011A S=0100 P=010E DCR   B
C0Z0M0E0I1 A=02 B=0700 D=0000 H=011A S=0100 P=010F JNZ   0107
C0Z0M0E0I1 A=02 B=0700 D=0000 H=011A S=0100 P=0107 MOV   A,M
C0Z0M0E0I1 A=00 B=0700 D=0000 H=011A S=0100 P=0108 SUB   C*0109
```

Automatic Breakpoint

-U5, Trace without listing intermediate states

```
C0Z1M0E1I1 A=00 B=0700 D=0000 H=011A S=0100 P=0109 JNC   010D*0108
```

-X, CPU state at end of U5,

```
C0Z0M0E1I1 A=04 B=0600 D=0000 H=011B S=0100 P=0108 SUB   C
```

Appendix D

-G Run Program from current PC until completion (in real-time)

*0116 breakpoint at 116H, caused by executing RST 7 in machine code

-X CPU state at end of Program

```
C0Z1M0E1I1 A=00 B=0000 D=0000 H=0121 S=0100 P=0116 RST  07
```

-XP examine and change Program counter

```
P=0116 100

-X

C0Z1M0E1I1 A=00 B=0000 D=0000 H=0121 S=0100 P=0100 MVI  B,08
```

-T10 Trace 10 (hexadecimal) steps

first data element — current largest value — subtract for comparison A<C

```
C0Z1M0E1I1 A=00 B=0000 D=0000 H=0121 S=0100 P=0100 MVI  B,08
C0Z1M0E1I1 A=00 B=0800 D=0000 H=0121 S=0100 P=0102 MVI  C,00
C0Z1M0E1I1 A=00 B=0800 D=0000 H=0121 S=0100 P=0104 LXI  H,0119
C0Z1M0E1I1 A=00 B=0800 D=0000 H=0119 S=0100 P=0107 MOV  A,M
C0Z1M0E1I1 A=02 B=0800 D=0000 H=0119 S=0100 P=0108 SUB  C
C0Z0M0E0I1 A=02 B=0800 D=0000 H=0119 S=0100 P=0109 JNC  010D
C0Z0M0E0I1 A=02 B=0800 D=0000 H=0119 S=0100 P=010D INX  H
C0Z0M0E0I1 A=02 B=0800 D=0000 H=011A S=0100 P=010E DCR  B
C0Z0M0E0I1 A=02 B=0700 D=0000 H=011A S=0100 P=010F JNZ  0107
C0Z0M0E0I1 A=02 B=0700 D=0000 H=011A S=0100 P=0107 MOV  A,M
C0Z0M0E0I1 A=00 B=0700 D=0000 H=011A S=0100 P=0108 SUB  C
C0Z1M0E1I1 A=00 B=0700 D=0000 H=011A S=0100 P=0109 JNC  010D
C0Z1M0E1I1 A=00 B=0700 D=0000 H=011A S=0100 P=010D INX  H
C0Z1M0E1I1 A=00 B=0700 D=0000 H=011B S=0100 P=010E DCR  B
C0Z0M0E1I1 A=00 B=0600 D=0000 H=011B S=0100 P=010F JNZ  0107
C0Z0M0E1I1 A=00 B=0600 D=0000 H=011B S=0100 P=0107 MOV  A,M*0108
```

-A109 Insert a "hot patch" into the machine code to change the JNC to JC

```
0109  JC 10D
010C
```

Program should have moved the value from A into C since A>C. Since this code was not executed, it appears that the JNC should have been a JC instruction

-G0 Stop DDT so that a version of the patched program can be saved

SAVE 1 SCAN.COM Program resides on first page, so save 1 page.

A>DDT SCAN.COM Restart DDT with the saved memory image to continue testing

```
16K DDT VER 1.0
NEXT  PC
0200 0100
```

-L100 List some code

```
0100  MVI  B,08
0102  MVI  C,00
0104  LXI  H,0119
0107  MOV  A,M
0108  SUB  C
0109  JC   010D
```

Previous patch is present in X.COM

```
0100C  MOV  C,A
010D   INX  H
010E   DCR  B
010F   JNZ  0107
0112   MOV  A,C
-XP
```

P=0100

-T10 Trace to see how patched version operates

Data is moved from A to C

```
C0Z0M0E0I0 A=00 B=0000 D=0000 H=0000 S=0100 P=0100 MVI  B,08
C0Z0M0E0I0 A=00 B=0800 D=0000 H=0000 S=0100 P=0102 MVI  C,00
C0Z0M0E0I0 A=00 B=0800 D=0000 H=0000 S=0100 P=0104 LXI  H,0119
C0Z0M0E0I0 A=00 B=0800 D=0000 H=0119 S=0100 P=0107 MOV  A,M
C0Z0M0E0I0 A=02 B=0800 D=0000 H=0119 S=0100 P=0108 SUB  C
C0Z0M0E0I1 A=02 B=0800 D=0000 H=0119 S=0100 P=0109 JC   010D
C0Z0M0E0I1 A=02 B=0800 D=0000 H=0119 S=0100 P=010C MOV  C,A
C0Z0M0E0I1 A=02 B=0802 D=0000 H=0119 S=0100 P=010D INX  H
C0Z0M0E0I1 A=02 B=0802 D=0000 H=011A S=0100 P=010E DCR  B
C0Z0M0E0I1 A=02 B=0702 D=0000 H=011A S=0100 P=010F JNZ  0107
C0Z0M0E0I1 A=02 B=0702 D=0000 H=011A S=0100 P=0107 MOV  A,M
C0Z0M0E0I1 A=00 B=0702 D=0000 H=011A S=0100 P=0108 SUB  C
C1Z0M1E0I0 A=FE B=0702 D=0000 H=011A S=0100 P=0109 JC   010D
C1Z0M1E0I0 A=FE B=0702 D=0000 H=011A S=0100 P=010D INX  H
C1Z0M1E0I0 A=FE B=0702 D=0000 H=011B S=0100 P=010E DCR  B
C1Z0M0E1I1 A=FE B=0602 D=0000 H=011B S=0100 P=010F JNZ  0107*0107
-X
```

breakpoint after 16 steps

```
C1Z0M0E1I1 A=FE B=0602 D=0000 H=011B S=0100 P=0107 MOV  A,M
-G,108
```

Run from current PC and breakpoint at 108H

```
*0108
-X
```

next data item

```
C1Z0M0E1I1 A=04 B=0602 D=0000 H=011B S=0100 P=0108 SUB  C
-I
```

Single Step for a few cycles

```
C1Z0M0E1I1 A=04 B=0602 D=0000 H=011B S=0100 P=0108 SUB  C*0109
-I
C0Z0M0E0I1 A=02 B=0602 D=0000 H=011B S=0100 P=0109 JC   010D*010C
-X
C0Z0M0E0I1 A=02 B=0602 D=0000 H=011B S=0100 P=010C MOV  C,A
-G
```

Run to completion

```
*0116
-X
C0Z1M0E1I1 A=03 B=0003 D=0000 H=0121 S=0100 P=0116 RST  07
-S121
```

look at the value of "LARGE"

0121 03 Wrong Value!

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```
0122 00
0123 22
0124 21
0125 00
0126 02       End of the S command
0127 7E .
-L100
0100   MVI   B,08
0102   MVI   C,00
0104   LXI   H,0119
0107   MOV   A,M
0108   SUB   C
0109   JC    010D
010C   MOV   C,A
010D   INX   H
010E   DCR   B
010F   JNZ   0107
0112   MOV   A,C          Review the code
-L
0113   STA   0121
0116   RST   07
0117   NOP
0118   NOP
0119   STAX  B
011A   NOP
011B   INR   B
011C   INX   B
011D   DCR   B
011E   MVI   B,01
0120   DCR   B
-XP
P=0116 100    Reset the PC
-I   Single step, and watch data values
C0Z1M0E1I1 A=03 B=0003 D=0000 H=0121 S=0100 P=0100 MVI  B,08*0102
-I
C0Z1M0E1I1 A=03 B=0803 D=0000 H=0121 S=0100 P=0102 MVI  C,00*0104
-I
                 Count set
                   "largest" set
C0Z1M0E1I1 A=03 B=0800 D=0000 H=0121 S=0100 P=0104 LXI  H,0119*0107
-I
                                base address of data set
C0Z1M0E1I1 A=03 B=0800 D=0000 H=0119 S=0100 P=0107 MOV  A,M*0108
```

```
-T
                 first data item brought to A
C0Z1M0E1I1 A=02 B=0800 D=0000 H=0119 S=0100 P=0108 SUB  C*0109
-T

C0Z0M0E0I1 A=02 B=0800 D=0000 H=0119 S=0100 P=0109 JC   010D*010C
-T

C0Z0M0E0I1 A=02 B=0800 D=0000 H=0119 S=0100 P=010C MOV  C,A*010D
-T                     first data item moved to C correctly

C0Z0M0E0I1 A=02 B=0802 D=0000 H=0119 S=0100 P=010D INX  H*010E
-T

C0Z0M0E0I1 A=02 B=0802 D=0000 H=011A S=0100 P=010E DCR  B*010F
-T

C0Z0M0E0I1 A=02 B=0702 D=0000 H=011A S=0100 P=010F JNZ  0107*0107
-T

C0Z0M0E0I1 A=02 B=0702 D=0000 H=011A S=0100 P=0107 MOV  A,M*0108
-T               second data item brought to A

C0Z0M0E0I1 A=00 B=0702 D=0000 H=011A S=0100 P=0108 SUB  C*0109
-T               subtract destroys data value which was loaded!!!

C1Z0M1E0I0 A=FE B=0702 D=0000 H=011A S=0100 P=0109 JC   010D*010D
-T

C1Z0M1E0I0 A=FE B=0702 D=0000 H=011A S=0100 P=010D INX  H*010E
-L100

0100  MVI  B,08
0102  MVI  C,00
0104  LXI  H,0119
0107  MOV  A,M
0108  SUB  C  <----- This should have been a CMP so that register A
0109  JC   010D      would not be destroyed.
010C  MOV  C,A
010D  INX  H
010E  DCR  B
010F  JNZ  0107
0112  MOV  A,C
-A108

0108  CMP C       hot patch at 108H changes SUB to CMP

0109

-G0    stop DDT for SAVE
```

Append D

```
SAVE 1 SCAN.COM         Save memory image
A>DDT SCAN.COM          Restart DDT

16K DDT VER 1.0
NEXT  PC
0200 0100
-XP

P=0100

-L116

0116  RST  07
0117  NOP
0118  NOP         Look at code to see if it was properly Loaded
0119  STAX B      (long typeout aborted with rubout)
011A  NOP
- (rubout)

-G,116      Run from 100H to completion

*0116
-XC      Look at Carry (accidental typo)

C1

-X    Look at CPU state
C1Z1M0E1I1 A=06 B=0006 D=0000 H=0121 S=0100 P=0116 RST  07
-S121     Look at "Large" - it appears to be correct.
0121 06

0122 00

0123 22 .

-G0     stop DDT

ED SCAN.ASM      Re-edit the source program, and make both changes

*NSUB
*0LT                 ctl-z
        SUB     C          ;LARGER VALUE IN C?
*SSUB↑ZCMP↑Z0LT
        CMP     C          ;LARGER VALUE IN C?
*
        JNC     NFOUND     ;JUMP IF LARGER VALUE NOT FOUND
*SNC↑ZC↑Z0LT
        JC      NFOUND     ;JUMP IF LARGER VALUE NOT FOUND
*E
```

```
ASM SCAN.AAZ        Re-assemble, selecting source from disk A
                                               hex to disk A
CP/M ASSEMBLER - VER 1.0                       Print to Z (selects no print file)

0122
002H USE FACTOR
END OF ASSEMBLY

DDT SCAN.HEX        Re-run debugger to check changes

16K DDT VER 1.0
NEXT  PC
0121 0000
-L116

0116  JMP  0000     check to ensure end is still at 116H
0119  STAX B
011A  NOP
011B  INR  B
- (rubout)

-G100,116           Go from beginning with breakpoint at end

*0116    breakpoint reached
-D121    Look at "LARGE"          correct value computed

0121 06 00 22 21 00 02 7E EB 77 13 23 EB 0B 78 B1  .."!..^.W.#..X.
0130 C2 27 01 C3 03 29 00 00 00 00 00 00 00 00 00 00 .'...)..........
0140 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ................

- (rubout)      aborts long typeout

-G0             stop DDT, debug session complete
```

Append
D

APPENDIX E

OPERATION OF THE CP/M ASSEMBLER

DIGITAL RESEARCH

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CP/M ASSEMBLER (ASM)

USER'S GUIDE

Appendix E

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CP/M Assembler User's Guide

1. INTRODUCTION.

The CP/M assembler reads assembly language source files from the diskette, and produces 8080 machine language in Intel hex format. The CP/M assembler is initiated by typing

ASM filename

or

ASM filename.parms

In both cases, the assembler assumes there is a file on the diskette with the name

filename.ASM

which contains an 8080 assembly language source file. The first and second forms shown above differ only in that the second form allows parameters to be passed to the assembler to control source file access and hex and print file destinations.

In either case, the CP/M assembler loads, and prints the message

CP/M ASSEMBLER VER n.n

where n.n is the current version number. In the case of the first command, the assembler reads the source file with assumed file type "ASM" and creates two output files

filename.HEX

and

filename.PRN

the "HEX" file contains the machine code corresponding to the original program in Intel hex format, and the "PRN" file contains an annotated listing showing generated machine code, error flags, and source lines. If errors occur during translation, they will be listed in the PRN file as well as at the console

The second command form can be used to redirect input and output files from their defaults. In this case, the "parms" portion of the command is a three letter group which specifies the origin of the source file, the destination of the hex file, and the destination of the print file. The form is

filename.p1p2p3

where p1, p2, and p3 are single letters

p1: A,B, ..., Y designates the disk name which contains

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		the source file
p2:	A,B, ..., Y	designates the disk name which will receive the hex file
	Z	skips the generation of the hex file
p3:	A,B, ..., Y	designates the disk name which will receive the print file
	X	places the listing at the console
	Z	skips generation of the print file

Thus, the command

```
ASM X.AAA
```

indicates that the source file (X.ASM) is to be taken from disk A, and that the hex (X.HEX) and print (X.PRN) files are to be created also on disk A. This form of the command is implied if the assembler is run from disk A. That is, given that the operator is currently addressing disk A, the above command is equivalent to

```
ASM X
```

The command

```
ASM X.ABX
```

indicates that the source file is to be taken from disk A, the hex file is placed on disk B, and the listing file is to be sent to the console. The command

```
ASM X.BZZ
```

takes the source file from disk B, and skips the generation of the hex and print files (this command is useful for fast execution of the assembler to check program syntax).

The source program format is compatible with both the Intel 8080 assembler (macros are not currently implemented in the CP/M assembler, however), as well as the Processor Technology Software Package #1 assembler. That is, the CP/M assembler accepts source programs written in either format. There are certain extensions in the CP/M assembler which make it somewhat easier to use. These extensions are described below.

2. PROGRAM FORMAT.

An assembly language program acceptable as input to the assembler consists of a sequence of statements of the form

```
line#    label    operation    operand    ;comment
```

where any or all of the fields may be present in a particular instance. Each

-embly language statement is terminated with a carriage return and line feed (the line feed is inserted automatically by the ED program), or with the character "!" which is a treated as an end-of-line by the assembler (thus, multiple assembly language statements can be written on the same physical line if separated by exclaim symbols).

The line# is an optional decimal integer value representing the source program line number, which is allowed on any source line to maintain compatibility with the Processor Technology format. In general, these line numbers will be inserted if a line-oriented editor is used to construct the original program, and thus ASM ignores this field if present.

The label field takes the form

identifier

or

identifier:

and is optional, except where noted in particular statement types. The identifier is a sequence of alphanumeric characters (alphabetics and numbers), where the first character is alphabetic. Identifiers can be freely used by the programmer to label elements such as program steps and assembler directives, but cannot exceed 16 characters in length. All characters are significant in an identifier, except for the embedded dollar symbol ($) which can be used to improve readability of the name. Further, all lower case alphabetics become are treated as if they were upper case. Note that the ":" following the identifier in a label is optional (to maintain compatibility between Intel and Processor Technology). Thus, the following are all valid instances of labels

```
x       xy      long$name
x:      yxl:    longer$named$data:
XlY2    Xlx2    x234$5678$9Ø12$3456:
```

The operation field contains either an assembler directive, or pseudo operation, or an 8Ø8Ø machine operation code. The pseudo operations and machine operation codes are described below.

The operand field of the statement, in general, contains an expression formed out of constants and labels, along with arithmetic and logical operations on these elements. Again, the complete details of properly formed expressions are given below.

The comment field contains arbitrary characters following the ";" symbol until the next real or logical end-of-line. These characters are read, listed, and otherwise ignored by the assembler. In order to maintain compatability with the Processor Technology assembler, the CP/M assembler also treat statements which begin with a "*" in column one as comment statements, which are listed and ignored in the assembly process. Note that the Processor

Technology assembler has the side effect in its operation of ignoring the characters after the operand field has been scanned. This causes an ambiguous situation when attempting to be compatible with Intel's language, since arbitrary expressions are allowed in this case. Hence, programs which use this side effect to introduce comments, must be edited to place a ";" before these fields in order to assemble correctly.

The assembly language program is formulated as a sequence of statements of the above form, terminated optionally by an END statement. All statements following the END are ignored by the assembler.

3. FORMING THE OPERAND.

In order to completely describe the operation codes and pseudo operations, it is necessary to first present the form of the operand field, since it is used in nearly all statements. Expressions in the operand field consist of simple operands (labels, constants, and reserved words), combined in properly formed subexpressions by arithmetic and logical operators. The expression computation is carried out by the assembler as the assembly proceeds. Each expression must produce a 16-bit value during the assembly. Further, the number of significant digits in the result must not exceed the intended use. That is, if an expression is to be used in a byte move immediate instruction, then the most significant 8 bits of the expression must be zero. The restrictions on the expression significance is given with the individual instructions.

3.1. Labels.

As discussed above, a label is an identifier which occurs on a particular statement. In general, the label is given a value determined by the type of statement which it precedes. If the label occurs on a statement which generates machine code or reserves memory space (e.g, a MOV instruction, or a DS pseudo operation), then the label is given the value of the program address which it labels. If the label precedes an EQU or SET, then the label is given the value which results from evaluating the operand field. Except for the SET statement, an identifier can label only one statement.

When a label appears in the operand field, its value is substituted by the assembler. This value can then be combined with other operands and operators to form the operand field for a particular instruction.

3.2. Numeric Constants.

A numeric constant is a 16-bit value in one of several bases. The base, called the radix of the constant, is denoted by a trailing radix indicator. The radix indicators are

B binary constant (base 2)
O octal constant (base 8)

Q	octal constant (base 8)
D	decimal constant (base 1Ø)
H	hexadecimal constant (base 16)

Q is an alternate radix indicator for octal numbers since the letter O is easily confused with the digit Ø. Any numeric constant which does not terminate with a radix indicator is assumed to be a decimal constant.

A constant is thus composed as a sequence of digits, followed by an optional radix indicator, where the digits are in the appropriate range for the radix. That is binary constants must be composed of Ø and 1 digits, octal constants can contain digits in the range Ø - 7, while decimal constants contain decimal digits. Hexadecimal constants contain decimal digits as well as hexadecimal digits A (1ØD), B (11D), C (12D), D (13D), E (14D), and F (15D). Note that the leading digit of a hexadecimal constant must be a decimal digit in order to avoid confusing a hexadecimal constant with an identifier (a leading Ø will always suffice). A constant composed in this manner must evaluate to a binary number which can be contained within a 16-bit counter, otherwise it is truncated on the right by the assembler. Similar to identifiers, imbedded "$" are allowed within constants to improve their readability. Finally, the radix indicator is translated to upper case if a lower case letter is encountered. The following are all valid instances of numeric constants

1234	1234D	11ØØB	1111$ØØØØ$1111$ØØØØB
1234H	ØFFEH	3377O	33$77$22Q
3377o	Øfe3h	1234d	Øffffh

3.3. Reserved Words.

There are several reserved character sequences which have predefined meanings in the operand field of a statement. The names of 8Ø8Ø registers are given below, which, when encountered, produce the value shown to the right

A	7
B	Ø
C	1
D	2
E	3
H	4
L	5
M	6
SP	6
PSW	6

(again, lower case names have the same values as their upper case equivalents). Machine instructions can also be used in the operand field, and evaluate to their internal codes. In the case of instructions which require operands, where the specific operand becomes a part of the binary bit pattern

Appen
E

of the instruction (e.g, MOV A,B), the value of the instruction (in this case MOV) is the bit pattern of the instruction with zeroes in the optional fields (e.g, MOV produces 40H).

When the symbol "$" occurs in the operand field (not imbedded within identifiers and numeric constants) its value becomes the address of the next instruction to generate, not including the instruction contained withing the current logical line.

3.4. String Constants.

String constants represent sequences of ASCII characters, and are represented by enclosing the characters within apostrophe symbols (´). All strings must be fully contained within the current physical line (thus allowing "!" symbols within strings), and must not exceed 64 characters in length. The apostrophe character itself can be included within a string by representing it as a double apostrophe (the two keystrokes ´´), which becomes a single apostrophe when read by the assembler. In most cases, the string length is restricted to either one or two characters (the DB pseudo operation is an exception), in which case the string becomes an 8 or 16 bit value, respectively. Two character strings become a 16-bit constant, with the second character as the low order byte, and the first character as the high order byte.

The value of a character is its corresponding ASCII code. There is no case translation within strings, and thus both upper and lower case characters can be represented. Note however, that only graphic (printing) ASCII characters are allowed within strings. Valid strings are

```
´A´        ´AB´        ´ab´      ´c´
´´´´       ´a´´´       ´´´´´´    ´´´"´
´Walla Walla Wash.´
´She said ´´Hello´´ to me.´
´I said "Hello" to her.´
```

3.5. Arithmetic and Logical Operators.

The operands described above can be combined in normal algebraic notation using any combination of properly formed operands, operators, and parenthesized expressions. The operators recognized in the operand field are

a + b	unsigned arithmetic sum of a and b
a - b	unsigned arithmetic difference between a and b
+ b	unary plus (produces b)
- b	unary minus (identical to 0 - b)
a * b	unsigned magnitude multiplication of a and b
a / b	unsigned magnitude division of a by b
a MOD b	remainder after a / b
NOT b	logical inverse of b (all 0´s become 1´s, 1´s become 0´s), where b is considered a 16-bit value

a AND b	bit-by-bit logical and of a and b
a OR b	bit-by-bit logical or of a and b
a XOR b	bit-by-bit logicl exclusive or of a and b
a SHL b	the value which results from shifting a to the left by an amount b, with zero fill
a SHR b	the value which results from shifting a to the right by an amount b, with zero fill

In each case, a and b represent simple operands (labels, numeric constants, reserved words, and one or two character strings), or fully enclosed parenthesized subexpressions such as

```
10+20        10h+37Q      L1 /3     (L2+4) SHR 3
('a' and 5fh) + '0'       ('B'+B) OR (PSW+M)
(1+(2+c)) shr (A-(B+1))
```

Note that all computations are performed at assembly time as 16-bit unsigned operations. Thus, -1 is computed as 0-1 which results in the value 0ffffh (i.e., all 1's). The resulting expression must fit the operation code in which it is used. If, for example, the expression is used in a ADI (add immediate) instruction, then the high order eight bits of the expression must be zero. As a result, the operation "ADI -1" produces an error message (-1 becomes 0ffffh which cannot be represented as an 8 bit value), while "ADI (-1) AND 0FFH" is accepted by the assembler since the "AND" operation zeroes the high order bits of the expression.

3.6. Precedence of Operators.

As a convenience to the programmer, ASM assumes that operators have a relative precedence of application which allows the programmer to write expressions without nested levels of parentheses. The resulting expression has assumed parentheses which are defined by the relative precedence. The order of application of operators in unparenthesize expressions is listed below. Operators listed first have highest precedence (they are applied first in an unparenthesized expression), while operators listed last have lowest precedence. Operators listed on the same line have equal precedence, and are applied from left to right as they are encountered in an expression

```
* / MOD SHL SHR
    - +
    NOT
    AND
   OR XOR
```

Thus, the expressions shown to the left below are interpreted by the assembler as the fully parenthesize expressions shown to the right below

```
a * b + c                 (a * b) + c
a + b * c                 a + (b * c)
a MOD b * c SHL d         ((a MOD b) * c) SHL d
```

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a OR b AND NOT c + d SHL e   a OR (b AND (NOT (c + (d SHL e))))

Balanced parenthesized subexpressions can always be used to override the assumed parentheses, and thus the last expression above could be rewritten to force application of operators in a different order as

(a OR b) AND (NOT c) + d SHL e

resulting in the assumed parentheses

(a OR b) AND ((NOT c) + (d SHL e))

Note that an unparenthesized expression is well-formed only if the expression which results from inserting the assumed parentheses is well-formed.

4. ASSEMBLER DIRECTIVES.

Assembler directives are used to set labels to specific values during the assmbly, perform conditional assembly, define storage areas, and specify starting addresses in the program. Each assembler directive is denoted by a "pseudo operation" which appears in the operation field of the line. The acceptable pseudo operations are

ORG	set the program or data origin
END	end program, optional start address
EQU	numeric "equate"
SET	numeric "set"
IF	begin conditional assembly
ENDIF	end of conditional assembly
DB	define data bytes
DW	define data words
DS	define data storage area

The individual pseudo operations are detailed below

4.1. The ORG directive.

The ORG statement takes the form

label   ORG   expression

where "label" is an optional program label, and expression is a 16-bit expression, consisting of operands which are defined previous to the ORG statement. The assembler begins machine code generation at the location specified in the expression. There can be any number of ORG statements within a particular program, and there are no checks to ensure that the programmer is not defining overlapping memory areas. Note that most programs written for the CP/M system begin with an ORG statement of the form

ORG 100H

which causes machine code generation to begin at the base of the CP/M transient program area. If a label is specified in the ORG statement, then the label is given the value of the expression (this label can then be used in the operand field of other statements to represent this expression).

4.2. The END directive.

The END statement is optional in an assembly language program, but if it is present it must be the last statement (all subsequent statements are ignored in the assembly). The two forms of the END directive are

```
label   END
label   END   expression
```

where the label is again optional. If the first form is used, the assembly process stops, and the default starting address of the program is taken as 0000. Otherwise, the expression is evaluated, and becomes the program starting address (this starting address is included in the last record of the Intel formatted machine code "hex" file which results from the assembly). Thus, most CP/M assembly language programs end with the statement

```
END 100H
```

resulting in the default starting address of 100H (beginning of the transient program area).

4.3. The EQU directive.

The EQU (equate) statement is used to set up synonyms for particular numeric values. the form is

```
label   EQU   expression
```

where the label must be present, and must not label any other statement. The assembler evaluates the expression, and assigns this value to the identifier given in the label field. The identifier is usually a name which describes the value in a more human-oriented manner. Further, this name is used throughout the program to "parameterize" certain functions. Suppose for example, that data received from a Teletype appears on a particular input port, and data is sent to the Teletype through the next output port in sequence. The series of equate statements could be used to define these ports for a particular hardware environment

```
TTYBASE   EQU   10H        ;BASE PORT NUMBER FOR TTY
TTYIN     EQU   TTYBASE    ;TTY DATA IN
TTYOUT    EQU   TTYBASE+1;TTY DATA OUT
```

At a later point in the program, the statements which access the Teletype could appear as

```
IN      TTYIN      ;READ TTY DATA TO REG-A
...
OUT     TTYOUT     ;WRITE DATA TO TTY FROM REG-A
```

making the program more readable than if the absolute i/o ports had been used. Further, if the hardware environment is redefined to start the Teletype communications ports at 7FH instead of 1ØH, the first statement need only be changed to

```
TTYBASE   EQU   7FH     ;BASE PORT NUMBER FOR TTY
```

and the program can be reassembled without changing any other statements.

4.4. The SET Directive.

The SET statement is similar to the EQU, taking the form

```
label   SET   expression
```

except that the label can occur on other SET statements within the program. The expression is evaluated and becomes the current value associated with the label. Thus, the EQU statement defines a label with a single value, while the SET statement defines a value which is valid from the current SET statement to the point where the label occurs on the next SET statement. The use of the SET is similar to the EQU statement, but is used most often in controlling conditional assembly.

4.5. The IF and ENDIF directives.

The IF and ENDIF statements define a range of assembly language statements which are to be included or excluded during the assembly process. The form is

```
IF   expression
statement#1
statement#2
   ...
statement#n
ENDIF
```

Upon encountering the IF statement, the assembler evaluates the expression following the IF (all operands in the expression must be defined ahead of the IF statement). If the expression evaluates to a non-zero value, then statement#1 through statement#n are assembled; if the expression evaluates to zero, then the statements are listed but not assembled. Conditional assembly is often used to write a single "generic" program which includes a number of possible run-time environments, with only a few specific portions of the program selected for any particular assembly. The following program segments for example, might be part of a program which communicates with either a Teletype or a CRT console (but not both) by selecting a particular value for TTY before the assembly begins

```
TRUE     EQU    0FFFFH      ;DEFINE VALUE OF TRUE
FALSE    EQU    NOT TRUE    ;DEFINE VALUE OF FALSE
;
TTY      EQU    TRUE        ;TRUE IF TTY, FALSE IF CRT
;
TTYBASE  EQU    10H         ;BASE OF TTY I/O PORTS
CRTBASE  EQU    20H         ;BASE OF CRT I/O PORTS
         IF     TTY         ;ASSEMBLE RELATIVE TO TTYBASE
CONIN    EQU    TTYBASE     ;CONSOLE INPUT
CONOUT   EQU    TTYBASE+1   ;CONSOLE OUTPUT
         ENDIF
;
         IF     NOT TTY     ;ASSEMBLE RELATIVE TO CRTBASE
CONIN    EQU    CRTBASE     ;CONSOLE INPUT
CONOUT   EQU    CRTBASE+1   ;CONSOLE OUTPUT
         ENDIF
         ...
         IN      CONIN      ;READ CONSOLE DATA
         ...
         OUT     CONOUT     ;WRITE CONSOLE DATA
```

In this case, the program would assemble for an environment where a Teletype is connected, based at port 10H. The statement defining TTY could be changed to

```
TTY      EQU     FALSE
```

and, in this case, the program would assemble for a CRT based at port 20H.

4.6. The DB Directive.

The DB directive allows the programmer to define initialize storage areas in single precision (byte) format. The statement form is

```
label    DB    e#1, e#2, ..., e#n
```

where e#1 through e#n are either expressions which evaluate to 8-bit values (the high order eight bits must be zero), or are ASCII strings of length no greater than 64 characters. There is no practical restriction on the number of expressions included on a single source line. The expressions are evaluated and placed sequentially into the machine code file following the last program address generated by the assembler. String characters are similarly placed into memory starting with the first character and ending with the last character. Strings of length greater than two characters cannot be used as operands in more complicated expressions (i.e., they must stand alone between the commas). Note that ASCII characters are always placed in memory with the parity bit reset (0). Further, recall that there is no translation from lower to upper case within strings. The optional label can be used to reference the data area throughout the remainder of the program. Examples of

Appen
E

valid DB statements are

```
data:   DB   Ø,1,2,3,4,5
        DB   data and Øffh,5,377Q,1+2+3+4
signon: DB   'please type your name',cr,lf,Ø
        DB   'AB' SHR 8, 'C', 'DE' AND 7FH
```

4.7. The DW Directive.

The DW statement is similar to the DB statement except double precision (two byte) words of storage are initialized. The form is

```
label   DW   e#1, e#2, ..., e#n
```

where e#1 through e#n are expressions which evaluate to 16-bit results. Note that ASCII strings of length one or two characters are allowed, but strings longer than two characters disallowed. In all cases, the data storage is consistent with the 8Ø8Ø processor: the least significant byte of the expression is stored forst in memory, followed by the most significant byte. Examples are

```
doub:   DW   Øffefh,doub+4,signon-$,255+255
        DW   'a', 5, 'ab', 'CD', 6 shl 8 or 11b
```

4.8. The DS Directive.

The DS statement is used to reserve an area of uninitialized memory, and takes the form

```
label   DS   expression
```

where the label is optional. The assembler begins subsequent code generation after the area reserved by the DS. Thus, the DS statement given above has exactly the same effect as the statement

```
label:  EQU  $    ;LABEL VALUE IS CURRENT CODE LOCATION
        ORG  $+expression   ;MOVE PAST RESERVED AREA
```

5. OPERATION CODES.

Assembly language operation codes form the principal part of assembly language programs, and form the operation field of the instruction. In general, ASM accepts all the standard mnemonics for the Intel 8Ø8Ø microcomputer, which are given in detail in the Intel manual "8Ø8Ø Assembly Language Programming Manual." Labels are optional on each input line and, if included, take the value of the instruction address immediately before the instruction is issued. The individual operators are listed breifly in the following sections for completeness, although it is understood that the Intel manuals should be referenced for exact operator details. In each case,

e3	represents a 3-bit value in the range Ø-7 which can be one of the predefined registers A, B, C, D, E, H, L, M, SP, or PSW.
e8	represents an 8-bit value in the range Ø-255
e16	represents a 16-bit value in the range Ø-65535

which can themselves be formed from an arbitrary combination of operands and operators. In some cases, the operands are restricted to particular values within the allowable range, such as the PUSH instruction. These cases will be noted as they are encountered.

In the sections which follow, each operation codes is listed in its most general form, along with a specific example, with a short explanation and special restrictions.

5.1. Jumps, Calls, and Returns.

The Jump, Call, and Return instructions allow several different forms which test the condition flags set in the 8Ø8Ø microcomputer CPU. The forms are

```
JMP  e16    JMP L1       Jump unconditionally to label
JNZ  e16    JMP L2       Jump on non zero condition to label
JZ   e16    JMP 1ØØH     Jump on zero condition to label
JNC  e16    JNC L1+4     Jump no carry to label
JC   e16    JC  L3       Jump on carry to label
JPO  e16    JPO $+8      Jump on parity odd to label
JPE  e16    JPE L4       Jump on even parity to label
JP   e16    JP  GAMMA    Jump on positive result to label
JM   e16    JM  al       Jump on minus to label

CALL e16    CALL S1      Call subroutine unconditionally
CNZ  e16    CNZ  S2      Call subroutine if non zero flag
CZ   e16    CZ   1ØØH    Call subroutine on zero flag
CNC  e16    CNC  S1+4    Call subroutine if no carry set
CC   e16    CC   S3      Call subroutine if carry set
CPO  e16    CPO  $+8     Call subroutine if parity odd
CPE  e16    CPE  S4      Call subroutine if parity even
CP   e16    CP   GAMMA   Call subroutine if positive result
CM   e16    CM   b1$c2   Call subroutine if minus flag

RST  e3     RST  Ø       Programmed "restart", equivalent to
                         CALL 8*e3, except one byte call
```

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RET	Return from subroutine
RNZ	Return if non zero flag set
RZ	Return if zero flag set
RNC	Return if no carry
RC	Return if carry flag set
RPO	Return if parity is odd
RPE	Return if parity is even
RP	Return if positive result
RM	Return if minus flag is set

5.2. Immediate Operand Instructions.

Several instructions are available which load single or double precision registers, or single precision memory cells, with constant values, along with instructions which perform immediate arithmetic or logical operations on the accumulator (register A).

MVI e3,e8	MVI B,255	Move immediate data to register A, B, C, D, E, H, L, or M (memory)
ADI e8	ADI 1	Add immediate operand to A without carry
ACI e8	ACI ØFFH	Add immediate operand to A with carry
SUI e8	SUI L + 3	Subtract from A without borrow (carry)
SBI e8	SBI L AND 11B	Subtract from A with borrow (carry)
ANI e8	ANI $ AND 7FH	Logical "and" A with immediate data
XRI e8	XRI 1111$ØØØØB	"Exclusive or" A with immediate data
ORI e8	ORI L AND 1+1	Logical "or" A with immediate data
CPI e8	CPI ´a´	Compare A with immediate data (same as SUI except register A not changed)
LXI e3,e16	LXI B,1ØØH	Load extended immediate to register pair (e3 must be equivalent to B,D,H, or SP)

5.3. Increment and Decrement Instructions.

Instructions are provided in the 8Ø8Ø repetoire for incrementing or decrementing single and double precision registers. The instructions are

INR e3	INR E	Single precision increment register (e3 produces one of A, B, C, D, E, H, L, M)
DCR e3	DCR A	Single precision decrement register (e3 produces one of A, B, C, D, E, H, L, M)
INX e3	INX SP	Double precision increment register pair (e3 must be equivalent to B,D,H, or SP)
DCX e3	DCX B	Double precision decrement register pair (e3 must be equivalent to B,D,H, or SP)

5.4. Data Movement Instructions.

Instructions which move data from memory to the CPU and from CPU to memory are given below

MOV e3,e3	MOV A,B	Move data to leftmost element from rightmost element (e3 produces one of A,B,C D,E,H,L, or M). MOV M,M is disallowed
LDAX e3	LDAX B	Load register A from computed address (e3 must produce either B or D)
STAX e3	STAX D	Store register A to computed address (e3 must produce either B or D)
LHLD e16	LHLD L1	Load HL direct from location e16 (double precision load to H and L)
SHLD e16	SHLD L5+x	Store HL direct to location e16 (double precision store from H and L to memory)
LDA e16	LDA Gamma	Load register A from address e16
STA e16	STA X3-5	Store register A into memory at e16
POP e3	POP PSW	Load register pair from stack, set SP (e3 must produce one of B, D, H, or PSW)
PUSH e3	PUSH B	Store register pair into stack, set SP (e3 must produce one of B, D, H, or PSW)
IN e8	IN Ø	Load register A with data from port e8
OUT e8	OUT 255	Send data from register A to port e8
XTHL		Exchange data from top of stack with HL
PCHL		Fill program counter with data from HL
SPHL		Fill stack pointer with data from HL
XCHG		Exchange DE pair with HL pair

5.5. Arithmetic Logic Unit Operations.

Instructions which act upon the single precision accumulator to perform arithmetic and logic operations are

ADD e3	ADD B	Add register given by e3 to accumulator without carry (e3 must produce one of A, B, C, D, E, H, or L)
ADC e3	ADC L	Add register to A with carry, e3 as above
SUB e3	SUB H	Subtract reg e3 from A without carry, e3 is defined as above
SBB e3	SBB 2	Subtract register e3 from A with carry, e3 defined as above
ANA e3	ANA 1+1	Logical "and" reg with A, e3 as above
XRA e3	XRA A	"Exclusive or" with A, e3 as above
ORA e3	ORA B	Logical "or" with A, e3 defined as above
CMP e3	CMP H	Compare register with A, e3 as above
DAA		Decimal adjust register A based upon last arithmetic logic unit operation
CMA		Complement the bits in register A
STC		Set the carry flag to 1

CMC		Complement the carry flag
RLC		Rotate bits left, (re)set carry as a side effect (high order A bit becomes carry)
RRC		Rotate bits right, (re)set carry as side effect (low order A bit becomes carry)
RAL		Rotate carry/A register to left (carry is involved in the rotate)
RAR		Rotate carry/A register to right (carry is involved in the rotate)
DAD e3	DAD B	Double precision add register pair e3 to HL (e3 must produce B, D, H, or SP)

5.6. Control Instructions.

The four remaining instructions are categorized as control instructions, and are listed below

HLT	Halt the 8080 processor
DI	Disable the interrupt system
EI	Enable the interrupt system
NOP	No operation

6. ERROR MESSAGES.

When errors occur within the assembly language program, they are listed as single character flags in the leftmost position of the source listing. The line in error is also echoed at the console so that the source listing need not be examined to determine if errors are present. The error codes are

D	Data error: element in data statement cannot be placed in the specified data area
E	Expression error: expression is ill-formed and cannot be computed at assembly time
L	Label error: label cannot appear in this context (may be duplicate label)
N	Not implemented: features which will appear in future ASM versions (e.g., macros) are recognized, but flagged in this version)
O	Overflow: expression is too complicated (i.e., too many pending operators) to computed, simplify it
P	Phase error: label does not have the same value on two subsequent passes through the program

R	Register error: the value specified as a register is not compatible with the operation code
V	Value error: operand encountered in expression is improperly formed

Several error message are printed which are due to terminal error conditions

NO SOURCE FILE PRESENT	The file specified in the ASM command does not exist on disk
NO DIRECTORY SPACE	The disk directory is full, erase files which are not needed, and retry
SOURCE FILE NAME ERROR	Improperly formed ASM file name (e.g., it is specified with "?" fields)
SOURCE FILE READ ERROR	Source file cannot be read properly by the assembler, execute a TYPE to determine the point of error
OUTPUT FILE WRITE ERROR	Output files cannot be written properly, most likely cause is a full disk, erase and retry
CANNOT CLOSE FILE	Output file cannot be closed, check to see if disk is write protected

7. A SAMPLE SESSION.

The following session shows interaction with the assembler and debugger in the development of a simple assembly language program.

Append
E

```
ASM SORT↲   assemble SORT.ASM

CP/M ASSEMBLER - VER 1.0

015C next free address
003H USE FACTOR  % of table used  00 TO FF (hexadecimal)
END OF ASSEMBLY

DIR SORT.*↲

SORT     ASM  source file
SORT     BAK  backup from last edit
SORT     PRN  print file (contains tab characters)
SORT     HEX  machine code file
A>TYPE SORT.PRN↲

                                 source line
machine code location ;       SORT PROGRAM IN CP/M ASSEMBLY LANGUAGE
                      ;       START AT THE BEGINNING OF THE TRANSIENT PROGRAM
 0100                         ORG     100H
      generated machine code
 0100 214601          SORT:   LXI     H,SW     ;ADDRESS SWITCH TOGGLE
 0103 3601                    MVI     M,1      ;SET TO 1 FOR FIRST ITERATION
 0105 214701                  LXI     H,I      ;ADDRESS INDEX
 0108 3600                    MVI     M,0      ;I = 0
                      ;
                      ;       COMPARE I WITH ARRAY SIZE
 010A 7E              COMP:   MOV     A,M      ;A REGISTER = I
 010B FE09                    CPI     N-1      ;CY SET IF I < (N-1)
 010D D21901                  JNC     CONT     ;CONTINUE IF I <= (N-2)
                      ;
                      ;       END OF ONE PASS THROUGH DATA
 0110 214601                  LXI     H,SW     ;CHECK FOR ZERO SWITCHES
 0113 7EB7C20001              MOV A,M! ORA A! JNZ SORT ;END OF SORT IF SW=0
                      ;
 0118 FF                      RST 7            ;GO TO THE DEBUGGER INSTEAD OF I
                      ;truncated
                      ;       CONTINUE THIS PASS
                      ;       ADDRESSING I, SO LOAD AV(I) INTO REGISTERS
 0119 5F16002148CONT:         MOV E,A! MVI D,0! LXI H,AV! DAD D! DAD D
 0121 4E792346                MOV C,M! MOV A,C! INX H! MOV B,M
                      ;       LOW ORDER BYTE IN A AND C, HIGH ORDER BYTE IN B
                      ;
                      ;       MOV H AND L TO ADDRESS AV(I+1)
 0125 23                      INX     H
                      ;
                      ;       COMPARE VALUE WITH REGS CONTAINING AV(I)
 0126 965778239E              SUB M! MOV D,A! MOV A,B! INX H! SBB M   ;SUBTRA(
                      ;
                      ;       BORROW SET IF AV(I+1) > AV(I)
 012B DA3F01                  JC      INCI     ;SKIP IF IN PROPER ORDER
                      ;
                      ;       CHECK FOR EQUAL VALUES
 012E B2CA3F01                ORA D! JZ INCI ;SKIP IF AV(I) = AV(I+1)
```

```
0132 56702B5E           MOV D,M! MOV M,B! DCX H! MOV E,M
0136 712B722B73         MOV M,C! DCX H! MOV M,D! DCX H! MOV M,E
                    ;
                    ;   INCREMENT SWITCH COUNT
013B 21460134           LXI H,SW! INR M
                    ;
                    ;   INCREMENT I
013F 21470134C3INCI:    LXI H,I! INR M! JMP COMP
                    ;
                    ;   DATA DEFINITION SECTION
0146 00             SW: DB      0       ;RESERVE SPACE FOR SWITCH COUNT
0147                I:  DS      1       ;SPACE FOR INDEX
0148 050064001EAV:      DW      5,100,30,50,20,7,1000,300,100,-32767
000A =              N   EQU     ($-AV)/2        ;COMPUTE N INSTEAD OF PRE
015C                    END
```
equate value

```
>TYPE SORT.HEX
```

```
10010000214601360121470136007EFE09D2190140
100110002146017EB7C20001FF5F16002148011988
10012000194E79234623965778239EDA3F01B2CAA7
100130003F0156702B5E712B722B732146013421C7
07014000470134C30A01006E
1001480005006400 1E00320014000700E8032C01BB
04015800640001800BE
0000000000
```
machine code in HEX format

```
>DDT SORT.HEX
```
start debug run

```
5K DDT VER 1.0
EXT   PC
15C 0000
```
default address (no address on END statement)

```
XP
=0000 100
```
Change PC to 100

```
JFFFF
```
untrace for 65535 steps

abort with rubout

```
0Z0M0E0I0 A=00 B=0000 D=0000 H=0000 S=0100 P=0100 LXI  H,0146*0100
T10
```
trace 10_{16} steps

```
0Z0M0E0I0 A=01 B=0000 D=0000 H=0146 S=0100 P=0100 LXI  H,0146
0Z0M0E0I0 A=01 B=0000 D=0000 H=0146 S=0100 P=0103 MVI  M,01
0Z0M0E0I0 A=01 B=0000 D=0000 H=0146 S=0100 P=0105 LXI  H,0147
0Z0M0E0I0 A=01 B=0000 D=0000 H=0147 S=0100 P=0108 MVI  M,00
0Z0M0E0I0 A=01 B=0000 D=0000 H=0147 S=0100 P=010A MOV  A,M
0Z0M0E0I0 A=00 B=0000 D=0000 H=0147 S=0100 P=010B CPI  09
1Z0M1E0I0 A=00 B=0000 D=0000 H=0147 S=0100 P=010D JNC  0119
1Z0M1E0I0 A=00 B=0000 D=0000 H=0147 S=0100 P=0110 LXI  H,0146
1Z0M1E0I0 A=00 B=0000 D=0000 H=0146 S=0100 P=0113 MOV  A,M
1Z0M1E0I0 A=01 B=0000 D=0000 H=0146 S=0100 P=0114 ORA  A
0Z0M0E0I0 A=01 B=0000 D=0000 H=0146 S=0100 P=0115 JNZ  0100
0Z0M0E0I0 A=01 B=0000 D=0000 H=0146 S=0100 P=0100 LXI  H,0146
0Z0M0E0I0 A=01 B=0000 D=0000 H=0146 S=0100 P=0103 MVI  M,01
0Z0M0E0I0 A=01 B=0000 D=0000 H=0146 S=0100 P=0105 LXI  H,0147
0Z0M0E0I0 A=01 B=0000 D=0000 H=0147 S=0100 P=0108 MVI  M,00
0Z0M0E0I0 A=01 B=0000 D=0000 H=0147 S=0100 P=010A MOV  A,M*010B
A10D
```
stopped at 10BH

```
10D  JC 119
110
```
change to a jump on carry

Appendix E

```
-XP
P=010B 100
```
reset program counter back to beginning of program

```
-T10
```
trace execution for 10H steps

```
C0Z0M0E0I0 A=00 B=0000 D=0000 H=0147 S=0100 P=0100 LXI  H,0146
C0Z0M0E0I0 A=00 B=0000 D=0000 H=0146 S=0100 P=0103 MVI  M,01
C0Z0M0E0I0 A=00 B=0000 D=0000 H=0146 S=0100 P=0105 LXI  H,0147
C0Z0M0E0I0 A=00 B=0000 D=0000 H=0147 S=0100 P=0108 MVI  M,00
C0Z0M0E0I0 A=00 B=0000 D=0000 H=0147 S=0100 P=010A MOV  A,M
C0Z0M0E0I0 A=00 B=0000 D=0000 H=0147 S=0100 P=010B CPI  09
C1Z0M1E0I0 A=00 B=0000 D=0000 H=0147 S=0100 P=010D JC   0119
C1Z0M1E0I0 A=00 B=0000 D=0000 H=0147 S=0100 P=0119 MOV  E,A
C1Z0M1E0I0 A=00 B=0000 D=0000 H=0147 S=0100 P=011A MVI  D,00
C1Z0M1E0I0 A=00 B=0000 D=0000 H=0147 S=0100 P=011C LXI  H,0148
C1Z0M1E0I0 A=00 B=0000 D=0000 H=0148 S=0100 P=011F DAD  D
C0Z0M1E0I0 A=00 B=0000 D=0000 H=0148 S=0100 P=0120 DAD  D
C0Z0M1E0I0 A=00 B=0000 D=0000 H=0148 S=0100 P=0121 MOV  C,M
C0Z0M1E0I0 A=00 B=0005 D=0000 H=0148 S=0100 P=0122 MOV  A,C
C0Z0M1E0I0 A=05 B=0005 D=0000 H=0148 S=0100 P=0123 INX  H
C0Z0M1E0I0 A=05 B=0005 D=0000 H=0149 S=0100 P=0124 MOV  B,M*0125
-L100
```
Altered instr

Automatic breakpoint

```
0100  LXI  H,0146
0103  MVI  M,01
0105  LXI  H,0147
0108  MVI  M,00
010A  MOV  A,M
010B  CPI  09
010D  JC   0119
0110  LXI  H,0146
0113  MOV  A,M
0114  ORA  A
0115  JNZ  0100
-L
```
list some code from 100H

```
0118  RST  07
0119  MOV  E,A
011A  MVI  D,00
011C  LXI  H,0148
```
list more

- abort list with rubout

```
-G,11B
```
start program from current PC (0125H) and run in real time to 11BH

```
*0127
```
stopped with an external interrupt 7 from front panel (program was looping indefinitely)

```
-T4
```
look at looping program in trace mode

```
C0Z0M0E0I0 A=38 B=0064 D=0006 H=0156 S=0100 P=0127 MOV  D,A
C0Z0M0E0I0 A=38 B=0064 D=3806 H=0156 S=0100 P=0128 MOV  A,B
C0Z0M0E0I0 A=00 B=0064 D=3806 H=0156 S=0100 P=0129 INX  H
C0Z0M0E0I0 A=00 B=0064 D=3806 H=0157 S=0100 P=012A SBB  M*012B
-D148
```
data is sorted, but program doesn't stop.

```
0148 05 00 07 00 14 00 1E 00 ........
0150 32 00 64 00 64 00 2C 01 E8 03 01 80 00 00 00 00 2.D.D...........
0160 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ................
```

```
-G0  return to CP/M

DDT SORT.HEX  reload the memory image

16K DDT VER 1.0
NEXT  PC
015C 0000
-XP

P=0000 100  set PC to beginning of program

-L10D  list bad opcode

010D  JNC  0119
0110  LXI  H,0146
- abort list with rubout

-A10D  assemble new opcode

010D  JC 119

0110

-L100  list starting section of program

0100  LXI  H,0146
0103  MVI  M,01
0105  LXI  H,0147
0108  MVI  M,00
- abort list with rubout

-A103  change "switch" initialization to 00

0103  MVI M,0

0105

-^C  return to CP/M with ctl-C (G0 works as well)

SAVE 1 SORT.COM  save 1 page (256 bytes, from 100H to 1FFH) on disk in case
                                        we have to reload later

A>DDT SORT.COM  restart DDT with
                saved memory image
16K DDT VER 1.0
NEXT  PC
0200 0100 "COM" file always starts with address 100H
-G  run the program from PC=100H

*0118 programmed stop (RST 7) encountered
-D148
                                   data properly sorted
0148 05 00 07 00 14 00 1E 00 ........
0150 32 00 64 00 64 00 2C 01 E8 03 01 80 00 00 00 00 2.D.D.,.........
0160 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ................
0170 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ................

-G0  return to CP/M
```

Appendix E

```
ED SORT.ASM    make changes to original program
 ctl-z
*N,0^Z0TT    find next ",0"
        MVI       M,0       ;I = 0
*-   up one line in text
        LXI       H,I       ;ADDRESS INDEX
*-   up another line
        MVI       M,1       ;SET TO 1 FOR FIRST ITERATION
*KT   kill line and type next line
        LXI       H,I       ;ADDRESS INDEX
*I   insert new line
        MVI       M,0       ;ZERO SW
*T
        LXI       H,I       ;ADDRESS INDEX
*NJNC^Z0T
        JNC*T
        CONT      ;CONTINUE IF I <= (N-2)
*-2DIC^Z0LT
        JC        CONT      ;CONTINUE IF I <= (N-2)
*E
                  source from disk A
                  hex to disk A
ASM SORT.AAZ      skip prn file

CP/M ASSEMBLER - VER 1.0

015C next address to assemble
003H USE FACTOR
END OF ASSEMBLY

DDT SORT.HEX    test program changes

16K DDT VER 1.0
NEXT  PC
015C 0000
-G100

*0118
-D148
                                          data sorted
0148 05 00 07 00 14 00 1E 00 ........
0150 32 00 64 00 64 00 2C 01 E8 03 01 80 00 00 00 00 2.D.D.,.........
0160 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ................

- abort with rubout

-G0   return to CP/M - program checks OK.
```

APPENDIX F

THE CP/M 2.0 INTERFACE GUIDE

DIGITAL RESEARCH

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CP/M 2.0 INTERFACE GUIDE

Appendix
F

CP/M 2.0 INTERFACE GUIDE

Digital Research, Box 579
Pacific Grove, California

1. INTRODUCTION.

This manual describes CP/M, release 2, system organization including the structure of memory and system entry points. The intention is to provide the necessary information required to write programs which operate under CP/M, and which use the peripheral and disk I/O facilities of the system.

CP/M is logically divided into four parts, called the Basic I/O System (BIOS), the Basic Disk Operating System (BDOS), the Console command processor (CCP), and the Transient Program Area (TPA). The BIOS is a hardware-dependent module which defines the exact low level interface to a particular computer system which is necessary for peripheral device I/O. Although a standard BIOS is supplied by Digital Research, explicit instructions are provided for field reconfiguration of the BIOS to match nearly any hardware environment (see the Digital Research manual entitled "CP/M Alteration Guide"). The BIOS and BDOS are logically combined into a single module with a common entry point, and referred to as the FDOS. The CCP is a distinct program which uses the FDOS to provide a human-oriented interface to the information which is cataloged on the backup storage device. The TPA is an area of memory (i.e., the portion which is not used by the FDOS and CCP) where various non-resident operating system commands and user programs are executed. The lower portion of memory is reserved for system information and is detailed later sections. Memory organization of the CP/M system in shown below:

```
         ---------------------------
   high  |                         |
 memory  |                         |
         |     FDOS (BDOS+BIOS)    |
 FBASE:  |                         |
         ---------------------------
         |                         |
         |           CCP           |
 CBASE:  |                         |
         ---------------------------
         |                         |
         |                         |
         |                         |
         |           TPA           |
         |                         |
 TBASE:  |                         |
         ---------------------------
         |    system  parameters   |
 BOOT:   |                         |
         ---------------------------
```

The exact memory addresses corresponding to BOOT, TBASE, CBASE, and FBASE vary from version to version, and are described fully in the "CP/M Alteration Guide." All standard CP/M versions, however, assume BOOT = 0000H, which is the base of random access memory. The machine code found at location BOOT performs a system "warm start" which loads and initializes the programs and variables necessary to return control to the CCP. Thus, transient programs need only jump to location BOOT to return control to CP/M at the command level. Further, the standard versions assume TBASE = BOOT+0100H which is normally location 0100H. The principal entry point to the FDOS is at location BOOT+0005H (normally 0005H) where a jump to FBASE is found. The address field at BOOT+0006H (normally 0006H) contains the value of FBASE and can be used to determine the size of available memory, assuming the CCP is being overlayed by a transient program.

Transient programs are loaded into the TPA and executed as follows. The operator communicates with the CCP by typing command lines following each prompt. Each command line takes one of the forms:

```
command
command file1
command file1 file2
```

where "command" is either a built-in function such as DIR or TYPE, or the name of a transient command or program. If the command is a built-in function of CP/M, it is executed immediately. Otherwise, the CCP searches the currently addressed disk for a file by the name

```
command.COM
```

If the file is found, it is assumed to be a memory image of a program which executes in the TPA, and thus implicitly originates at TBASE in memory. The CCP loads the COM file from the disk into memory starting at TBASE and possibly extending up to CBASE.

If the command is followed by one or two file specifications, the CCP prepares one or two file control block (FCB) names in the system parameter area. These optional FCB's are in the form necessary to access files through the FDOS, and are described in the next section.

The transient program receives control from the CCP and begins execution, perhaps using the I/O facilities of the FDOS. The transient program is "called" from the CCP, and thus can simply return to the CCP upon completion of its processing, or can jump to BOOT to pass control back to CP/M. In the first case, the transient program must not use memory above CBASE, while in the latter case, memory up through FBASE-1 is free.

The transient program may use the CP/M I/O facilities to communicate with the operator's console and peripheral devices, including the disk subsystem. The I/O system is accessed by passing a "function number" and an "information address" to CP/M through the FDOS entry point at BOOT+0005H. In the case of a disk read, for example, the transient program sends the number corresponding to a disk read, along with the address of an FCB to the CP/M FDOS. The FDOS, in turn, performs the operation and returns with either a disk read completion indication or an error number indicating that the disk read was unsuccessful. The function numbers and error indicators are given in below.

2. OPERATING SYSTEM CALL CONVENTIONS.

The purpose of this section is to provide detailed information for performing direct operating system calls from user programs. Many of the functions listed below, however, are more simply accessed through the I/O macro library provided with the MAC macro assembler, and listed in the Digital Research manual entitled "MAC Macro Assembler: Language Manual and Applications Guide."

CP/M facilities which are available for access by transient programs fall into two general categories: simple device I/O, and disk file I/O. The simple device operations include:

- Read a Console Character
- Write a Console Character
- Read a Sequential Tape Character
- Write a Sequential Tape Character
- Write a List Device Character
- Get or Set I/O Status
- Print Console Buffer
- Read Console Buffer
- Interrogate Console Ready

The FDOS operations which perform disk Input/Output are

- Disk System Reset
- Drive Selection
- File Creation
- File Open
- File Close
- Directory Search
- File Delete
- File Rename
- Random or Sequential Read
- Random or Sequential Write
- Interrogate Available Disks
- Interrogate Selected Disk
- Set DMA Address
- Set/Reset File Indicators

As mentioned above, access to the FDOS functions is accomplished by passing a function number and information address through the primary entry point at location BOOT+0005H. In general, the function number is passed in register C with the information address in the double byte pair DE. Single byte values are returned in register A, with double byte values returned in HL (a zero value is returned when the function number is out of range). For reasons of compatibility, register A = L and register B = H upon return in all cases. Note that the register passing conventions of CP/M agree with those of Intel's PL/M systems programming language. The list of CP/M function numbers is given below.

0 System Reset
1 Console Input
2 Console Output
3 Reader Input
4 Punch Output
5 List Output
6 Direct Console I/O
7 Get I/O Byte
8 Set I/O Byte
9 Print String
10 Read Console Buffer
11 Get Console Status
12 Return Version Number
13 Reset Disk System
14 Select Disk
15 Open File
16 Close File
17 Search for First
18 Search for Next
19 Delete File
20 Read Sequential
21 Write Sequential
22 Make File
23 Rename File
24 Return Login Vector
25 Return Current Disk
26 Set DMA Address
27 Get Addr(Alloc)
28 Write Protect Disk
29 Get R/O Vector
30 Set File Attributes
31 Get Addr(Disk Parms)
32 Set/Get User Code
33 Read Random
34 Write Random
35 Compute File Size
36 Set Random Record

(Functions 28 and 32 should be avoided in application programs to maintain upward compatibility with MP/M.)

Upon entry to a transient program, the CCP leaves the stack pointer set to an eight level stack area with the CCP return address pushed onto the stack, leaving seven levels before overflow occurs. Although this stack is usually not used by a transient program (i.e., most transients return to the CCP though a jump to location 0000H), it is sufficiently large to make CP/M system calls since the FDOS switches to a local stack at system entry. The following assembly language program segment, for example, reads characters continuously until an asterisk is encountered, at which time control returns to the CCP (assuming a standard CP/M system with BOOT = 0000H):

```
BDOS    EQU     0005H       ;STANDARD CP/M ENTRY
CONIN   EQU     1           ;CONSOLE INPUT FUNCTION
;
        ORG     0100H       ;BASE OF TPA
NEXTC:  MVI     C,CONIN     ;READ NEXT CHARACTER
        CALL    BDOS        ;RETURN CHARACTER IN <A>
        CPI     '*'         ;END OF PROCESSING?
        JNZ     NEXTC       ;LOOP IF NOT
        RET                 ;RETURN TO CCP
        END
```

CP/M implements a named file structure on each disk, providing a logical organization which allows any particular file to contain any number of records from completely empty, to the full capacity of the drive. Each drive is logically distinct with a disk directory and file data area. The disk file names are in three parts: the drive select code, the file name consisting of one to eight non-blank characters, and the file type consisting of zero to three non-blank characters. The file type names the generic category of a particular file, while the file name distinguishes individual files in each category. The file types listed below name a few generic categories which have been established, although they are generally arbitrary:

ASM	Assembler Source	PLI	PL/I Source File
PRN	Printer Listing	REL	Relocatable Module
HEX	Hex Machine Code	TEX	TEX Formatter Source
BAS	Basic Source File	BAK	ED Source Backup
INT	Intermediate Code	SYM	SID Symbol File
COM	CCP Command File	$$$	Temporary File

Source files are treated as a sequence of ASCII characters, where each "line" of the source file is followed by a carriage-return line-feed sequence (0DH followed by 0AH). Thus one 128 byte CP/M record could contain several lines of source text. The end of an ASCII file is denoted by a control-Z character (1AH) or a real end of file, returned by the CP/M read operation. Control-Z characters embedded within machine code files (e.g., COM files) are ignored, however, and the end of file condition returned by CP/M is used to terminate read operations.

Files in CP/M can be thought of as a sequence of up to 65536 records of 128 bytes each, numbered from 0 through 65535, thus allowing a maximum of 8 megabytes per file. Note, however, that although the records may be considered logically contiguous, they may not be physically contiguous in the disk data area. Internally, all files are broken into 16K byte segments called logical extents, so that counters are easily maintained as 8-bit values. Although the decomposition into extents is discussed in the paragraphs which follow, they are of no particular consequence to the programmer since each extent is automatically accessed in both sequential and random access modes.

In the file operations starting with function number 15, DE usually addresses a file control block (FCB). Transient programs often use the default file control block area reserved by CP/M at location BOOT+005CH (normally 005CH) for simple file operations. The basic unit of file information is a 128 byte record used for all file operations, thus a default location for disk I/O is provided by CP/M at location BOOT+0080H (normally 0080H) which is the initial default DMA address (see function 26). All directory operations take place in a reserved area which does not affect write buffers as was the case in release 1, with the exception of Search First and Search Next, where compatibility is required.

The File Control Block (FCB) data area consists of a sequence of 33 bytes for sequential access and a series of 36 bytes in the case that the file is accessed randomly. The default file control block normally located at 005CH can be used for random access files, since the three bytes starting at BOOT+007DH are available for this purpose. The FCB format is shown with the following fields:

```
-----------------------------------------------------------------
|dr|f1|f2|/ /|f8|t1|t2|t3|ex|s1|s2|rc|d0|/ /|dn|cr|r0|r1|r2|
-----------------------------------------------------------------
 00 01 02 ... 08 09 10 11 12 13 14 15 16 ... 31 32 33 34 35
```

where

```
   dr         drive code (0 - 16)
              0 => use default drive for file
              1 => auto disk select drive A,
              2 => auto disk select drive B,
              ...
              16=> auto disk select drive P.

   f1...f8    contain the file name in ASCII
              upper case, with high bit = 0

   t1,t2,t3   contain the file type in ASCII
              upper case, with high bit = 0
              t1', t2', and t3' denote the
              bit of these positions,
              t1' = 1 => Read/Only file,
              t2' = 1 => SYS file, no DIR list

    ex        contains the current extent number,
              normally set to 00 by the user, but
              in range 0 - 31 during file I/O

    s1        reserved for internal system use

    s2        reserved for internal system use, set
              to zero on call to OPEN, MAKE, SEARCH

    rc        record count for extent "ex,"
              takes on values from 0 - 128

    d0...dn   filled-in by CP/M, reserved for
              system use

    cr        current record to read or write in
              a sequential file operation, normally
              set to zero by user

    r0,r1,r2  optional random record number in the
              range 0-65535, with overflow to r2,
              r0,r1 constitute a 16-bit value with
              low byte r0, and high byte r1
```

Each file being accessed through CP/M must have a corresponding FCB which provides the name and allocation information for all subsequent file operations. When accessing files, it is the programmer's responsibility to fill the lower sixteen bytes of the FCB and initialize the "cr" field. Normally, bytes 1 through 11 are set to the ASCII character values for the file name and file type, while all other fields are zero.

FCB's are stored in a directory area of the disk, and are brought into central memory before proceeding with file operations (see the OPEN and MAKE functions). The memory copy of the FCB is updated as file operations take place and later recorded permanently on disk at the termination of the file operation (see the CLOSE command).

The CCP constructs the first sixteen bytes of two optional FCB's for a transient by scanning the remainder of the line following the transient name, denoted by "file1" and "file2" in the prototype command line described above, with unspecified fields set to ASCII blanks. The first FCB is constructed at location BOOT+005CH, and can be used as-is for subsequent file operations. The second FCB occupies the d0 ... dn portion of the first FCB, and must be moved to another area of memory before use. If, for example, the operator types

```
PROGNAME B:X.ZOT Y.ZAP
```

the file PROGNAME.COM is loaded into the TPA, and the default FCB at BOOT+005CH is initialized to drive code 2, file name "X" and file type "ZOT". The second drive code takes the default value 0, which is placed at BOOT+006CH, with the file name "Y" placed into location BOOT+006DH and file type "ZAP" located 8 bytes later at BOOT+0075H. All remaining fields through "cr" are set to zero. Note again that it is the programmer's responsibility to move this second file name and type to another area, usually a separate file control block, before opening the file which begins at BOOT+005CH, due to the fact that the open operation will overwrite the second name and type.

If no file names are specified in the original command, then the fields beginning at BOOT+005DH and BOOT+006DH contain blanks. In all cases, the CCP translates lower case alphabetics to upper case to be consistent with the CP/M file naming conventions.

As an added convenience, the default buffer area at location BOOT+0080H is initialized to the command line tail typed by the operator following the program name. The first position contains the number of characters, with the characters themselves following the character count. Given the above command line, the area beginning at BOOT+0080H is initialized as follows:

```
BOOT+0080H:
+00 +01 +02 +03 +04 +05 +06 +07 +08 +09 +10 +11 +12 +13 +14
 14 " "  "B" ":" "X" "." "Z" "O" "T" " "  "Y" "." "Z" "A" "P"
```

where the characters are translated to upper case ASCII with uninitialized memory following the last valid character. Again, it is the responsibility of the programmer to extract the information from this buffer before any file operations are performed, unless the default DMA address is explicitly changed.

The individual functions are described in detail in the pages which follow.

```
***************************************
*                                     *
*  FUNCTION Ø:  System Reset          *
*                                     *
***************************************
*  Entry Parameters:                  *
*      Register  C:  ØØH              *
***************************************
```

The system reset function returns control to the CP/M operating system at the CCP level. The CCP re-initializes the disk subsystem by selecting and logging-in disk drive A. This function has exactly the same effect as a jump to location BOOT.

```
***************************************
*                                     *
*  FUNCTION 1:  CONSOLE INPUT         *
*                                     *
***************************************
*  Entry Parameters:                  *
*      Register  C:  Ø1H              *
*                                     *
*  Returned   Value:                  *
*      Register  A:  ASCII Character  *
***************************************
```

The console input function reads the next console character to register A. Graphic characters, along with carriage return, line feed, and backspace (ctl-H) are echoed to the console. Tab characters (ctl-I) are expanded in columns of eight characters. A check is made for start/stop scroll (ctl-S) and start/stop printer echo (ctl-P). The FDOS does not return to the calling program until a character has been typed, thus suspending execution if a character is not ready.

```
***************************************
*                                     *
*  FUNCTION 2:  CONSOLE OUTPUT        *
*                                     *
***************************************
*  Entry Parameters:                  *
*      Register  C:  Ø2H              *
*      Register  E:  ASCII Character  *
*                                     *
***************************************
```

The ASCII character from register E is sent to the console device. Similar to function 1, tabs are expanded and checks are made for start/stop scroll and printer echo.

```
****************************************
*                                      *
*  FUNCTION 3:  READER INPUT           *
*                                      *
****************************************
*  Entry Parameters:                   *
*      Register   C:  Ø3H              *
*                                      *
*  Returned   Value:                   *
*      Register   A:  ASCII Character  *
****************************************
```

The Reader Input function reads the next character from the logical reader into register A (see the IOBYTE definition in the "CP/M Alteration Guide"). Control does not return until the character has been read.

```
****************************************
*                                      *
*  FUNCTION 4:  PUNCH OUTPUT           *
*                                      *
****************************************
*  Entry Parameters:                   *
*      Register   C:  Ø4H              *
*      Register   E:  ASCII Character  *
*                                      *
****************************************
```

The Punch Output function sends the character from register E to the logical punch device.

```
****************************************
*                                      *
*  FUNCTION 5:  LIST OUTPUT            *
*                                      *
****************************************
*  Entry Parameters:                   *
*      Register   C:  Ø5H              *
*      Register   E:  ASCII Character  *
*                                      *
****************************************
```

The List Output function sends the ASCII character in register E to the logical listing device.

Appendix F

```
***************************************
*                                     *
*  FUNCTION 6:  DIRECT CONSOLE I/O    *
*                                     *
***************************************
*  Entry Parameters:                  *
*      Register   C:  Ø6H             *
*      Register   E:  ØFFH (input) or *
*                     char (output)   *
*                                     *
*  Returned   Value:                  *
*      Register   A:  char or status  *
*                     (no value)      *
***************************************
```

Direct console I/O is supported under CP/M for those specialized applications where unadorned console input and output is required. Use of this function should, in general, be avoided since it bypasses all of CP/M's normal control character functions (e.g., control-S and control-P). Programs which perform direct I/O through the BIOS under previous releases of CP/M, however, should be changed to use direct I/O under BDOS so that they can be fully supported under future releases of MP/M and CP/M.

Upon entry to function 6, register E either contains hexadecimal FF, denoting a console input request, or register E contains an ASCII character. If the input value is FF, then function 6 returns A = ØØ if no character is ready, otherwise A contains the next console input character.

If the input value in E is not FF, then function 6 assumes that E contains a valid ASCII character which is sent to the console.

```
****************************************
*                                      *
*   FUNCTION 7:  GET I/O BYTE          *
*                                      *
****************************************
*   Entry Parameters:                  *
*       Register   C:  Ø7H             *
*                                      *
*   Returned   Value:                  *
*       Register   A:  I/O Byte Value  *
****************************************
```

The Get I/O Byte function returns the current value of IOBYTE in register A. See the "CP/M Alteration Guide" for IOBYTE definition.

```
****************************************
*                                      *
*   FUNCTION 8:  SET I/O BYTE          *
*                                      *
****************************************
*   Entry Parameters:                  *
*       Register   C:  Ø8H             *
*       Register   E:  I/O Byte Value  *
*                                      *
****************************************
```

The Set I/O Byte function changes the system IOBYTE value to that given in register E.

```
****************************************
*                                      *
*   FUNCTION 9:  PRINT STRING          *
*                                      *
****************************************
*   Entry Parameters:                  *
*       Register   C:  Ø9H             *
*       Registers DE:  String Address  *
*                                      *
****************************************
```

The Print String function sends the character string stored in memory at the location given by DE to the console device, until a "$" is encountered in the string. Tabs are expanded as in function 2, and checks are made for start/stop scroll and printer echo.

Append
F

```
***************************************
*                                     *
*  FUNCTION 10: READ CONSOLE BUFFER   *
*                                     *
***************************************
*  Entry Parameters:                  *
*      Register    C:  0AH            *
*      Registers DE:  Buffer Address  *
*                                     *
*  Returned   Value:                  *
*      Console Characters in Buffer   *
***************************************
```

The Read Buffer function reads a line of edited console input into a buffer addressed by registers DE. Console input is terminated when either the input buffer overflows. The Read Buffer takes the form:

```
DE: +0 +1 +2 +3 +4 +5 +6 +7 +8    . . .    +n
    ------------------------------------------
    |mx|nc|c1|c2|c3|c4|c5|c6|c7|   . . .   |??|
    ------------------------------------------
```

where "mx" is the maximum number of characters which the buffer will hold (1 to 255), "nc" is the number of characters read (set by FDOS upon return), followed by the characters read from the console. if nc < mx, then uninitialized positions follow the last character, denoted by "??" in the above figure. A number of control functions are recognized during line editing:

rub/del	removes and echoes the last character
ctl-C	reboots when at the beginning of line
ctl-E	causes physical end of line
ctl-H	backspaces one character position
ctl-J	(line feed) terminates input line
ctl-M	(return) terminates input line
ctl-R	retypes the current line after new line
ctl-U	removes currnt line after new line
ctl-X	backspaces to beginning of current line

Note also that certain functions which return the carriage to the leftmost position (e.g., ctl-X) do so only to the column position where the prompt ended (in earlier releases, the carriage returned to the extreme left margin). This convention makes operator data input and line correction more legible.

```
***************************************
                                      *
  FUNCTION 11: GET CONSOLE STATUS     *
                                      *
***************************************
  Entry Parameters:                   *
      Register   C:  0BH              *
                                      *
  Returned   Value:                   *
      Register   A:  Console Status   *
***************************************
```

The Console Status function checks to see if a character has been typed at the console. If a character is ready, the value 0FFH is returned in register A. Otherwise a 00H value is returned.

```
***************************************
                                      *
  FUNCTION 12: RETURN VERSION NUMBER  *
                                      *
***************************************
  Entry Parameters:                   *
      Register   C:  0CH              *
                                      *
  Returned   Value:                   *
      Registers HL:  Version Number   *
***************************************
```

Function 12 provides information which allows version independent programming. A two-byte value is returned, with H = 00 designating the CP/M release (H = 01 for MP/M), and L = 00 for all releases previous to 2.0. CP/M 2.0 returns a hexadecimal 20 in register L, with subsequent version 2 releases in the hexadecimal range 21, 22, through 2F. Using function 12, for example, you can write application programs which provide both sequential and random access functions, with random access disabled when operating under early releases of CP/M.

Appendix F

```
***************************************
*                                     *
*  FUNCTION 13: RESET DISK SYSTEM     *
*                                     *
***************************************
*  Entry Parameters:                  *
*      Register   C:  ØDH             *
*                                     *
***************************************
```

The Reset Disk Function is used to programmatically restore the file system to a reset state where all disks are set to read/write (see functions 28 and 29), only disk drive A is selected, and the default DMA address is reset to BOOT+ØØ8ØH. This function can be used, for example, by an application program which requires a disk change without a system reboot.

```
***************************************
*                                     *
*  FUNCTION 14: SELECT DISK           *
*                                     *
***************************************
*  Entry Parameters:                  *
*      Register   C:  ØEH             *
*      Register   E:  Selected Disk   *
*                                     *
***************************************
```

The Select Disk function designates the disk drive named in register E as the default disk for subsequent file operations, with E = Ø for drive A, 1 for drive B, and so-forth through 15 corresponding to drive P in a full sixteen drive system. The drive is placed in an "on-line" status which, in particular, activates its directory until the next cold start, warm start, or disk system reset operation. If the disk media is changed while it is on-line, the drive automatically goes to a read/only status in a standard CP/M environment (see function 28). FCB's which specify drive code zero (dr = ØØH) automatically reference the currently selected default drive. Drive code values between 1 and 16, however, ignore the selected default drive and directly reference drives A through P.

```
**************************************
*                                    *
*  FUNCTION 15: OPEN FILE            *
*                                    *
**************************************
*  Entry Parameters:                 *
*      Register    C:  ØFH           *
*      Registers DE:  FCB Address    *
*                                    *
*  Returned   Value:                 *
*      Register    A:  Directory Code *
**************************************
```

The Open File operation is used to activate a file which currently exists in the disk directory for the currently active user number. The FDOS scans the referenced disk directory for a match in positions 1 through 14 of the FCB referenced by DE (byte s1 is automatically zeroed), where an ASCII question mark (3FH) matches any directory character in any of these positions. Normally, no question marks are included and, further, bytes "ex" and "s2" of the FCB are zero.

If a directory element is matched, the relevant directory information is copied into bytes dØ through dn of the FCB, thus allowing access to the files through subsequent read and write operations. Note that an existing file must not be accessed until a sucessful open operation is completed. Upon return, the open function returns a "directory code" with the value Ø through 3 if the open was successful, or ØFFH (255 decimal) if the file cannot be found. If question marks occur in the FCB then the first matching FCB is activated. Note that the current record ("cr") must be zeroed by the program if the file is to be accessed sequentially from the first record.

```
***************************************
*                                     *
*  FUNCTION 16: CLOSE FILE            *
*                                     *
***************************************
*  Entry Parameters:                  *
*      Register   C:  10H             *
*      Registers DE:  FCB Address     *
*                                     *
*  Returned   Value:                  *
*      Register   A:  Directory Code  *
***************************************
```

The Close File function performs the inverse of the open file function. Given that the FCB addressed by DE has been previously activated through an open or make function (see functions 15 and 22), the close function permanently records the new FCB in the referenced disk directory. The FCB matching process for the close is identical to the open function. The directory code returned for a successful close operation is 0, 1, 2, or 3, while a 0FFH (255 decimal) is returned if the file name cannot be found in the directory. A file need not be closed if only read operations have taken place. If write operations have occurred, however, the close operation is necessary to permanently record the new directory information.

```
***************************************
*                                     *
*  FUNCTION 17: SEARCH FOR FIRST      *
*                                     *
***************************************
*  Entry Parameters:                  *
*      Register  C:  11H              *
*      Registers DE:  FCB Address     *
*                                     *
*  Returned  Value:                   *
*      Register  A:  Directory Code   *
***************************************
```

Search First scans the directory for a match with the file given by the FCB addressed by DE. The value 255 (hexadecimal FF) is returned if the file is not found, otherwise 0, 1, 2, or 3 is returned indicating the file is present. In the case that the file is found, the current DMA address is filled with the record containing the directory entry, and the relative starting position is A * 32 (i.e., rotate the A register left 5 bits, or ADD A five times). Although not normally required for application programs, the directory information can be extracted from the buffer at this position.

An ASCII question mark (63 decimal, 3F hexadecimal) in any position from "f1" through "ex" matches the corresponding field of any directory entry on the default or auto-selected disk drive. If the "dr" field contains an ASCII question mark, then the auto disk select function is disabled, the default disk is searched, with the search function returning any matched entry, allocated or free, belonging to any user number. This latter function is not normally used by application programs, but does allow complete flexibility to scan all current directory values. If the "dr" field is not a question mark, the "s2" byte is automatically zeroed.

```
***************************************
*                                     *
*  FUNCTION 18: SEARCH FOR NEXT       *
*                                     *
***************************************
*  Entry Parameters:                  *
*      Register  C:  12H              *
*                                     *
*  Returned  Value:                   *
*      Register  A:  Directory Code   *
***************************************
```

The Search Next function is similar to the Search First function, except that the directory scan continues from the last matched entry. Similar to function 17, function 18 returns the decimal value 255 in A when no more directory items match.

Appendix F

```
***************************************
*                                     *
*  FUNCTION 19: DELETE FILE           *
*                                     *
***************************************
*  Entry Parameters:                  *
*      Register   C:  13H             *
*      Registers DE:  FCB Address     *
*                                     *
*  Returned   Value:                  *
*      Register   A:  Directory Code  *
***************************************
```

The Delete File function removes files which match the FCB addressed by DE. The filename and type may contain ambiguous references (i.e., question marks in various positions), but the drive select code cannot be ambiguous, as in the Search and Search Next functions.

Function 19 returns a decimal 255 if the referenced file or files cannot be found, otherwise a value in the range Ø to 3 is returned.

```
***************************************
*                                     *
*  FUNCTION 2Ø: READ SEQUENTIAL       *
*                                     *
***************************************
*  Entry Parameters:                  *
*      Register   C:  14H             *
*      Registers DE:  FCB Address     *
*                                     *
*  Returned   Value:                  *
*      Register   A:  Directory Code  *
***************************************
```

Given that the FCB addressed by DE has been activated through an open or make function (numbers 15 and 22), the Read Sequential function reads the next 128 byte record from the file into memory at the current DMA address. the record is read from position "cr" of the extent, and the "cr" field is automatically incremented to the next record position. If the "cr" field overflows then the next logical extent is automatically opened and the "cr" field is reset to zero in preparation for the next read operation. The value ØØH is returned in the A register if the read operation was successful, while a non-zero value is returned if no data exists at the next record position (e.g., end of file occurs).

```
*****************************************
*                                       *
*  FUNCTION 21: WRITE SEQUENTIAL        *
*                                       *
*****************************************
*  Entry Parameters:                    *
*       Register    C:  15H             *
*       Registers DE:  FCB Address      *
*                                       *
*  Returned   Value:                    *
*       Register    A:  Directory Code  *
*****************************************
```

Given that the FCb addressed by DE has been activated through an open or make function (numbers 15 and 22), the Write Sequential function writes the 128 byte data record at the current DMA address to the file named by the FCB. the record is placed at position "cr" of the file, and the "cr" field is automatically incremented to the next record position. If the "cr" field overflows then the next logical extent is automatically opened and the "cr" field is reset to zero in preparation for the next write operation. Write operations can take place into an existing file, in which case newly written records overlay those which already exist in the file. Register A = 00H upon return from a successful write operation, while a non-zero value indicates an unsuccessful write due to a full disk.

```
*****************************************
*                                       *
*  FUNCTION 22: MAKE FILE               *
*                                       *
*****************************************
*  Entry Parameters:                    *
*       Register    C:  16H             *
*       Registers DE:  FCB Address      *
*                                       *
*  Returned   Value:                    *
*       Register    A:  Directory Code  *
*****************************************
```

The Make File operation is similar to the open file operation except that the FCB must name a file which does not exist in the currently referenced disk directory (i.e., the one named explicitly by a non-zero "dr" code, or the default disk if "dr" is zero). The FDOS creates the file and initializes both the directory and main memory value to an empty file. The programmer must ensure that no duplicate file names occur, and a preceding delete operation is sufficient if there is any possibility of duplication. Upon return, register A = 0, 1, 2, or 3 if the operation was successful and 0FFH (255 decimal) if no more directory space is available. The make function has the side-effect of activating the FCB and thus a subsequent open is not necessary.

```
****************************************
*                                      *
*  FUNCTION 23: RENAME FILE            *
*                                      *
****************************************
*  Entry Parameters:                   *
*      Register   C:  17H              *
*      Registers DE:  FCB Address      *
*                                      *
*  Returned   Value:                   *
*      Register   A:  Directory Code   *
****************************************
```

The Rename function uses the FCB addressed by DE to change all occurrences of the file named in the first 16 bytes to the file named in the second 16 bytes. The drive code "dr" at position Ø is used to select the drive, while the drive code for the new file name at position 16 of the FCB is assumed to be zero. Upon return, register A is set to a value between Ø and 3 if the rename was successful, and ØFFH (255 decimal) if the first file name could not be found in the directory scan.

```
****************************************
*                                      *
*  FUNCTION 24: RETURN LOGIN VECTOR    *
*                                      *
****************************************
*  Entry Parameters:                   *
*      Register   C:  18H              *
*                                      *
*  Returned   Value:                   *
*      Registers HL:  Login Vector     *
****************************************
```

The login vector value returned by CP/M is a 16-bit value in HL, where the least significant bit of L corresponds to the first drive A, and the high order bit of H corresponds to the sixteenth drive, labelled P. A "Ø" bit indicates that the drive is not on-line, while a "1" bit marks an drive that is actively on-line due to an explicit disk drive selection, or an implicit drive select caused by a file operation which specified a non-zero "dr" field. Note that compatibility is maintained with earlier releases, since registers A and L contain the same values upon return.

```
***************************************
*                                     *
*  FUNCTION 25: RETURN CURRENT DISK   *
*                                     *
***************************************
*  Entry Parameters:                  *
*      Register   C:  19H             *
*                                     *
*  Returned   Value:                  *
*      Register   A:  Current Disk    *
***************************************
```

Function 25 returns the currently selected default disk number in register A. The disk numbers range from Ø through 15 corresponding to drives A through P.

```
***************************************
*                                     *
*  FUNCTION 26: SET DMA ADDRESS       *
*                                     *
***************************************
*  Entry Parameters:                  *
*      Register   C:  1AH             *
*      Registers DE:  DMA Address     *
*                                     *
***************************************
```

"DMA" is an acronym for Direct Memory Address, which is often used in connection with disk controllers which directly access the memory of the mainframe computer to transfer data to and from the disk subsystem. Although many computer systems use non-DMA access (i.e., the data is transfered through programmed I/O operations), the DMA address has, in CP/M, come to mean the address at which the 128 byte data record resides before a disk write and after a disk read. Upon cold start, warm start, or disk system reset, the DMA address is automatically set to BOOT+ØØ8ØH. The Set DMA function, however, can be used to change this default value to address another area of memory where the data records reside. Thus, the DMA address becomes the value specified by DE until it is changed by a subsequent Set DMA function, cold start, warm start, or disk system reset.

```
***************************************
*                                     *
*  FUNCTION 27: GET ADDR(ALLOC)       *
*                                     *
***************************************
*  Entry Parameters:                  *
*      Register   C:  1BH             *
*                                     *
*  Returned   Value:                  *
*      Registers HL:  ALLOC Address   *
***************************************
```

An "allocation vector" is maintained in main memory for each on-line disk drive. Various system programs use the information provided by the allocation vector to determine the amount of remaining storage (see the STAT program). Function 27 returns the base address of the allocation vector for the currently selected disk drive. The allocation information may, however, be invalid if the selected disk has been marked read/only. Although this function is not normally used by application programs, additional details of the allocation vector are found in the "CP/M Alteration Guide."

```
***************************************
*                                     *
*  FUNCTION 28: WRITE PROTECT DISK    *
*                                     *
***************************************
*  Entry Parameters:                  *
*      Register   C:  1CH             *
*                                     *
***************************************
```

The disk write protect function provides temporary write protection for the currently selected disk. Any attempt to write to the disk, before the next cold or warm start operation produces the message

Bdos Err on d: R/O

```
***************************************
*                                     *
*  FUNCTION 29: GET READ/ONLY VECTOR  *
*                                     *
***************************************
*  Entry Parameters:                  *
*      Register   C:  1DH             *
*                                     *
*  Returned   Value:                  *
*      Registers HL:  R/O Vector Value*
***************************************
```

Function 29 returns a bit vector in register pair HL which indicates drives which have the temporary read/only bit set. Similar to function 24, the least significant bit corresponds to drive A, while the most significant bit corresponds to drive P. The R/O bit is set either by an explicit call to function 28, or by the automatic software mechanisms within CP/M which detect changed disks.

```
***************************************
*                                     *
*  FUNCTION 30: SET FILE ATTRIBUTES   *
*                                     *
***************************************
*  Entry Parameters:                  *
*      Register   C:  1EH             *
*      Registers DE:  FCB Address     *
*                                     *
*  Returned   Value:                  *
*      Register   A:  Directory Code  *
***************************************
```

The Set File Attributes function allows programmatic manipulation of permanent indicators attached to files. In particular, the R/O and System attributes (t1' and t2') can be set or reset. The DE pair addresses an unambiguous file name with the appropriate attributes set or reset. Function 30 searches for a match, and changes the matched directory entry to contain the selected indicators. Indicators f1' through f4' are not presently used, but may be useful for applications programs, since they are not involved in the matching process during file open and close operations. Indicators f5' through f8' and t3' are reserved for future system expansion.

Appendix F

```
****************************************
*                                      *
*   FUNCTION 31: GET ADDR(DISK PARMS)  *
*                                      *
****************************************
*   Entry Parameters:                  *
*       Register   C:  1FH             *
*                                      *
*   Returned   Value:                  *
*       Registers HL:  DPB Address     *
****************************************
```

The address of the BIOS resident disk parameter block is returned in HL as a result of this function call. This address can be used for either of two purposes. First, the disk parameter values can be extracted for display and space computation purposes, or transient programs can dynamically change the values of current disk parameters when the disk environment changes, if required. Normally, application programs will not require this facility.

```
****************************************
*                                      *
*   FUNCTION 32: SET/GET USER CODE     *
*                                      *
****************************************
*   Entry Parameters:                  *
*       Register   C:  20H             *
*       Register   E:  0FFH (get) or   *
*                      User Code (set) *
*                                      *
*   Returned   Value:                  *
*       Register   A:  Current Code or *
*                      (no value)      *
****************************************
```

An application program can change or interrogate the currently active user number by calling function 32. If register E = 0FFH, then the value of the current user number is returned in register A, where the value is in the range 0 to 31. If register E is not 0FFH, then the current user number is changed to the value of E (modulo 32).

```
;*************************************
;                                   *
;  FUNCTION 33: READ RANDOM         *
;                                   *
;*************************************
;  Entry Parameters:                *
;      Register   C:  21H           *
;      Registers DE:  FCB Address   *
;                                   *
;  Returned   Value:                *
;      Register   A:  Return Code   *
;*************************************
```

The Read Random function is similar to the sequential file read peration of previous releases, except that the read operation takes lace at a particular record number, selected by the 24-bit value onstructed from the three byte field following the FCB (byte ositions r0 at 33, rl at 34, and r2 at 35). Note that the sequence f 24 bits is stored with least significant byte first (r0), middle yte next (rl), and high byte last (r2). CP/M does not reference byte 2, except in computing the size of a file (function 35). Byte r2 ust be zero, however, since a non-zero value indicates overflow past he end of file.

Thus, the r0,rl byte pair is treated as a double-byte, or "word" alue, which contains the record to read. This value ranges from 0 to 5535, providing access to any particular record of the 8 megabyte ile. In order to process a file using random access, the base extent extent 0) must first be opened. Although the base extent may or may ot contain any allocated data, this ensures that the file is properly ecorded in the directory, and is visible in DIR requests. The elected record number is then stored into the random record field r0,rl), and the BDOS is called to read the record. Upon return from he call, register A either contains an error code, as listed below, r the value 00 indicating the operation was successful. In the atter case, the current DMA address contains the randomly accessed ecord. Note that contrary to the sequential read operation, the ecord number is not advanced. Thus, subsequent random read perations continue to read the same record.

Upon each random read operation, the logical extent and current ecord values are automatically set. Thus, the file can be equentially read or written, starting from the current randomly ccessed position. Note, however, that in this case, the last andomly read record will be re-read as you switch from random mode to equential read, and the last record will be re-written as you switch o a sequential write operation. You can, of course, simply advance he random record position following each random read or write to btain the effect of a sequential I/O operation.

Error codes returned in register A following a random read are isted below.

Ø1 reading unwritten data
Ø2 (not returned in random mode)
Ø3 cannot close current extent
Ø4 seek to unwritten extent
Ø5 (not returned in read mode)
Ø6 seek past physical end of disk

Error code Ø1 and Ø4 occur when a random read operation accesses a data block which has not been previously written, or an extent which has not been created, which are equivalent conditions. Error 3 does not normally occur under proper system operation, but can be cleared by simply re-reading, or re-opening extent zero as long as the disk is not physically write protected. Error code Ø6 occurs whenever byte r2 is non-zero under the current 2.Ø release. Normally, non-zero return codes can be treated as missing data, with zero return codes indicating operation complete.

```
***************************************
*                                     *
*  FUNCTION 34: WRITE RANDOM          *
*                                     *
***************************************
*  Entry Parameters:                  *
*      Register    C:  22H            *
*      Registers DE:  FCB Address     *
*                                     *
*  Returned   Value:                  *
*      Register    A:  Return Code    *
***************************************
```

The Write Random operation is initiated similar to the Read Random call, except that data is written to the disk from the current DMA address. Further, if the disk extent or data block which is the target of the write has not yet been allocated, the allocation is performed before the write operation continues. As in the Read Random operation, the random record number is not changed as a result of the write. The logical extent number and current record positions of the file control block are set to correspond to the random record which is being written. Again, sequential read or write operations can commence following a random write, with the notation that the currently addressed record is either read or rewritten again as the sequential operation begins. You can also simply advance the random record position following each write to get the effect of a sequential write operation. Note that in particular, reading or writing the last record of an extent in random mode does not cause an automatic extent switch as it does in sequential mode.

The error codes returned by a random write are identical to the random read operation with the addition of error code Ø5, which indicates that a new extent cannot be created due to directory overflow.

Append
F

(All Information Contained Herein is Proprietary to Digital Research.)

```
****************************************
*                                      *
*  FUNCTION 35: COMPUTE FILE SIZE      *
*                                      *
****************************************
*  Entry Parameters:                   *
*      Register   C:  23H              *
*      Registers DE:  FCB Address      *
*                                      *
*  Returned   Value:                   *
*      Random Record Field Set         *
****************************************
```

When computing the size of a file, the DE register pair addresses an FCB in random mode format (bytes rØ, r1, and r2 are present). The FCB contains an unambiguous file name which is used in the directory scan. Upon return, the random record bytes contain the "virtual" file size which is, in effect, the record address of the record following the end of the file. if, following a call to function 35, the high record byte r2 is Ø1, then the file contains the maximum record count 65536. Otherwise, bytes rØ and r1 constitute a 16-bit value (rØ is the least significant byte, as before) which is the file size.

Data can be appended to the end of an existing file by simply calling function 35 to set the random record position to the end of file, then performing a sequence of random writes starting at the preset record address.

The virtual size of a file corresponds to the physical size when the file is written sequentially. If, instead, the file was created in random mode and "holes" exist in the allocation, then the file may in fact contain fewer records than the size indicates. If, for example, only the last record of an eight megabyte file is written in random mode (i.e., record number 65535), then the virtual size is 65536 records, although only one block of data is actually allocated.

```
**************************************
*                                    *
*  FUNCTION 36: SET RANDOM RECORD    *
*                                    *
**************************************
*  Entry Parameters:                 *
*      Register  C:  24H             *
*      Registers DE:  FCB Address    *
*                                    *
*  Returned   Value:                 *
*      Random Record Field Set       *
**************************************
```

The Set Random Record function causes the BDOS to automatically produce the random record position from a file which has been read or written sequentially to a particular point. The function can be useful in two ways.

First, it is often necessary to initially read and scan a sequential file to extract the positions of various "key" fields. As each key is encountered, function 36 is called to compute the random record position for the data corresponding to this key. If the data unit size is 128 bytes, the resulting record position is placed into a table with the key for later retrieval. After scanning the entire file and tabularizing the keys and their record numbers, you can move instantly to a particular keyed record by performing a random read using the corresponding random record number which was saved earlier. The scheme is easily generalized when variable record lengths are involved since the program need only store the buffer-relative byte position along with the key and record number in order to find the exact starting position of the keyed data at a later time.

A second use of function 36 occurs when switching from a sequential read or write over to random read or write. A file is sequentially accessed to a particular point in the file, function 36 is called which sets the record number, and subsequent random read and write operations continue from the selected point in the file.

Appendix F

3. A SAMPLE FILE-TO-FILE COPY PROGRAM.

The program shown below provides a relatively simple example of file operations. The program source file is created as COPY.ASM using the CP/M ED program and then assembled using ASM or MAC, resulting in a "HEX" file. The LOAD program is the used to produce a COPY.COM file which executes directly under the CCP. The program begins by setting the stack pointer to a local area, and then proceeds to move the second name from the default area at 006CH to a 33-byte file control block called DFCB. The DFCB is then prepared for file operations by clearing the current record field. At this point, the source and destination FCB's are ready for processing since the SFCB at 005CH is properly set-up by the CCP upon entry to the COPY program. That is, the first name is placed into the default fcb, with the proper fields zeroed, including the current record field at 007CH. The program continues by opening the source file, deleting any exising destination file, and then creating the destination file. If all this is successful, the program loops at the label COPY until each record has been read from the source file and placed into the destination file. Upon completion of the data transfer, the destination file is closed and the program returns to the CCP command level by jumping to BOOT.

```
                ;       sample file-to-file copy program
                ;
                ;       at the ccp level, the command
                ;
                ;               copy a:x.y b:u.v
                ;
                ;       copies the file named x.y from drive
                ;       a to a file named u.v on drive b.
                ;
0000 =          boot    equ     0000h   ; system reboot
0005 =          bdos    equ     0005h   ; bdos entry point
005c =          fcbl    equ     005ch   ; first file name
005c =          sfcb    equ     fcbl    ; source fcb
006c =          fcb2    equ     006ch   ; second file name
0080 =          dbuff   equ     0080h   ; default buffer
0100 =          tpa     equ     0100h   ; beginning of tpa
                ;
0009 =          printf  equ     9       ; print buffer func#
000f =          openf   equ     15      ; open file func#
0010 =          closef  equ     16      ; close file func#
0013 =          deletef equ     19      ; delete file func#
0014 =          readf   equ     20      ; sequential read
0015 =          writef  equ     21      ; sequential write
0016 =          makef   equ     22      ; make file func#
                ;
0100                    org     tpa     ; beginning of tpa
0100 311b02             lxi     sp,stack; local stack
                ;
                ;       move second file name to dfcb
0103 0e10               mvi     c,16    ; half an fcb
```

```
0105 116c00            lxi     d,fcb2  ; source of move
0108 21da01            lxi     h,dfcb  ; destination fcb
010b 1a        mfcb:   ldax    d       ; source fcb
010c 13                inx     d       ; ready next
010d 77                mov     m,a     ; dest fcb
010e 23                inx     h       ; ready next
010f 0d                dcr     c       ; count 16...0
0110 c20b01            jnz     mfcb    ; loop 16 times
               ;
               ;       name has been moved, zero cr
0113 af                xra     a       ; a = 00h
0114 32fa01            sta     dfcbcr  ; current rec = 0
               ;
               ;       source and destination fcb's ready
               ;
0117 115c00            lxi     d,sfcb  ; source file
011a cd6901            call    open    ; error if 255
011d 118701            lxi     d,nofile; ready message
0120 3c                inr     a       ; 255 becomes 0
0121 cc6101            cz      finis   ; done if no file
               ;
               ;       source file open, prep destination
0124 11da01            lxi     d,dfcb  ; destination
0127 cd7301            call    delete  ; remove if present
               ;
012a 11da01            lxi     d,dfcb  ; destination
012d cd8201            call    make    ; create the file
0130 119601            lxi     d,nodir ; ready message
0133 3c                inr     a       ; 255 becomes 0
0134 cc6101            cz      finis   ; done if no dir space
               ;
               ;       source file open, dest file open
               ;       copy until end of file on source
               ;
0137 115c00    copy:   lxi     d,sfcb  ; source
013a cd7801            call    read    ; read next record
013d b7                ora     a       ; end of file?
013e c25101            jnz     eofile  ; skip write if so
               ;
               ;       not end of file, write the record
0141 11da01            lxi     d,dfcb  ; destination
0144 cd7d01            call    write   ; write record
0147 11a901            lxi     d,space ; ready message
014a b7                ora     a       ; 00 if write ok
014b c46101            cnz     finis   ; end if so
014e c33701            jmp     copy    ; loop until eof
               ;
               eofile: ; end of file, close destination
0151 11da01            lxi     d,dfcb  ; destination
0154 cd6e01            call    close   ; 255 if error
0157 21bb01            lxi     h,wrprot; ready message
015a 3c                inr     a       ; 255 becomes 00
015b cc6101            cz      finis   ; shouldn't happen
               ;
               ;       copy operation complete, end
```

Appendix F

```
015e 11cc01          lxi     d,normal; ready message
               ;
               finis:  ; write message given by de, reboot
0161 0e09            mvi     c,printf
0163 cd0500          call    bdos     ; write message
0166 c30000          jmp     boot     ; reboot system
               ;
               ;       system interface subroutines
               ;       (all return directly from bdos)
               ;
0169 0e0f      open:   mvi     c,openf
016b c30500            jmp     bdos
               ;
016e 0e10      close:  mvi     c,closef
0170 c30500            jmp     bdos
               ;
0173 0e13      delete: mvi     c,deletef
0175 c30500            jmp     bdos
               ;
0178 0e14      read:   mvi     c,readf
017a c30500            jmp     bdos
               ;
017d 0e15      write:  mvi     c,writef
017f c30500            jmp     bdos
               ;
0182 0e16      make:   mvi     c,makef
0184 c30500            jmp     bdos
               ;
               ;       console messages
0187 6e6f20fnofile: db      'no source file$'
0196 6e6f209nodir:  db      'no directory space$'
01a9 6f7574fspace:  db      'out of data space$'
01bb 7772695wrprot: db      'write protected?$'
01cc 636f700normal: db      'copy complete$'
               ;
               ;       data areas
01da           dfcb:   ds      33       ; destination fcb
01fa =         dfcbcr  equ     dfcb+32 ; current record
               ;
01fb                   ds      32       ; 16 level stack
               stack:
021b                   end
```

Note that there are several simplifications in this particular program. First, there are no checks for invalid file names which could, for example, contain ambiguous references. This situation could be detected by scanning the 32 byte default area starting at location 005CH for ASCII question marks. A check should also be made to ensure that the file names have, in fact, been included (check locations 005DH and 006DH for non-blank ASCII characters). Finally, a check should be made to ensure that the source and destination file names are different. A speed improvement could be made by buffering more data on each read operation. One could, for example, determine the size of memory by fetching FBASE from location 0006H and use the entire remaining portion of memory for a data buffer. In this case, the programmer simply resets the DMA address to the next successive 128 byte area before each read. Upon writing to the destination file, the DMA address is reset to the beginning of the buffer and incremented by 128 bytes to the end as each record is transferred to the destination file.

Appendix F

4. A SAMPLE FILE DUMP UTILITY.

The file dump program shown below is slightly more complex than the simple copy program given in the previous section. The dump program reads an input file, specified in the CCP command line, and displays the content of each record in hexadecimal format at the console. Note that the dump program saves the CCP's stack upon entry, resets the stack to a local area, and restores the CCP's stack before returning directly to the CCP. Thus, the dump program does not perform and warm start at the end of processing.

```
                ; DUMP program reads input file and displays hex data
                ;
0100                    org     100h
0005 =          bdos    equ     0005h    ;dos entry point
0001 =          cons    equ     1        ;read console
0002 =          typef   equ     2        ;type function
0009 =          printf  equ     9        ;buffer print entry
000b =          brkf    equ     11       ;break key function (true if char
000f =          openf   equ     15       ;file open
0014 =          readf   equ     20       ;read function
                ;
005c =          fcb     equ     5ch      ;file control block address
0080 =          buff    equ     80h      ;input disk buffer address
                ;
                ;       non graphic characters
000d =          cr      equ     0dh      ;carriage return
000a =          lf      equ     0ah      ;line feed
                ;
                ;       file control block definitions
005c =          fcbdn   equ     fcb+0    ;disk name
005d =          fcbfn   equ     fcb+1    ;file name
0065 =          fcbft   equ     fcb+9    ;disk file type (3 characters)
0068 =          fcbrl   equ     fcb+12   ;file's current reel number
006b =          fcbrc   equ     fcb+15   ;file's record count (0 to 128)
007c =          fcbcr   equ     fcb+32   ;current (next) record number (0
007d =          fcbln   equ     fcb+33   ;fcb length
                ;
                ;       set up stack
0100 210000             lxi     h,0
0103 39                 dad     sp
                ;       entry stack pointer in hl from the ccp
0104 221502             shld    oldsp
                ;       set sp to local stack area (restored at finis)
0107 315702             lxi     sp,stktop
                ;       read and print successive buffers
010a cdc101             call    setup    ;set up input file
010d feff               cpi     255      ;255 if file not present
010f c21b01             jnz     openok   ;skip if open is ok
                ;
                ;       file not there, give error message and return
0112 11f301             lxi     d,opnmsg
0115 cd9c01             call    err
0118 c35101             jmp     finis    ;to return
                ;
```

```
               openok: ;open operation ok, set buffer index to end
0llb 3e80              mvi     a,80h
0lld 321302            sta     ibp      ;set buffer pointer to 80h
               ;       hl contains next address to print
0120 210000            lxi     h,0      ;start with 0000
               ;
               gloop:
0123 e5                push    h        ;save line position
0124 cda201            call    gnb
0127 el                pop     h        ;recall line position
0128 da5101            jc      finis    ;carry set by gnb if end file
012b 47                mov     b,a
               ;       print hex values
               ;       check for line fold
012c 7d                mov     a,l
012d e60f              ani     0fh      ;check low 4 bits
012f c24401            jnz     nonum
               ;       print line number
0132 cd7201            call    crlf
               ;
               ;       check for break key
0135 cd5901            call    break
               ;       accum lsb = 1 if character ready
0138 0f                rrc              ;into carry
0139 da5101            jc      finis    ;don't print any more
               ;
013c 7c                mov     a,h
013d cd8f01            call    phex
0140 7d                mov     a,l
0141 cd8f01            call    phex
               nonum:
0144 23                inx     h        ;to next line number
0145 3e20              mvi     a,' '
0147 cd6501            call    pchar
014a 78                mov     a,b
014b cd8f01            call    phex
014e c32301            jmp     gloop
               ;
               finis:
               ;       end of dump, return to ccp
               ;       (note that a jmp to 0000h reboots)
0151 cd7201            call    crlf
0154 2al502            lhld    oldsp
0157 f9                sphl
               ;       stack pointer contains ccp's stack location
0158 c9                ret              ;to the ccp
               ;
               ;
               ;       subroutines
               ;
               break:  ;check break key (actually any key will do)
0159 e5d5c5            push h! push d! push b; environment saved
015c 0e0b              mvi     c,brkf
015e cd0500            call    bdos
0161 cldlel            pop b! pop d! pop h; environment restored
```

Appendix F

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```
Ø164 c9                 ret
              ;
              pchar:    ;print a character
Ø165 e5d5c5             push h! push d! push b; saved
Ø168 Øe02               mvi     c,typef
Ø16a 5f                 mov     e,a
Ø16b cdØ5ØØ             call    bdos
Ø16e cldlel             pop b! pop d! pop h; restored
Ø171 c9                 ret
              ;
              crlf:
Ø172 3eØd               mvi     a,cr
Ø174 cd65Ø1             call    pchar
Ø177 3eØa               mvi     a,lf
Ø179 cd65Ø1             call    pchar
Ø17c c9                 ret
              ;
              ;
              pnib:     ;print nibble in reg a
Ø17d e6Øf               ani     Øfh     ;low 4 bits
Ø17f feØa               cpi     1Ø
Ø181 d289Ø1             jnc     p1Ø
              ;         less than or equal to 9
Ø184 c63Ø               adi     'Ø'
Ø186 c38bØ1             jmp     prn
              ;
              ;         greater or equal to 1Ø
Ø189 c637     p1Ø:      adi     'a' - 1Ø
Ø18b cd65Ø1   prn:      call    pchar
Ø18e c9                 ret
              ;
              phex:     ;print hex char in reg a
Ø18f f5                 push    psw
Ø19Ø Øf                 rrc
Ø191 Øf                 rrc
Ø192 Øf                 rrc
Ø193 Øf                 rrc
Ø194 cd7dØ1             call    pnib    ;print nibble
Ø197 f1                 pop     psw
Ø198 cd7dØ1             call    pnib
Ø19b c9                 ret
              ;
              err:      ;print error message
              ;         d,e addresses message ending with "$"
Ø19c ØeØ9               mvi     c,printf        ;print buffer function
Ø19e cdØ5ØØ             call    bdos
Ø1a1 c9                 ret
              ;
              ;
              gnb:      ;get next byte
Ø1a2 3a13Ø2             lda     ibp
Ø1a5 fe8Ø               cpi     8Øh
Ø1a7 c2b3Ø1             jnz     gØ
              ;         read another buffer
              ;
```

```
                ;
01aa cdce01         call    diskr
01ad b7             ora     a       ;zero value if read ok
01ae cab301         jz      g0      ;for another byte
                ;   end of data, return with carry set for eof
01b1 37             stc
01b2 c9             ret
                ;
                g0:     ;read the byte at buff+reg a
01b3 5f             mov     e,a     ;ls byte of buffer index
01b4 1600           mvi     d,0     ;double precision index to de
01b6 3c             inr     a       ;index=index+1
01b7 321302         sta     ibp     ;back to memory
                ;   pointer is incremented
                ;   save the current file address
01ba 218000         lxi     h,buff
01bd 19             dad     d
                ;   absolute character address is in hl
01be 7e             mov     a,m
                ;   byte is in the accumulator
01bf b7             ora     a       ;reset carry bit
01c0 c9             ret
                ;
                setup:  ;set up file
                ;   open the file for input
01c1 af             xra     a       ;zero to accum
01c2 327c00         sta     fcbcr   ;clear current record
                ;
01c5 115c00         lxi     d,fcb
01c8 0e0f           mvi     c,openf
01ca cd0500         call    bdos
                ;   255 in accum if open error
01cd c9             ret
                ;
                diskr:  ;read disk file record
01ce e5d5c5         push h! push d! push b
01d1 115c00         lxi     d,fcb
01d4 0e14           mvi     c,readf
01d6 cd0500         call    bdos
01d9 c1d1e1         pop b! pop d! pop h
01dc c9             ret
                ;
                ;   fixed message area
01dd 46494c0signon: db      'file dump version 2.0$'
01f3 0d0a4e0opnmsg: db      cr,lf,'no input file present on disk$'

                ;   variable area
0213            ibp:    ds      2       ;input buffer pointer
0215            oldsp:  ds      2       ;entry sp value from ccp
                ;
                ;   stack area
0217                ds      64      ;reserve 32 level stack
                stktop:
                ;
0257                end
```

Appen F

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5. A SAMPLE RANDOM ACCESS PROGRAM.

This manual is concluded with a rather extensive, but complete example of random access operation. The program listed below performs the simple function of reading or writing random records upon command from the terminal. Given that the program has been created, assembled, and placed into a file labelled RANDOM.COM, the CCP level command:

RANDOM X.DAT

starts the test program. The program looks for a file by the name X.DAT (in this particular case) and, if found, proceeds to prompt the console for input. If not found, the file is created before the prompt is given. Each prompt takes the form

next command?

and is followed by operator input, terminated by a carriage return. The input commands take the form

nW nR Q

where n is an integer value in the range Ø to 65535, and W, R, and Q are simple command characters corresponding to random write, random read, and quit processing, respectively. If the W command is issued, the RANDOM program issues the prompt

type data:

The operator then responds by typing up to 127 characters, followed by a carriage return. RANDOM then writes the character string into the X.DAT file at record n. If the R command is issued, RANDOM reads record number n and displays the string value at the console. If the Q command is issued, the X.DAT file is closed, and the program returns to the console command processor. In the interest of brevity, the only error message is

error, try again

The program begins with an initialization section where the input file is opened or created, followed by a continuous loop at the label "ready" where the individual commands are interpreted. The default file control block at ØØ5CH and the default buffer at ØØ8ØH are used in all disk operations. The utility subroutines then follow, which contain the principal input line processor, called "readc." This particular program shows the elements of random access processing, and can be used as the basis for further program development.

```
          ;**************************************************
          ;*                                                *
          ;* sample random access program for cp/m 2.0      *
          ;*                                                *
          ;**************************************************
0100                    org     100h    ;base of tpa
          ;
0000 =    reboot  equ     0000h   ;system reboot
0005 =    bdos    equ     0005h   ;bdos entry point
          ;
0001 =    coninp  equ     1       ;console input function
0002 =    conout  equ     2       ;console output function
0009 =    pstring equ     9       ;print string until '$'
000a =    rstring equ     10      ;read console buffer
000c =    version equ     12      ;return version number
000f =    openf   equ     15      ;file open function
0010 =    closef  equ     16      ;close function
0016 =    makef   equ     22      ;make file function
0021 =    readr   equ     33      ;read random
0022 =    writer  equ     34      ;write random
          ;
005c =    fcb     equ     005ch   ;default file control block
007d =    ranrec  equ     fcb+33  ;random record position
007f =    ranovf  equ     fcb+35  ;high order (overflow) byte
0080 =    buff    equ     0080h   ;buffer address
          ;
000d =    cr      equ     0dh     ;carriage return
000a =    lf      equ     0ah     ;line feed
          ;
          ;**************************************************
          ;*                                                *
          ;* load SP, set-up file for random access        *
          ;*                                                *
          ;**************************************************
0100 31bc0              lxi     sp,stack
          ;
          ;             version 2.0?
0103 0e0c               mvi     c,version
0105 cd050              call    bdos
0108 fe20               cpi     20h     ;version 2.0 or better?
010a d2160              jnc     versok
          ;             bad version, message and go back
010d 111b0              lxi     d,badver
0110 cdda0              call    print
0113 c3000              jmp     reboot
          ;
          versok:
          ;             correct version for random access
0116 0e0f               mvi     c,openf ;open default fcb
0118 115c0              lxi     d,fcb
011b cd050              call    bdos
011e 3c                 inr     a       ;err 255 becomes zero
011f c2370              jnz     ready
          ;
          ;             cannot open file, so create it
```

```
0122 0e16               mvi     c,makef
0124 115c0              lxi     d,fcb
0127 cd050              call    bdos
012a 3c                 inr     a       ;err 255 becomes zero
012b c2370              jnz     ready
                ;
                ;       cannot create file, directory full
012e 113a0              lxi     d,nospace
0131 cdda0              call    print
0134 c3000              jmp     reboot  ;back to ccp
                ;
                ;***************************************************
                ;*                                                 *
                ;*  loop back to "ready" after each command       *
                ;*                                                 *
                ;***************************************************
                ;
                ready:
                ;       file is ready for processing
                ;
0137 cde50              call    readcom ;read next command
013a 227d0              shld    ranrec  ;store input record#
013d 217f0              lxi     h,ranovf
0140 3600               mvi     m,0     ;clear high byte if set
0142 fe51               cpi     'Q'     ;quit?
0144 c2560              jnz     notq
                ;
                ;       quit processing, close file
0147 0e10               mvi     c,closef
0149 115c0              lxi     d,fcb
014c cd050              call    bdos
014f 3c                 inr     a       ;err 255 becomes 0
0150 cab90              jz      error   ;error message, retry
0153 c3000              jmp     reboot  ;back to ccp
                ;
                ;***************************************************
                ;*                                                 *
                ;* end of quit command, process write             *
                ;*                                                 *
                ;***************************************************
                notq:
                ;       not the quit command, random write?
0156 fe57               cpi     'W'
0158 c2890              jnz     notw
                ;
                ;       this is a random write, fill buffer until cr
015b 114d0              lxi     d,datmsg
015e cdda0              call    print   ;data prompt
0161 0e7f               mvi     c,127   ;up to 127 characters
0163 21800              lxi     h,buff  ;destination
                rloop:  ;read next character to buff
0166 c5                 push    b       ;save counter
0167 e5                 push    h       ;next destination
0168 cdc20              call    getchr  ;character to a
016b e1                 pop     h       ;restore counter
```

```
Ø16c cl              pop     b          ;restore next to fill
Ø16d feØd            cpi     cr         ;end of line?
Ø16f ca78Ø           jz      erloop
            ;        not end, store character
Ø172 77              mov     m,a
Ø173 23              inx     h          ;next to fill
Ø174 Ød              dcr     c          ;counter goes down
Ø175 c266Ø           jnz     rloop      ;end of buffer?
            erloop:
            ;        end of read loop, store ØØ
Ø178 36ØØ            mvi     m,Ø
            ;
            ;        write the record to selected record number
Ø17a Øe22            mvi     c,writer
Ø17c 115cØ           lxi     d,fcb
Ø17f cdØ5Ø           call    bdos
Ø182 b7              ora     a          ;error code zero?
Ø183 c2b9Ø           jnz     error      ;message if not
Ø186 c337Ø           jmp     ready      ;for another record
            ;
            ;***************************************************
            ;*                                                 *
            ;* end of write command, process read              *
            ;*                                                 *
            ;***************************************************
            notw:
            ;        not a write command, read record?
Ø189 fe52            cpi     'R'
Ø18b c2b9Ø           jnz     error      ;skip if not
            ;
            ;        read random record
Ø18e Øe21            mvi     c,readr
Ø19Ø 115cØ           lxi     d,fcb
Ø193 cdØ5Ø           call    bdos
Ø196 b7              ora     a          ;return code ØØ?
Ø197 c2b9Ø           jnz     error
            ;
            ;        read was successful, write to console
Ø19a cdcfØ           call    crlf       ;new line
Ø19d Øe8Ø            mvi     c,128      ;max 128 characters
Ø19f 218ØØ           lxi     h,buff     ;next to get
            wloop:
Ø1a2 7e              mov     a,m        ;next character
Ø1a3 23              inx     h          ;next to get
Ø1a4 e67f            ani     7fh        ;mask parity
Ø1a6 ca37Ø           jz      ready      ;for another command if ØØ
Ø1a9 c5              push    b          ;save counter
Ø1aa e5              push    h          ;save next to get
Ø1ab fe2Ø            cpi     ' '        ;graphic?
Ø1ad d4c8Ø           cnc     putchr     ;skip output if not
Ø1bØ el              pop     h
Ø1bl cl              pop     b
Ø1b2 Ød              dcr     c          ;count=count-1
Ø1b3 c2a2Ø           jnz     wloop
Ø1b6 c337Ø           jmp     ready
```

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```
          ;
          ;************************************************
          ;*                                              *
          ;* end of read command, all errors end-up here  *
          ;*                                              *
          ;************************************************
          ;
          error:
Ø1b9 1159Ø          lxi     d,errmsg
Ø1bc cddaØ          call    print
Ø1bf c337Ø          jmp     ready
          ;
          ;************************************************
          ;*                                              *
          ;* utility subroutines for console i/o          *
          ;*                                              *
          ;************************************************
          getchr:
                    ;read next console character to a
Ø1c2 ØeØ1           mvi     c,coninp
Ø1c4 cdØ5Ø          call    bdos
Ø1c7 c9             ret
          ;
          putchr:
                    ;write character from a to console
Ø1c8 ØeØ2           mvi     c,conout
Ø1ca 5f             mov     e,a     ;character to send
Ø1cb cdØ5Ø          call    bdos    ;send character
Ø1ce c9             ret
          ;
          crlf:
                    ;send carriage return line feed
Ø1cf 3eØd           mvi     a,cr    ;carriage return
Ø1d1 cdc8Ø          call    putchr
Ø1d4 3eØa           mvi     a,lf    ;line feed
Ø1d6 cdc8Ø          call    putchr
Ø1d9 c9             ret
          ;
          print:
                    ;print the buffer addressed by de until $
Ø1da d5             push    d
Ø1db cdcfØ          call    crlf
Ø1de d1             pop     d       ;new line
Ø1df ØeØ9           mvi     c,pstring
Ø1e1 cdØ5Ø          call    bdos    ;print the string
Ø1e4 c9             ret
          ;
          readcom:
                    ;read the next command line to the conbuf
Ø1e5 116bØ          lxi     d,prompt
Ø1e8 cddaØ          call    print   ;command?
Ø1eb ØeØa           mvi     c,rstring
Ø1ed 117aØ          lxi     d,conbuf
Ø1fØ cdØ5Ø          call    bdos    ;read command line
          ;         command line is present, scan it
```

```
01f3 210000           lxi     h,0       ;start with 0000
01f6 117c0            lxi     d,conlin;command line
01f9 1a      readc:   ldax    d         ;next command character
01fa 13               inx     d         ;to next command position
01fb b7               ora     a         ;cannot be end of command
01fc c8               rz
             ;        not zero, numeric?
01fd d630             sui     '0'
01ff fe0a             cpi     10        ;carry if numeric
0201 d2130            jnc     endrd
             ;        add-in next digit
0204 29               dad     h         ;*2
0205 4d               mov     c,l
0206 44               mov     b,h       ;bc = value * 2
0207 29               dad     h         ;*4
0208 29               dad     h         ;*8
0209 09               dad     b         ;*2 + *8 = *10
020a 85               add     l         ;+digit
020b 6f               mov     l,a
020c d2f90            jnc     readc     ;for another char
020f 24               inr     h         ;overflow
0210 c3f90            jmp     readc     ;for another char
             endrd:
             ;        end of read, restore value in a
0213 c630             adi     '0'       ;command
0215 fe61             cpi     'a'       ;translate case?
0217 d8               rc
             ;        lower case, mask lower case bits
0218 e65f             ani     101$1111b
021a c9               ret
             ;
             ;*****************************************************
             ;*                                                   *
             ;* string data area for console messages             *
             ;*                                                   *
             ;*****************************************************
             badver:
021b 536f79           db      'sorry, you need cp/m version 2$'
             nospace:
023a 4e6f29           db      'no directory space$'
             datmsg:
024d 547970           db      'type data: $'
             errmsg:
0259 457272           db      'error, try again.$'
             prompt:
026b 4e6570           db      'next command? $'
             ;
```

Appendix F

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```
            ;*****************************************************
            ;*                                                   *
            ;* fixed and variable data area                      *
            ;*                                                   *
            ;*****************************************************
027a 21     conbuf: db      conlen  ;length of console buffer
027b        consiz: ds      1       ;resulting size after read
027c        conlin: ds      32      ;length 32 buffer
0021 =      conlen  equ     $-consiz
            ;
029c                ds      32      ;16 level stack
            stack:
02bc                end
```

Again, major improvements could be made to this particular program to enhance its operation. In fact, with some work, this program could evolve into a simple data base management system. One could, for example, assume a standard record size of 128 bytes, consisting of arbitrary fields within the record. A program, called GETKEY, could be developed which first reads a sequential file and extracts a specific field defined by the operator. For example, the command

GETKEY NAMES.DAT LASTNAME 10 20

would cause GETKEY to read the data base file NAMES.DAT and extract the "LASTNAME" field from each record, starting at position 10 and ending at character 20. GETKEY builds a table in memory consisting of each particular LASTNAME field, along with its 16-bit record number location within the file. The GETKEY program then sorts this list, and writes a new file, called LASTNAME.KEY, which is an alphabetical list of LASTNAME fields with their corresponding record numbers. (This list is called an "inverted index" in information retrieval parlance.)

Rename the program shown above as QUERY, and massage it a bit so that it reads a sorted key file into memory. The command line might appear as:

QUERY NAMES.DAT LASTNAME.KEY

Instead of reading a number, the QUERY program reads an alphanumeric string which is a particular key to find in the NAMES.DAT data base. Since the LASTNAME.KEY list is sorted, you can find a particular entry quite rapidly by performing a "binary search," similar to looking up a name in the telephone book. That is, starting at both ends of the list, you examine the entry halfway in between and, if not matched, split either the upper half or the lower half for the next search. You'll quickly reach the item you're looking for (in log2(n) steps) where you'll find the corresponding record number. Fetch and display this record at the console, just as we have done in the program shown above.

At this point you're just getting started. With a little more work, you can allow a fixed grouping size which differs from the 128 byte record shown above. This is accomplished by keeping track of the record number as well as the byte offset within the record. Knowing the group size, you randomly access the record containing the proper group, offset to the beginning of the group within the record read sequentially until the group size has been exhausted.

Finally, you can improve QUERY considerably by allowing boolean expressions which compute the set of records which satisfy several relationships, such as a LASTNAME between HARDY and LAUREL, and an AGE less than 45. Display all the records which fit this description. Finally, if your lists are getting too big to fit into memory, randomly access your key files from the disk as well. One note of consolation after all this work: if you make it through the project, you'll have no more need for this manual!

6. SYSTEM FUNCTION SUMMARY.

FUNC	FUNCTION NAME	INPUT PARAMETERS	OUTPUT RESULTS
Ø	System Reset	none	none
1	Console Input	none	A = char
2	Console Output	E = char	none
3	Reader Input	none	A = char
4	Punch Output	E = char	none
5	List Output	E = char	none
6	Direct Console I/O	see def	see def
7	Get I/O Byte	none	A = IOBYTE
8	Set I/O Byte	E = IOBYTE	none
9	Print String	DE = .Buffer	none
1Ø	Read Console Buffer	DE = .Buffer	see def
11	Get Console Status	none	A = ØØ/FF
12	Return Version Number	none	HL= Version*
13	Reset Disk System	none	see def
14	Select Disk	E = Disk Number	see def
15	Open File	DE = .FCB	A = Dir Code
16	Close File	DE = .FCB	A = Dir Code
17	Search for First	DE = .FCB	A = Dir Code
18	Search for Next	none	A = Dir Code
19	Delete File	DE = .FCB	A = Dir Code
2Ø	Read Sequential	DE = .FCB	A = Err Code
21	Write Sequential	DE = .FCB	A = Err Code
22	Make File	DE = .FCB	A = Dir Code
23	Rename File	DE = .FCB	A = Dir Code
24	Return Login Vector	none	HL= Login Vect*
25	Return Current Disk	none	A = Cur Disk#
26	Set DMA Address	DE = .DMA	none
27	Get Addr(Alloc)	none	HL= .Alloc
28	Write Protect Disk	none	see def
29	Get R/O Vector	none	HL= R/O Vect*
3Ø	Set File Attributes	DE = .FCB	see def
31	Get Addr(disk parms)	none	HL= .DPB
32	Set/Get User Code	see def	see def
33	Read Random	DE = .FCB	A = Err Code
34	Write Random	DE = .FCB	A = Err Code
35	Compute File Size	DE = .FCB	rØ, r1, r2
36	Set Random Record	DE = .FCB	rØ, r1, r2

* Note that A = L, and B = H upon return

APPENDIX G

THE CP/M 2.0 SYSTEM ALTERATION GUIDE

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CP/M 2.0 ALTERATION GUIDE

Appendix G

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CP/M 2.Ø ALTERATION GUIDE

Digital Research, Box 579
Pacific Grove, California

1. INTRODUCTION

The standard CP/M system assumes operation on an Intel MDS-800 microcomputer development system, but is designed so that the user can alter a specific set of subroutines which define the hardware operating environment. In this way, the user can produce a diskette which operates with any IBM-3741 format compatible drive controller and other peripheral devices.

Although standard CP/M 2.0 is configured for single density floppy disks, field-alteration features allow adaptation to a wide variety of disk subsystems from single drive minidisks through high-capacity "hard disk" systems. In order to simplify the following adaptation process, we assume that CP/M 2.0 will first be configured for single density floppy disks where minimal editing and debugging tools are available. If an earlier version of CP/M is available, the customizing process is eased considerably. In this latter case, you may wish to briefly review the system generation process, and skip to later sections which discuss system alteration for non-standard disk systems.

In order to achieve device independence, CP/M is separated into three distinct modules:

BIOS - basic I/O system which is environment dependent
BDOS - basic disk operating system which is not dependent upon the hardware configuration
CCP - the console command processor which uses the BDOS

Of these modules, only the BIOS is dependent upon the particular hardware. That is, the user can "patch" the distribution version of CP/M to provide a new BIOS which provides a customized interface between the remaining CP/M modules and the user's own hardware system. The purpose of this document is to provide a step-by-step procedure for patching your new BIOS into CP/M.

If CP/M is being tailored to your computer system for the first time, the new BIOS requires some relatively simple software development and testing. The standard BIOS is listed in Appendix B, and can be used as a model for the customized package. A skeletal version of the BIOS is given in Appendix C which can serve as the basis for a modified BIOS. In addition to the BIOS, the user must write a simple memory loader, called GETSYS, which brings the operating system into memory. In order to patch the new BIOS into CP/M, the user must write the reverse of GETSYS, called PUTSYS, which places an altered version of CP/M back onto the diskette. PUTSYS can be derived from GETSYS by changing the disk read commands into disk write commands. Sample skeletal GETSYS and PUTSYS programs are described in Section 3, and listed in Appendix D. In order to make the CP/M system work automatically, the user must also supply a cold start loader, similar to the one provided with CP/M (listed in Appendices A and B). A skeletal form of a cold start loader is given in Appendix E which can serve as a model for your loader.

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2. FIRST LEVEL SYSTEM REGENERATION

The procedure to follow to patch the CP/M system is given below in several steps. Address references in each step are shown with a following "H" which denotes the hexadecimal radix, and are given for a 20K CP/M system. For larger CP/M systems, add a "bias" to each address which is shown with a "+b" following it, where b is equal to the memory size - 20K. Values for b in various standard memory sizes are

24K:	b = 24K - 20K = 4K = 1000H
32K:	b = 32K - 20K = 12K = 3000H
40K:	b = 40K - 20K = 20K = 5000H
48K:	b = 48K - 20K = 28K = 7000H
56K:	b = 56K - 20K = 36K = 9000H
62K:	b = 62K - 20K = 42K = A800H
64K:	b = 64K - 20K = 44K = B000H

Note: The standard distribution version of CP/M is set for operation within a 20K memory system. Therefore, you must first bring up the 20K CP/M system, and then configure it for your actual memory size (see Second Level System Generation).

(1) Review Section 4 and write a GETSYS program which reads the first two tracks of a diskette into memory. The data from the diskette must begin at location 3380H. Code GETSYS so that it starts at location 100H (base of the TPA), as shown in the first part of Appendix D.

(2) Test the GETSYS program by reading a blank diskette into memory, and check to see that the data has been read properly, and that the diskette has not been altered in any way by the GETSYS program.

(3) Run the GETSYS program using an initialized CP/M diskette to see if GETSYS loads CP/M starting at 3380H (the operating system actually starts 128 bytes later at 3400H).

(4) Review Section 4 and write the PUTSYS program which writes memory starting at 3380H back onto the first two tracks of the diskette. The PUTSYS program should be located at 200H, as shown in the second part of Appendix D.

(5) Test the PUTSYS program using a blank uninitialized diskette by writing a portion of memory to the first two tracks; clear memory and read it back using GETSYS. Test PUTSYS completely, since this program will be used to alter CP/M on disk.

(6) Study Sections 5, 6, and 7, along with the distribution version of the BIOS given in Appendix B, and write a simple version which performs a similar function for the customized environment. Use the program given in Appendix C as a model. Call this new BIOS by the name CBIOS (customized BIOS). Implement only the primitive disk operations on a single drive, and simple console input/output functions in this phase.

(7) Test CBIOS completely to ensure that it properly performs console character I/O and disk reads and writes. Be especially careful to ensure that no disk write operations occur accidently during read operations, and check that the proper track and sectors are addressed on all reads and writes. Failure to make these checks may cause destruction of the initialized CP/M system after it is patched.

(8) Referring to Figure 1 in Section 5, note that the BIOS is placed between locations 4A00H and 4FFFH. Read the CP/M system using GETSYS and replace the BIOS segment by the new CBIOS developed in step (6) and tested in step (7). This replacement is done in the memory of the machine, and will be placed on the diskette in the next step.

(9) Use PUTSYS to place the patched memory image of CP/M onto the first two tracks of a blank diskette for testing.

(10) Use GETSYS to bring the copied memory image from the test diskette back into memory at 3380H, and check to ensure that it has loaded back properly (clear memory, if possible, before the load). Upon successful load, branch to the cold start code at location 4A00H. The cold start routine will initialize page zero, then jump to the CCP at location 3400H which will call the BDOS, which will call the CBIOS. The CBIOS will be asked by the CCP to read sixteen sectors on track 2, and if successful, CP/M will type "A>", the system prompt.

When you make it this far, you are almost on the air. If you have trouble, use whatever debug facilities you have available to trace and breakpoint your CBIOS.

(11) Upon completion of step (10), CP/M has prompted the console for a command input. Test the disk write operation by typing

```
SAVE 1 X.COM
```

(recall that all commands must be followed by a carriage return).

CP/M should respond with another prompt (after several disk accesses):

```
A>
```

If it does not, debug your disk write functions and retry.

(12) Then test the directory command by typing

```
DIR
```

CP/M should respond with

```
A: X      COM
```

(13) Test the erase command by typing

```
ERA X.COM
```

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CP/M should respond with the A prompt. When you make it this far, you should have an operational system which will only require a bootstrap loader to function completely.

(14) Write a bootstrap loader which is similar to GETSYS, and place it on track Ø, sector 1 using PUTSYS (again using the test diskette, not the distribution diskette). See Sections 5 and 8 for more information on the bootstrap operation.

(15) Retest the new test diskette with the bootstrap loader installed by executing steps (11), (12), and (13). Upon completion of these tests, type a control-C (control and C keys simultaneously). The system should then execute a "warm start" which reboots the system, and types the A prompt.

(16) At this point, you probably have a good version of your customized CP/M system on your test diskette. Use GETSYS to load CP/M from your test diskette. Remove the test diskette, place the distribution diskette (or a legal copy) into the drive, and use PUTSYS to replace the distribution version by your customized version. Do not make this replacement if you are unsure of your patch since this step destroys the system which was sent to you from Digital Research.

(17) Load your modified CP/M system and test it by typing

```
DIR
```

CP/M should respond with a list of files which are provided on the initialized diskette. One such file should be the memory image for the debugger, called DDT.COM.

NOTE: from now on, it is important that you always reboot the CP/M system (ctl-C is sufficient) when the diskette is removed and replaced by another diskette, unless the new diskette is to be read only.

(18) Load and test the debugger by typing

```
DDT
```

(see the document "CP/M Dynamic Debugging Tool (DDT)" for operating procedures. You should take the time to become familiar with DDT, it will be your best friend in later steps.

(19) Before making further CBIOS modifications, practice using the editor (see the ED user's guide), and assembler (see the ASM user's guide). Then recode and test the GETSYS, PUTSYS, and CBIOS programs using ED, ASM, and DDT. Code and test a COPY program which does a sector-to-sector copy from one diskette to another to obtain back-up copies of the original diskette (NOTE: read your CP/M Licensing Agreement; it specifies your legal responsibilities when copying the CP/M system). Place the copyright notice

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on each copy which is made with your COPY program.

(20) Modify your CBIOS to include the extra functions for punches, readers, signon messages, and so-forth, and add the facilities for a additional disk drives, if desired. You can make these changes with the GETSYS and PUTSYS programs which you have developed, or you can refer to the following section, which outlines CP/M facilities which will aid you in the regeneration process.

You now have a good copy of the customized CP/M system. Note that although the CBIOS portion of CP/M which you have developed belongs to you, the modified version of CP/M which you have created can be copied for your use only (again, read your Licensing Agreement), and cannot be legally copied for anyone else's use.

It should be noted that your system remains file-compatible with all other CP/M systems, (assuming media compatiblity, of course) which allows transfer of non-proprietary software between users of CP/M.

3. SECOND LEVEL SYSTEM GENERATION

Now that you have the CP/M system running, you will want to configure CP/M for your memory size. In general, you will first get a memory image of CP/M with the "MOVCPM" program (system relocator) and place this memory image into a named disk file. The disk file can then be loaded, examined, patched, and replaced using the debugger, and system generation program. For further details on the operation of these programs, see the "Guide to CP/M Features and Facilities" manual.

Your CBIOS and BOOT can be modified using ED, and assembled using ASM, producing files called CBIOS.HEX and BOOT.HEX, which contain the machine code for CBIOS and BOOT in Intel hex format.

To get the memory image of CP/M into the TPA configured for the desired memory size, give the command:

```
MOVCPM xx *
```

where "xx" is the memory size in decimal K bytes (e.g., 32 for 32K). The response will be:

```
CONSTRUCTING xxK CP/M VERS 2.Ø
READY FOR "SYSGEN" OR
"SAVE 34 CPMxx.COM"
```

At this point, an image of a CP/M in the TPA configured for the requested memory size. The memory image is at location Ø9ØØH through 227FH. (i.e., The BOOT is at Ø9ØØH, the CCP is at 98ØH, the BDOS starts at 118ØH, and the BIOS is at 1F8ØH.) Note that the memory image has the standard MDS-8ØØ BIOS and BOOT on it. It is now necessary to save the memory image in a file so that you can patch your CBIOS and CBOOT into it:

```
SAVE 34 CPMxx.COM
```

The memory image created by the "MOVCPM" program is offset by a negative bias so that it loads into the free area of the TPA, and thus does not interfere with the operation of CP/M in higher memory. This memory image can be subsequently loaded under DDT and examined or changed in preparation for a new generation of the system. DDT is loaded with the memory image by typing:

```
DDT CPMxx.COM                    Load DDT, then read the CP/M
                                 image
```

DDT should respond with

```
NEXT  PC
23ØØ  Ø1ØØ
-                                (The DDT prompt)
```

You can then use the display and disassembly commands to examine portions of the memory image between 900H and 227FH. Note, however, that to find any particular address within the memory image, you must apply the negative bias to the CP/M address to find the actual address. Track 00, sector 01 is loaded to location 900H (you should find the cold start loader at 900H to 97FH), track 00, sector 02 is loaded into 980H (this is the base of the CCP), and so-forth through the entire CP/M system load. In a 20K system, for example, the CCP resides at the CP/M address 3400H, but is placed into memory at 980H by the SYSGEN program. Thus, the negative bias, denoted by n, satisfies

    3400H + n = 980H, or n = 980H - 3400H

Assuming two's complement arithmetic, n = D580H, which can be checked by

    3400H + D580H = 10980H = 0980H (ignoring high-order
                                    overflow).

Note that for larger systems, n satisfies

    (3400H+b) + n = 980H, or
    n = 980H - (3400H + b), or
    n = D580H - b.

The value of n for common CP/M systems is given below

memory size	bias b	negative offset n
20K	0000H	D580H - 0000H = D580H
24K	1000H	D580H - 1000H = C580H
32K	3000H	D580H - 3000H = A580H
40K	5000H	D580H - 5000H = 8580H
48K	7000H	D580H - 7000H = 6580H
56K	9000H	D580H - 9000H = 4580H
62K	A800H	D580H - A800H = 2D80H
64K	B000H	D580H - B000H = 2580H

Assume, for example, that you want to locate the address x within the memory image loaded under DDT in a 20K system. First type

    Hx,n   Hexadecimal sum and difference

and DDT will respond with the value of x+n (sum) and x-n (difference). The first number printed by DDT will be the actual memory address in the image where the data or code will be found. The input

    H3400,D580

for example, will produce 980H as the sum, which is where the CCP is located in the memory image under DDT.

Use the L command to disassemble portions the BIOS located at (4A00H+b)-n which, when you use the H command, produces an actual address of 1F80H. The disassembly command would thus be

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L1F80

It is now necessary to patch in your CBOOT and CBIOS routines. The BOOT resides at location 0900H in the memory image. If the actual load address is "n", then to calculate the bias (m) use the command:

H900,n	Subtract load address from target address.

The second number typed in response to the command is the desired bias (m). For example, if your BOOT executes at 0080H, the command:

H900,80

will reply

0980 0880	Sum and difference in hex.

Therefore, the bias "m" would be 0880H. To read-in the BOOT, give the command:

ICBOOT.HEX	Input file CBOOT.HEX

Then:

Rm	Read CBOOT with a bias of m (=900H-n)

You may now examine your CBOOT with:

L900

We are now ready to replace the CBIOS. Examine the area at 1F80H where the original version of the CBIOS resides. Then type

ICBIOS.HEX	Ready the "hex" file for loading

assume that your CBIOS is being integrated into a 20K CP/M system, and thus is origined at location 4A00H. In order to properly locate the CBIOS in the memory image under DDT, we must apply the negative bias n for a 20K system when loading the hex file. This is accomplished by typing

RD580	Read the file with bias D580H

Upon completion of the read, re-examine the area where the CBIOS has been loaded (use an "L1F80" command), to ensure that is was loaded properly. When you are satisfied that the change has been made, return from DDT using a control-C or "G0" command.

Now use SYSGEN to replace the patched memory image back onto a diskette (use a test diskette until you are sure of your patch), as shown in the following interaction

```
SYSGEN                     Start the SYSGEN program
SYSGEN VERSION 2.0         Sign-on message from SYSGEN
SOURCE DRIVE NAME (OR RETURN TO SKIP)
                           Respond with a carriage return
                           to skip the CP/M read operation
                           since the system is already in
                           memory.
DESTINATION DRIVE NAME (OR RETURN TO REBOOT)
                           Respond with "B" to write the
                           new system to the diskette in
                           drive B.
DESTINATION ON B, THEN TYPE RETURN
                           Place a scratch diskette in
                           drive B, then type return.
FUNCTION COMPLETE
DESTINATION DRIVE NAME (OR RETURN TO REBOOT)
```

Place the scratch diskette in your drive A, and then perform a coldstart to bring up the new CP/M system you have configured.

Test the new CP/M system, and place the Digital Research copyright notice on the diskette, as specified in your Licensing Agreement:

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4. SAMPLE GETSYS AND PUTSYS PROGRAMS

The following program provides a framework for the GETSYS and PUTSYS programs referenced in Section 2. The READSEC and WRITESEC subroutines must be inserted by the user to read and write the specific sectors.

```
;       GETSYS PROGRAM - READ TRACKS Ø AND 1 TO MEMORY AT 338ØH
;       REGISTER                   USE
;          A                  (SCRATCH REGISTER)
;          B                  TRACK COUNT (Ø, 1)
;          C                  SECTOR COUNT (1,2,...,26)
;          DE                 (SCRATCH REGISTER PAIR)
;          HL                 LOAD ADDRESS
;          SP                 SET TO STACK ADDRESS
;
START:  LXI     SP,338ØH        ;SET STACK POINTER TO SCRATCH AREA
        LXI     H, 338ØH        ;SET BASE LOAD ADDRESS
        MVI     B, Ø            ;START WITH TRACK Ø
RDTRK:                          ;READ NEXT TRACK (INITIALLY Ø)
        MVI     C,1             ;READ STARTING WITH SECTOR 1
RDSEC:                          ;READ NEXT SECTOR
        CALL    READSEC         ;USER-SUPPLIED SUBROUTINE
        LXI     D,128           ;MOVE LOAD ADDRESS TO NEXT 1/2 PAGE
        DAD     D               ;HL = HL + 128
        INR     C               ;SECTOR = SECTOR + 1
        MOV     A,C             ;CHECK FOR END OF TRACK
        CPI     27
        JC      RDSEC           ;CARRY GENERATED IF SECTOR < 27
;
;       ARRIVE HERE AT END OF TRACK, MOVE TO NEXT TRACK
        INR     B
        MOV     A,B             ;TEST FOR LAST TRACK
        CPI     2
        JC      RDTRK           ;CARRY GENERATED IF TRACK < 2
;
;       ARRIVE HERE AT END OF LOAD, HALT FOR NOW
        HLT
;
;       USER-SUPPLIED SUBROUTINE TO READ THE DISK
READSEC:
;       ENTER WITH TRACK NUMBER IN REGISTER B,
;             SECTOR NUMBER IN REGISTER C, AND
;             ADDRESS TO FILL IN HL
;
        PUSH    B               ;SAVE B AND C REGISTERS
        PUSH    H               ;SAVE HL REGISTERS
        ..........................................
        perform disk read at this point, branch to

        label START if an error occurs
        ..........................................
        POP     H               ;RECOVER HL
        POP     B               ;RECOVER B AND C REGISTERS
        RET                     ;BACK TO MAIN PROGRAM

        END     START
```

Note that this program is assembled and listed in Appendix C for reference purposes, with an assumed origin of 100H. The hexadecimal operation codes which are listed on the left may be useful if the program has to be entered through your machine's front panel switches.

The PUTSYS program can be constructed from GETSYS by changing only a few operations in the GETSYS program given above, as shown in Appendix D. The register pair HL become the dump address (next address to write), and operations upon these registers do not change within the program. The READSEC subroutine is replaced by a WRITESEC subroutine which performs the opposite function: data from address HL is written to the track given by register B and sector given by register C. It is often useful to combine GETSYS and PUTSYS into a single program during the test and development phase, as shown in the Appendix.

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5. DISKETTE ORGANIZATION

The sector allocation for the standard distribution version of CP/M is given here for reference purposes. The first sector (see table on the following page) contains an optional software boot section. Disk controllers are often set up to bring track 0, sector 1 into memory at a specific location (often location 0000H). The program in this sector, called BOOT, has the responsibility of bringing the remaining sectors into memory starting at location 3400H+b. If your controller does not have a built-in sector load, you can ignore the program in track 0, sector 1, and begin the load from track 0 sector 2 to location 3400H+b.

As an example, the Intel MDS-800 hardware cold start loader brings track 0, sector 1 into absolute address 3000H. Upon loading this sector, control transfers to location 3000H, where the bootstrap operation commences by loading the remainder of tracks 0, and all of track 1 into memory, starting at 3400H+b. The user should note that this bootstrap loader is of little use in a non-MDS environment, although it is useful to examine it since some of the boot actions will have to be duplicated in your cold start loader.

Track#	Sector#	Page#	Memory Address	CP/M Module name
00	01		(boot address)	Cold Start Loader
00	02	00	3400H+b	CCP
"	03	"	3480H+b	"
"	04	01	3500H+b	"
"	05	"	3580H+b	"
"	06	02	3600H+b	"
"	07	"	3680H+b	"
"	08	03	3700H+b	"
"	09	"	3780H+b	"
"	10	04	3800H+b	"
"	11	"	3880H+b	"
"	12	05	3900H+b	"
"	13	"	3980H+b	"
"	14	06	3A00H+b	"
"	15	"	3A80H+b	"
"	16	07	3B00H+b	"
00	17	"	3B80H+b	CCP
00	18	08	3C00H+b	BDOS
"	19	"	3C80H+b	"
"	20	09	3D00H+b	"
"	21	"	3D80H+b	"
"	22	10	3E00H+b	"
"	23	"	3E80H+b	"
"	24	11	3F00H+b	"
"	25	"	3F80H+b	"
"	26	12	4000H+b	"
01	01	"	4080H+b	"
"	02	13	4100H+b	"
"	03	"	4180H+b	"
"	04	14	4200H+b	"
"	05	"	4280H+b	"
"	06	15	4300H+b	"
"	07	"	4380H+b	"
"	08	16	4400H+b	"
"	09	"	4480H+b	"
"	10	17	4500H+b	"
"	11	"	4580H+b	"
"	12	18	4600H+b	"
"	13	"	4680H+b	"
"	14	19	4700H+b	"
"	15	"	4780H+b	"
"	16	20	4800H+b	"
"	17	"	4880H+b	"
"	18	21	4900H+b	"
01	19	"	4980H+b	BDOS
01	20	22	4A00H+b	BIOS
"	21	"	4A80H+b	"
"	23	23	4B00H+b	"
"	24	"	4B80H+b	"
"	25	24	4C00H+b	"
01	26	"	4C80H+b	BIOS
02-76	01-26			(directory and data)

6. THE BIOS ENTRY POINTS

The entry points into the BIOS from the cold start loader and BDOS are detailed below. Entry to the BIOS is through a "jump vector" located at 4A00H+b, as shown below (see Appendices B and C, as well). The jump vector is a sequence of 17 jump instructions which send program control to the individual BIOS subroutines. The BIOS subroutines may be empty for certain functions (i.e., they may contain a single RET operation) during regeneration of CP/M, but the entries must be present in the jump vector.

The jump vector at 4A00H+b takes the form shown below, where the individual jump addresses are given to the left:

```
4A00H+b    JMP BOOT       ; ARRIVE HERE FROM COLD START LOAD
4A03H+b    JMP WBOOT      ; ARRIVE HERE FOR WARM START
4A06H+b    JMP CONST      ; CHECK FOR CONSOLE CHAR READY
4A09H+b    JMP CONIN      ; READ CONSOLE CHARACTER IN
4A0CH+b    JMP CONOUT     ; WRITE CONSOLE CHARACTER OUT
4A0FH+b    JMP LIST       ; WRITE LISTING CHARACTER OUT
4A12H+b    JMP PUNCH      ; WRITE CHARACTER TO PUNCH DEVICE
4A15H+b    JMP READER     ; READ READER DEVICE
4A18H+b    JMP HOME       ; MOVE TO TRACK 00 ON SELECTED DISK
4A1BH+b    JMP SELDSK     ; SELECT DISK DRIVE
4A1EH+b    JMP SETTRK     ; SET TRACK NUMBER
4A21H+b    JMP SETSEC     ; SET SECTOR NUMBER
4A24H+b    JMP SETDMA     ; SET DMA ADDRESS
4A27H+b    JMP READ       ; READ SELECTED SECTOR
4A2AH+b    JMP WRITE      ; WRITE SELECTED SECTOR
4A2DH+b    JMP LISTST     ; RETURN LIST STATUS
4A30H+b    JMP SECTRAN    ; SECTOR TRANSLATE SUBROUTINE
```

Each jump address corresponds to a particular subroutine which performs the specific function, as outlined below. There are three major divisions in the jump table: the system (re)initialization which results from calls on BOOT and WBOOT, simple character I/O performed by calls on CONST, CONIN, CONOUT, LIST, PUNCH, READER, and LISTST, and diskette I/O performed by calls on HOME, SELDSK, SETTRK, SETSEC, SETDMA, READ, WRITE, and SECTRAN.

All simple character I/O operations are assumed to be performed in ASCII, upper and lower case, with high order (parity bit) set to zero. An end-of-file condition for an input device is given by an ASCII control-z (1AH). Peripheral devices are seen by CP/M as "logical" devices, and are assigned to physical devices within the BIOS.

In order to operate, the BDOS needs only the CONST, CONIN, and CONOUT subroutines (LIST, PUNCH, and READER may be used by PIP, but not the BDOS). Further, the LISTST entry is used currently only by DESPOOL, and thus, the initial version of CBIOS may have empty subroutines for the remaining ASCII devices.

The characteristics of each device are

CONSOLE — The principal interactive console which communicates with the operator, accessed through CONST, CONIN, and CONOUT. Typically, the CONSOLE is a device such as a CRT or Teletype.

LIST — The principal listing device, if it exists on your system, which is usually a hard-copy device, such as a printer or Teletype.

PUNCH — The principal tape punching device, if it exists, which is normally a high-speed paper tape punch or Teletype.

READER — The principal tape reading device, such as a simple optical reader or Teletype.

Note that a single peripheral can be assigned as the LIST, PUNCH, and READER device simultaneously. If no peripheral device is assigned as the LIST, PUNCH, or READER device, the CBIOS created by the user may give an appropriate error message so that the system does not "hang" if the device is accessed by PIP or some other user program. Alternately, the PUNCH and LIST routines can just simply return, and the READER routine can return with a 1AH (ctl-Z) in reg A to indicate immediate end-of-file.

For added flexibility, the user can optionally implement the "IOBYTE" function which allows reassignment of physical and logical devices. The IOBYTE function creates a mapping of logical to physical devices which can be altered during CP/M processing (see the STAT command). The definition of the IOBYTE function corresponds to the Intel standard as follows: a single location in memory (currently location 0003H) is maintained, called IOBYTE, which defines the logical to physical device mapping which is in effect at a particular time. The mapping is performed by splitting the IOBYTE into four distinct fields of two bits each, called the CONSOLE, READER, PUNCH, and LIST fields, as shown below:

```
                     most significant        least significant
                    -----------------------------------------
IOBYTE AT  0003H    | LIST     | PUNCH    | READER   | CONSOLE |
                    -----------------------------------------
                     bits 6,7  bits 4,5  bits 2,3  bits 0,1
```

The value in each field can be in the range 0-3, defining the assigned source or destination of each logical device. The values which can be assigned to each field are given below

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CONSOLE field (bits 0,1)
- 0 - console is assigned to the console printer device (TTY:)
- 1 - console is assigned to the CRT device (CRT:)
- 2 - batch mode: use the READER as the CONSOLE input, and the LIST device as the CONSOLE output (BAT:)
- 3 - user defined console device (UC1:)

READER field (bits 2,3)
- 0 - READER is the Teletype device (TTY:)
- 1 - READER is the high-speed reader device (RDR:)
- 2 - user defined reader # 1 (UR1:)
- 3 - user defined reader # 2 (UR2:)

PUNCH field (bits 4,5)
- 0 - PUNCH is the Teletype device (TTY:)
- 1 - PUNCH is the high speed punch device (PUN:)
- 2 - user defined punch # 1 (UP1:)
- 3 - user defined punch # 2 (UP2:)

LIST field (bits 6,7)
- 0 - LIST is the Teletype device (TTY:)
- 1 - LIST is the CRT device (CRT:)
- 2 - LIST is the line printer device (LPT:)
- 3 - user defined list device (UL1:)

Note again that the implementation of the IOBYTE is optional, and affects only the organization of your CBIOS. No CP/M systems use the IOBYTE (although they tolerate the existence of the IOBYTE at location 0003H), except for PIP which allows access to the physical devices, and STAT which allows logical-physical assignments to be made and/or displayed (for more information, see the "CP/M Features and Facilities Guide"). In any case, the IOBYTE implementation should be omitted until your basic CBIOS is fully implemented and tested; then add the IOBYTE to increase your facilities.

Disk I/O is always performed through a sequence of calls on the various disk access subroutines which set up the disk number to access, the track and sector on a particular disk, and the direct memory access (DMA) address involved in the I/O operation. After all these parameters have been set up, a call is made to the READ or WRITE function to perform the actual I/O operation. Note that there is often a single call to SELDSK to select a disk drive, followed by a number of read or write operations to the selected disk before selecting another drive for subsequent operations. Similarly, there may be a single call to set the DMA address, followed by several calls which read or write from the selected DMA address before the DMA address is changed. The track and sector subroutines are always called before the READ or WRITE operations are performed.

Note that the READ and WRITE routines should perform several retries (10 is standard) before reporting the error condition to the BDOS. If the error condition is returned to the BDOS, it will report the error to the user. The HOME subroutine may or may not actually perform the track 00 seek, depending upon your controller characteristics; the important point is that track 00 has been selected for the next operation, and is often treated in exactly the same manner as SETTRK with a parameter of 00.

The exact responsibilites of each entry point subroutine are given below:

BOOT The BOOT entry point gets control from the cold start loader and is responsible for basic system initialization, including sending a signon message (which can be omitted in the first version). If the IOBYTE function is implemented, it must be set at this point. The various system parameters which are set by the WBOOT entry point must be initialized, and control is transferred to the CCP at 3400H+b for further processing. Note that reg C must be set to zero to select drive A.

WBOOT The WBOOT entry point gets control when a warm start occurs. A warm start is performed whenever a user program branches to location 0000H, or when the CPU is reset from the front panel. The CP/M system must be loaded from the first two tracks of drive A up to, but not including, the BIOS (or CBIOS, if you have completed your patch). System parameters must be initialized as shown below:

location 0,1,2	set to JMP WBOOT for warm starts (0000H: JMP 4A03H+b)
location 3	set initial value of IOBYTE, if implemented in your CBIOS
location 5,6,7	set to JMP BDOS, which is the primary entry point to CP/M for transient programs. (0005H: JMP 3C06H+b)

(see Section 9 for complete details of page zero use) Upon completion of the initialization, the WBOOT program must branch to the CCP at 3400H+b to (re)start the system. Upon entry to the CCP, register C is set to the drive to select after system initialization.

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

CONIN Read the next console character into register A, and

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set the parity bit (high order bit) to zero. If no console character is ready, wait until a character is typed before returning.

CONOUT

Send the character from register C to the console output device. The character is in ASCII, with high order parity bit set to zero. You may want to include a time-out on a line feed or carriage return, if your console device requires some time interval at the end of the line (such as a TI Silent 700 terminal). You can, if you wish, filter out control characters which cause your console device to react in a strange way (a control-z causes the Lear Seigler terminal to clear the screen, for example).

LIST

Send the character from register C to the currently assigned listing device. The character is in ASCII with zero parity.

PUNCH

Send the character from register C to the currently assigned punch device. The character is in ASCII with zero parity.

READER

Read the next character from the currently assigned reader device into register A with zero parity (high order bit must be zero), an end of file condition is reported by returning an ASCII control-z (1AH).

HOME

Return the disk head of the currently selected disk (initially disk A) to the track 00 position. If your controller allows access to the track 0 flag from the drive, step the head until the track 0 flag is detected. If your controller does not support this feature, you can translate the HOME call into a call on SETTRK with a parameter of 0.

SELDSK

Select the disk drive given by register C for further operations, where register C contains 0 for drive A, 1 for drive B, and so-forth up to 15 for drive P (the standard CP/M distribution version supports four drives). On each disk select, SELDSK must return in HL the base address of a 16-byte area, called the Disk Parameter Header, described in the Section 10. For standard floppy disk drives, the contents of the header and associated tables does not change, and thus the program segment included in the sample CBIOS performs this operation automatically. If there is an attempt to select a non-existent drive, SELDSK returns HL=0000H as an error indicator. Although SELDSK must return the header address on each call, it is advisable to postpone the actual physical disk select operation until an I/O function (seek, read or write) is actually performed, since disk selects often occur without utimately performing any disk I/O, and many controllers will unload the head of the current disk before selecting the new drive. This would cause an excessive amount of noise and disk wear.

SETTRK — Register BC contains the track number for subsequent disk accesses on the currently selected drive. You can choose to seek the selected track at this time, or delay the seek until the next read or write actually occurs. Register BC can take on values in the range Ø-76 corresponding to valid track numbers for standard floppy disk drives, and Ø-65535 for non-standard disk subsystems.

SETSEC — Register BC contains the sector number (1 through 26) for subsequent disk accesses on the currently selected drive. You can choose to send this information to the controller at this point, or instead delay sector selection until a read or write operation occurs.

SETDMA — Register BC contains the DMA (disk memory access) address for subsequent read or write operations. For example, if B = ØØH and C = 8ØH when SETDMA is called, then all subsequent read operations read their data into 8ØH through ØFFH, and all subsequent write operations get their data from 8ØH through ØFFH, until the next call to SETDMA occurs. The initial DMA address is assumed to be 8ØH. Note that the controller need not actually support direct memory access. If, for example, all data is received and sent through I/O ports, the CBIOS which you construct will use the 128 byte area starting at the selected DMA address for the memory buffer during the following read or write operations.

READ — Assuming the drive has been selected, the track has been set, the sector has been set, and the DMA address has been specified, the READ subroutine attempts to read one sector based upon these parameters, and returns the following error codes in register A:

Ø	no errors occurred
1	non-recoverable error condition occurred

Currently, CP/M responds only to a zero or non-zero value as the return code. That is, if the value in register A is Ø then CP/M assumes that the disk operation completed properly. If an error occurs, however, the CBIOS should attempt at least 1Ø retries to see if the error is recoverable. When an error is reported the BDOS will print the message "BDOS ERR ON x: BAD SECTOR". The operator then has the option of typing <cr> to ignore the error, or ctl-C to abort.

WRITE — Write the data from the currently selected DMA address to the currently selected drive, track, and sector. The data should be marked as "non deleted data" to

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maintain compatibility with other CP/M systems. The error codes given in the READ command are returned in register A, with error recovery attempts as described above.

LISTST Return the ready status of the list device. Used by the DESPOOL program to improve console response during its operation. The value 00 is returned in A if the list device is not ready to accept a character, and 0FFH if a character can be sent to the printer. Note that a 00 value always suffices.

SECTRAN Performs sector logical to physical sector translation in order to improve the overall response of CP/M. Standard CP/M systems are shipped with a "skew factor" of 6, where six physical sectors are skipped between each logical read operation. This skew factor allows enough time between sectors for most programs to load their buffers without missing the next sector. In particular computer systems which use fast processors, memory, and disk subsystems, the skew factor may be changed to improve overall response. Note, however, that you should maintain a single density IBM compatible version of CP/M for information transfer into and out of your computer system, using a skew factor of 6. In general, SECTRAN receives a logical sector number in BC, and a translate table address in DE. The sector number is used as an index into the translate table, with the resulting physical sector number in HL. For standard systems, the tables and indexing code is provided in the CBIOS and need not be changed.

7. A SAMPLE BIOS

The program shown in Appendix C can serve as a basis for your first BIOS. The simplest functions are assumed in this BIOS, so that you can enter it through the front panel, if absolutely necessary. Note that the user must alter and insert code into the subroutines for CONST, CONIN, CONOUT, READ, WRITE, and WAITIO subroutines. Storage is reserved for user-supplied code in these regions. The scratch area reserved in page zero (see Section 9) for the BIOS is used in this program, so that it could be implemented in ROM, if desired.

Once operational, this skeletal version can be enhanced to print the initial sign-on message and perform better error recovery. The subroutines for LIST, PUNCH, and READER can be filled-out, and the IOBYTE function can be implemented.

8. A SAMPLE COLD START LOADER

The program shown in Appendix D can serve as a basis for your cold start loader. The disk read function must be supplied by the user, and the program must be loaded somehow starting at location 0000. Note that space is reserved for your patch so that the total amount of storage required for the cold start loader is 128 bytes. Eventually, you will probably want to get this loader onto the first disk sector (track 0, sector 1), and cause your controller to load it into memory automatically upon system start-up. Alternatively, you may wish to place the cold start loader into ROM, and place it above the CP/M system. In this case, it will be necessary to originate the program at a higher address, and key-in a jump instruction at system start-up which branches to the loader. Subsequent warm starts will not require this key-in operation, since the entry point 'WBOOT' gets control, thus bringing the system in from disk automatically. Note also that the skeletal cold start loader has minimal error recovery, which may be enhanced on later versions.

9. RESERVED LOCATIONS IN PAGE ZERO

Main memory page zero, between locations ØØH and ØFFH, contains several segments of code and data which are used during CP/M processing. The code and data areas are given below for reference purposes.

Locations from - to	Contents
ØØØØH - ØØØ2H	Contains a jump instruction to the warm start entry point at location 4AØ3H+b. This allows a simple programmed restart (JMP ØØØØH) or manual restart from the front panel.
ØØØ3H - ØØØ3H	Contains the Intel standard IOBYTE, which is optionally included in the user's CBIOS, as described in Section 6.
ØØØ4H - ØØØ4H	Current default drive number (Ø=A,...,15=P).
ØØØ5H - ØØØ7H	Contains a jump instruction to the BDOS,and serves two purposes: JMP ØØØ5H provides the primary entry point to the BDOS, as described in the manual "CP/M Interface Guide," and LHLD ØØØ6H brings the address field of the instruction to the HL register pair. This value is the lowest address in memory used by CP/M (assuming the CCP is being overlayed). Note that the DDT program will change the address field to reflect the reduced memory size in debug mode.
ØØØ8H - ØØ27H	(interrupt locations 1 through 5 not used)
ØØ3ØH - ØØ37H	(interrupt location 6, not currently used - reserved)
ØØ38H - ØØ3AH	Restart 7 - Contains a jump instruction into the DDT or SID program when running in debug mode for programmed breakpoints, but is not otherwise used by CP/M.
ØØ3BH - ØØ3FH	(not currently used - reserved)
ØØ4ØH - ØØ4FH	16 byte area reserved for scratch by CBIOS, but is not used for any purpose in the distribution version of CP/M
ØØ5ØH - ØØ5BH	(not currently used - reserved)
ØØ5CH - ØØ7CH	default file control block produced for a transient program by the Console Command Processor.
ØØ7DH - ØØ7FH	Optional default random record position

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0080H - 00FFH	default 128 byte disk buffer (also filled with the command line when a transient is loaded under the CCP).

Note that this information is set-up for normal operation under the CP/M system, but can be overwritten by a transient program if the BDOS facilities are not required by the transient.

If, for example, a particular program performs only simple I/O and must begin execution at location 0, it can be first loaded into the TPA, using normal CP/M facilities, with a small memory move program which gets control when loaded (the memory move program must get control from location 0100H, which is the assumed beginning of all transient programs). The move program can then proceed to move the entire memory image down to location 0, and pass control to the starting address of the memory load. Note that if the BIOS is overwritten, or if location 0 (containing the warm start entry point) is overwritten, then the programmer must bring the CP/M system back into memory with a cold start sequence.

10. DISK PARAMETER TABLES.

Tables are included in the BIOS which describe the particular characteristics of the disk subsystem used with CP/M. These tables can be either hand-coded, as shown in the sample CBIOS in Appendix C, or automatically generated using the DISKDEF macro library, as shown in Appendix B. The purpose here is to describe the elements of these tables.

In general, each disk drive has an associated (16-byte) disk parameter header which both contains information about the disk drive and provides a scratchpad area for certain BDOS operations. The format of the disk parameter header for each drive is shown below

Disk Parameter Header

XLT	0000	0000	0000	DIRBUF	DPB	CSV	ALV
16b	16b	16b	16b	16b	16b	16b	16b

where each element is a word (16-bit) value. The meaning of each Disk Parameter Header (DPH) element is

XLT — Address of the logical to physical translation vector, if used for this particular drive, or the value 0000H if no sector translation takes place (i.e, the physical and logical sector numbers are the same). Disk drives with identical sector skew factors share the same translate tables.

0000 — Scratchpad values for use within the BDOS (initial value is unimportant).

DIRBUF — Address of a 128 byte scratchpad area for directory operations within BDOS. All DPH's address the same scratchpad area.

DPB — Address of a disk parameter block for this drive. Drives with identical disk characteristics address the same disk parameter block.

CSV — Address of a scratchpad area used for software check for changed disks. This address is different for each DPH.

ALV — Address of a scratchpad area used by the BDOS to keep disk storage allocation information. This address is different for each DPH.

Given n disk drives, the DPH's are arranged in a table whose first row of 16 bytes corresponds to drive 0, with the last row corresponding to drive n-1. The table thus appears as

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```
DPBASE:
     -------------------------------------------------------
     00 |XLT 00| 0000 | 0000 | 0000 |DIRBUF|DBP 00|CSV 00|ALV 00|
     -------------------------------------------------------
     01 |XLT 01| 0000 | 0000 | 0000 |DIRBUF|DBP 01|CSV 01|ALV 01|
     -------------------------------------------------------
                      (and so-forth through)
     -------------------------------------------------------
     n-1|XLTn-1| 0000 | 0000 | 0000 |DIRBUF|DBPn-1|CSVn-1|ALVn-1|
     -------------------------------------------------------
```

where the label DPBASE defines the base address of the DPH table.

A responsibility of the SELDSK subroutine is to return the base address of the DPH for the selected drive. The following sequence of operations returns the table address, with a 0000H returned if the selected drive does not exist.

```
NDISKS   EQU   4   ;NUMBER OF DISK DRIVES
......
SELDSK:
         ;SELECT DISK GIVEN BY BC
         LXI   H,0000H  ;ERROR CODE
         MOV   A,C      ;DRIVE OK?
         CPI   NDISKS   ;CY IF SO
         RNC            ;RET IF ERROR
         ;NO ERROR, CONTINUE
         MOV   L,C      ;LOW(DISK)
         MOV   H,B      ;HIGH(DISK)
         DAD   H        ;*2
         DAD   H        ;*4
         DAD   H        ;*8
         DAD   H        ;*16
         LXI   D,DPBASE ;FIRST DPH
         DAD   D        ;DPH(DISK)
         RET
```

The translation vectors (XLT 00 through XLTn-1) are located elsewhere in the BIOS, and simply correspond one-for-one with the logical sector numbers zero through the sector count-1. The Disk Parameter Block (DPB) for each drive is more complex. A particular DPB, which is addressed by one or more DPH's, takes the general form

```
-------------------------------------------------------------
|  SPT  |BSH|BLM|EXM|  DSM  |  DRM  |AL0|AL1|  CKS  |  OFF  |
-------------------------------------------------------------
   16b   8b  8b  8b    16b     16b   8b  8b    16b     16b
```

where each is a byte or word value, as shown by the "8b" or "16b" indicator below the field.

SPT is the total number of sectors per track

BSH is the data allocation block shift factor, determined by the data block allocation size.

EXM	is the extent mask, determined by the data block allocation size and the number of disk blocks.
DSM	determines the total storage capacity of the disk drive
DRM	determines the total number of directory entries which can be stored on this drive AL0,AL1 determine reserved directory blocks.
CKS	is the size of the directory check vector
OFF	is the number of reserved tracks at the beginning of the (logical) disk.

The values of BSH and BLM determine (implicitly) the data allocation size BLS, which is not an entry in the disk parameter block. Given that the designer has selected a value for BLS, the values of BSH and BLM are shown in the table below

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

where all values are in decimal. The value of EXM depends upon both the BLS and whether the DSM value is less than 256 or greater than 255, as shown in the following table

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

The value of DSM is the maximum data block number supported by this particular drive, measured in BLS units. The product BLS times (DSM+1) is the total number of bytes held by the drive and, of course, must be within the capacity of the physical disk, not counting the reserved operating system tracks.

The DRM entry is the one less than the total number of directory entries, which can take on a 16-bit value. The values of AL0 and AL1, however, are determined by DRM. The two values AL0 and AL1 can together be considered a string of 16-bits, as shown below.

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```
-------------------------------------------------
|          ALØ          |          AL1          |
-------------------------------------------------
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
-------------------------------------------------
 ØØ Ø1 Ø2 Ø3 Ø4 Ø5 Ø6 Ø7 Ø8 Ø9 1Ø 11 12 13 14 15
```

where position ØØ corresponds to the high order bit of the byte labelled ALØ, and 15 corresponds to the low order bit of the byte labelled AL1. Each bit position reserves a data block for number of directory entries, thus allowing a total of 16 data blocks to be assigned for directory entries (bits are assigned starting at ØØ and filled to the right until position 15). Each directory entry occupies 32 bytes, resulting in the following table

BLS	Directory Entries
1,Ø24	32 times # bits
2,Ø48	64 times # bits
4,Ø96	128 times # bits
8,192	256 times # bits
16,384	512 times # bits

Thus, if DRM = 127 (128 directory entries), and BLS = 1Ø24, then there are 32 directory entries per block, requiring 4 reserved blocks. In this case, the 4 high order bits of ALØ are set, resulting in the values ALØ = ØFØH and AL1 = ØØH.

The CKS value is determined as follows: if the disk drive media is removable, then CKS = (DRM+1)/4, where DRM is the last directory entry number. If the media is fixed, then set CKS = Ø (no directory records are checked in this case).

Finally, the OFF field determines the number of tracks which are skipped at the beginning of the physical disk. This value is automatically added whenever SETTRK is called, and can be used as a mechanism for skipping reserved operating system tracks, or for partitioning a large disk into smaller segmented sections.

To complete the discussion of the DPB, recall that several DPH's can address the same DPB if their drive characteristics are identical. Further, the DPB can be dynamically changed when a new drive is addressed by simply changing the pointer in the DPH since the BDOS copies the DPB values to a local area whenever the SELDSK function is invoked.

Returning back to the DPH for a particular drive, note that the two address values CSV and ALV remain. Both addresses reference an area of uninitialized memory following the BIOS. The areas must be unique for each drive, and the size of each area is determined by the values in the DPB.

The size of the area addressed by CSV is CKS bytes, which is sufficient to hold the directory check information for this particular drive. If CKS = (DRM+1)/4, then you must reserve (DRM+1)/4 bytes for directory check use. If CKS = Ø, then no storage is reserved.

The size of the area addressed by ALV is determined by the maximum number of data blocks allowed for this particular disk, and is computed as (DSM/8)+1.

The CBIOS shown in Appendix C demonstrates an instance of these tables for standard 8" single density drives. It may be useful to examine this program, and compare the tabular values with the definitions given above.

11. THE DISKDEF MACRO LIBRARY.

A macro library is shown in Appendix F, called DISKDEF, which greatly simplifies the table construction process. You must have access to the MAC macro assembler, of course, to use the DISKDEF facility, while the macro library is included with all CP/M 2.0 distribution disks.

A BIOS disk definition consists of the following sequence of macro statements:

```
MACLIB   DISKDEF
......
DISKS    n
DISKDEF  Ø,...
DISKDEF  1,...
......
DISKDEF  n-1
......
ENDEF
```

where the MACLIB statement loads the DISKDEF.LIB file (on the same disk as your BIOS) into MAC's internal tables. The DISKS macro call follows, which specifies the number of drives to be configured with your system, where n is an integer in the range 1 to 16. A series of DISKDEF macro calls then follow which define the characteristics of each logical disk, Ø through n-1 (corresponding to logical drives A through P). Note that the DISKS and DISKDEF macros generate the in-line fixed data tables described in the previous section, and thus must be placed in a non-executable portion of your BIOS, typically directly following the BIOS jump vector.

The remaining portion of your BIOS is defined following the DISKDEF macros, with the ENDEF macro call immediately preceding the END statement. The ENDEF (End of Diskdef) macro generates the necessary uninitialized RAM areas which are located in memory above your BIOS.

The form of the DISKDEF macro call is

```
DISKDEF  dn,fsc,lsc,[skf],bls,dks,dir,cks,ofs,[Ø]
```

where

```
dn     is the logical disk number, Ø to n-1
fsc    is the first physical sector number (Ø or 1)
lsc    is the last sector number
skf    is the optional sector skew factor
bls    is the data allocation block size
dir    is the number of directory entries
cks    is the number of "checked" directory entries
ofs    is the track offset to logical track ØØ
[Ø]    is an optional 1.4 compatibility flag
```

The value "dn" is the drive number being defined with this DISKDE macro invocation. The "fsc" parameter accounts for differing sector numbering systems, and is usually Ø or 1. The "lsc" is the last numbered sector on a track. When present, the "skf" parameter defines the sector skew factor which is used to create a sector translation table according to the skew. If the number of sectors is less than 256, a single-byte table is created, otherwise each translation table element occupies two bytes. No translation table is created if the skf parameter is omitted (or equal to Ø). The "bls" parameter specifies the number of bytes allocated to each data block, and takes on the values 1Ø24, 2Ø48, 4Ø96, 8192, or 16384. Generally, performance increases with larger data block sizes since there are fewer directory references and logically connected data records are physically close on the disk. Further, each directory entry addresses more data and the BIOS-resident ram space is reduced. The "dks" specifies the total disk size in "bls" units. That is, if the bls = 2Ø48 and dks = 1ØØØ, then the total disk capacity is 2,Ø48,ØØØ bytes. If dks is greater than 255, then the block size parameter bls must be greater than 1Ø24. The value of "dir" is the total number of directory entries which may exceed 255, if desired. The "cks" parameter determines the number of directory items to check on each directory scan, and is used internally to detect changed disks during system operation, where an intervening cold or warm start has not occurred (when this situation is detected, CP/M automatically marks the disk read/only so that data is not subsequently destroyed). As stated in the previous section, the value of cks = dir when the media is easily changed, as is the case with a floppy disk subsystem. If the disk is permanently mounted, then the value of cks is typically Ø, since the probability of changing disks without a restart is quite low. The "ofs" value determines the number of tracks to skip when this particular drive is addressed, which can be used to reserve additional operating system space or to simulate several logical drives on a single large capacity physical drive. Finally, the [Ø] parameter is included when file compatibility is required with versions of 1.4 which have been modified for higher density disks. This parameter ensures that only 16K is allocated for each directory record, as was the case for previous versions. Normally, this parameter is not included.

For convenience and economy of table space, the special form

```
DISKDEF    i,j
```

gives disk i the same characteristics as a previously defined drive j. A standard four-drive single density system, which is compatible with version 1.4, is defined using the following macro invocations:

```
DISKS      4
DISKDEF    0,1,26,6,1024,243,64,64,2
DISKDEF    1,0
DISKDEF    2,0
DISKDEF    3,0
....
ENDEF
```

with all disks having the same parameter values of 26 sectors per track (numbered 1 through 26), with 6 sectors skipped between each access, 1024 bytes per data block, 243 data blocks for a total of 243k byte disk capacity, 64 checked directory entries, and two operating system tracks.

The DISKS macro generates n Disk Parameter Headers (DPH's), starting at the DPH table address DPBASE generated by the macro. Each disk header block contains sixteen bytes, as described above, and correspond one-for-one to each of the defined drives. In the four drive standard system, for example, the DISKS macro generates a table of the form:

```
DPBASE  EQU   $
DPE0:   DW    XLT0,0000H,0000H,0000H,DIRBUF,DPB0,CSV0,ALV0
DPE1:   DW    XLT0,0000H,0000H,0000H,DIRBUF,DPB0,CSV1,ALV1
DPE2:   DW    XLT0,0000H,0000H,0000H,DIRBUF,DPB0,CSV2,ALV2
DPE3:   DW    XLT0,0000H,0000H,0000H,DIRBUF,DPB0,CSV3,ALV3
```

where the DPH labels are included for reference purposes to show the beginning table addresses for each drive 0 through 3. The values contained within the disk parameter header are described in detail in the previous section. The check and allocation vector addresses are generated by the ENDEF macro in the ram area following the BIOS code and tables.

Note that if the "skf" (skew factor) parameter is omitted (or equal to 0), the translation table is omitted, and a 0000H value is inserted in the XLT position of the disk parameter header for the disk. In a subsequent call to perform the logical to physical translation, SECTRAN receives a translation table address of DE = 0000H, and simply returns the original logical sector from BC in the HL register pair. A translate table is constructed when the skf parameter is present, and the (non-zero) table address is placed into the corresponding DPH's. The table shown below, for example, is constructed when the standard skew factor skf = 6 is specified in the DISKDEF macro call:

```
XLT0:  DB    1,7,13,19,25,5,11,17,23,3,9,15,21
       DB    2,8,14,20,26,6,12,18,24,4,10,16,22
```

Following the ENDEF macro call, a number of uninitialized data areas are defined. These data areas need not be a part of the BIOS which is loaded upon cold start, but must be available between the BIOS and the end of memory. The size of the uninitialized RAM area is determined by EQU statements generated by the ENDEF macro. For a standard four-drive system, the ENDEF macro might produce

```
4C72 =          BEGDAT EQU $
                (data areas)
4DB0 =          ENDDAT EQU $
013C =          DATSIZ EQU $-BEGDAT
```

which indicates that uninitialized RAM begins at location 4C72H, ends at 4DB0H-1, and occupies 013CH bytes. You must ensure that these addresses are free for use after the system is loaded.

After modification, you can use the STAT program to check your drive characteristics, since STAT uses the disk parameter block to decode the drive information. The STAT command form

STAT d:DSK:

decodes the disk parameter block for drive d (d=A,...,P) and displays the values shown below:

```
r: 128 Byte Record Capacity
k: Kilobyte Drive  Capacity
d: 32  Byte Directory Entries
c: Checked  Directory Entries
e: Records/ Extent
b: Records/ Block
s: Sectors/ Track
t: Reserved Tracks
```

Three examples of DISKDEF macro invocations are shown below with corresponding STAT parameter values (the last produces a full 8-megabyte system).

```
        DISKDEF 0,1,58,,2048,256,128,128,2
r=4096, k=512, d=128, c=128, e=256, b=16, s=58, t=2

        DISKDEF 0,1,58,,2048,1024,300,0,2
r=16384, k=2048, d=300, c=0, e=128, b=16, s=58, t=2

        DISKDEF 0,1,58,,16384,512,128,128,2
r=65536, k=8192, d=128, c=128, e=1024, b=128, s=58, t=2
```

Appendix G

12. SECTOR BLOCKING AND DEBLOCKING.

Upon each call to the BIOS WRITE entry point, the CP/M BDOS includes information which allows effective sector blocking and deblocking where the host disk subsystem has a sector size which is a multiple of the basic 128-byte unit. The purpose here is to present a general-purpose algorithm which can be included within your BIOS which uses the BDOS information to perform the operations automatically.

Upon each call to WRITE, the BDOS provides the following information in register C:

```
0   =   normal sector write
1   =   write to directory sector
2   =   write to the first sector
        of a new data block
```

Condition 0 occurs whenever the next write operation is into a previously written area, such as a random mode record update, when the write is to other than the first sector of an unallocated block, or when the write is not into the directory area. Condition 1 occurs when a write into the directory area is performed. Condition 2 occurs when the first record (only) of a newly allocated data block is written. In most cases, application programs read or write multiple 128 byte sectors in sequence, and thus there is little overhead involved in either operation when blocking and deblocking records since pre-read operations can be avoided when writing records.

Appendix G lists the blocking and deblocking algorithms in skeletal form (this file is included on your CP/M disk). Generally, the algorithms map all CP/M sector read operations onto the host disk through an intermediate buffer which is the size of the host disk sector. Throughout the program, values and variables which relate to the CP/M sector involved in a seek operation are prefixed by "sek," while those related to the host disk system are prefixed by "hst." The equate statements beginning on line 29 of Appendix G define the mapping between CP/M and the host system, and must be changed if other than the sample host system is involved.

The entry points BOOT and WBOOT must contain the initialization code starting on line 57, while the SELDSK entry point must be augmented by the code starting on line 65. Note that although the SELDSK entry point computes and returns the Disk Parameter Header address, it does not physically selected the host disk at this point (it is selected later at READHST or WRITEHST). Further, SETTRK, SETTRK, and SETDMA simply store the values, but do not take any other action at this point. SECTRAN performs a trivial trivial function of returning the physical sector number.

The principal entry points are READ and WRITE, starting on lines 110 and 125, respectively. These subroutines take the place of your previous READ and WRITE operations.

The actual physical read or write takes place at either WRITEHST or READHST, where all values have been prepared: hstdsk is the host disk number, hsttrk is the host track number, and hstsec is the host sector number (which may require translation to a physical sector number). You must insert code at this point which performs the full host sector read or write into, or out of, the buffer at hstbuf of length hstsiz. All other mapping functions are performed by the algorithms.

This particular algorithm was tested using an 8Ø megabyte hard disk unit which was originally configured for 128 byte sectors, producing approximately 35 megabytes of formatted storage. When configured for 512 byte host sectors, usable storage increased to 57 megabytes, with a corresponding 4ØØ% improvement in overall response. In this situation, there is no apparent overhead involved in deblocking sectors, with the advantage that user programs still maintain the (less memory consuming) 128-byte sectors. This is primarily due, of course, to the information provided by the BDOS which eliminates the necessity for pre-read operations to take place.

APPENDIX A: THE MDS COLD START LOADER

```
                ;       MDS-800 Cold Start Loader for CP/M 2.0
                ;
                ;       Version 2.0 August, 1979
                ;
0000 =          false   equ     0
ffff =          true    equ     not false
0000 =          testing equ     false
                ;
                        if      testing
                bias    equ     03400h
                        endif
                        if      not testing
0000 =          bias    equ     0000h
                        endif
0000 =          cpmb    equ     bias            ;base of dos load
0806 =          bdos    equ     806h+bias       ;entry to dos for calls
1880 =          bdose   equ     1880h+bias      ;end of dos load
1600 =          boot    equ     1600h+bias      ;cold start entry point
1603 =          rboot   equ     boot+3          ;warm start entry point
                ;
3000                    org     3000h   ;loaded here by hardware
                ;
1880 =          bdosl   equ     bdose-cpmb
0002 =          ntrks   equ     2               ;tracks to read
0031 =          bdoss   equ     bdosl/128       ;# sectors in bdos
0019 =          bdos0   equ     25              ;# on track 0
0018 =          bdosl   equ     bdoss-bdos0     ;# on track 1
                ;
f800 =          mon80   equ     0f800h  ;intel monitor base
ff0f =          rmon80  equ     0ff0fh  ;restart location for mon80
0078 =          base    equ     078h    ;'base' used by controller
0079 =          rtype   equ     base+1  ;result type
007b =          rbyte   equ     base+3  ;result byte
007f =          reset   equ     base+7  ;reset controller
                ;
0078 =          dstat   equ     base    ;disk status port
0079 =          ilow    equ     base+1  ;low iopb address
007a =          ihigh   equ     base+2  ;high iopb address
00ff =          bsw     equ     0ffh    ;boot switch
0003 =          recal   equ     3h      ;recalibrate selected drive
0004 =          readf   equ     4h      ;disk read function
0100 =          stack   equ     100h    ;use end of boot for stack
                ;
                rstart:
3000 310001             lxi     sp,stack;in case of call to mon80
                ;       clear disk status
3003 db79               in      rtype
3005 db7b               in      rbyte
                ;       check if boot switch is off
                coldstart:
3007 dbff               in      bsw
3009 e602               ani     02h     ;switch on?
300b c20730             jnz     coldstart
```

```
                ;       clear the controller
300e d37f               out     reset   ;logic cleared
                ;
                ;
3010 0602               mvi     b,ntrks ;number of tracks to read
3012 214230             lxi     h,iopb0
                ;
                start:
                ;
                ;       read first/next track into cpmb
3015 7d                 mov     a,l
3016 d379               out     ilow
3018 7c                 mov     a,h
3019 d37a               out     ihigh
301b db78       wait0:  in      dstat
301d e604               ani     4
301f ca1b30             jz      wait0
                ;
                ;       check disk status
3022 db79               in      rtype
3024 e603               ani     11b
3026 fe02               cpi     2
                ;
                        if      testing
                        cnc     rmon80  ;go to monitor if 11 or 10
                        endif
                        if      not testing
3028 d20030             jnc     rstart  ;retry the load
                        endif
                ;
302b db7b               in      rbyte   ;i/o complete, check status
                ;       if not ready, then go to mon80
302d 17                 ral
302e dc0fff             cc      rmon80  ;not ready bit set
3031 1f                 rar             ;restore
3032 e61e               ani     11110b  ;overrun/addr err/seek/crc
                ;
                        if      testing
                        cnz     rmon80  ;go to monitor
                        endif
                        if      not testing
3034 c20030             jnz     rstart  ;retry the load
                        endif
                ;
                ;
3037 110700             lxi     d,iopbl ;length of iopb
303a 19                 dad     d       ;addressing next iopb
303b 05                 dcr     b       ;count down tracks
303c c21530             jnz     start
                ;
                ;
                ;       jmp boot, print message, set-up jmps
303f c30016             jmp     boot
                ;
                ;       parameter blocks
```

```
3042 80        iopb0:  db      80h         ;iocw, no update
3043 04                db      readf       ;read function
3044 19                db      bdos0       ;# sectors to read trk 0
3045 00                db      0           ;track 0
3046 02                db      2           ;start with sector 2, trk 0
3047 0000              dw      cpmb        ;start at base of bdos
0007 =         iopbl   equ     $-iopb0
               ;
3049 80        iopbl:  db      80h
304a 04                db      readf
304b 18                db      bdosl       ;sectors to read on track 1
304c 01                db      1           ;track 1
304d 01                db      1           ;sector 1
304e 800c              dw      cpmb+bdos0*128  ;base of second rd
3050                   end
```

```
                ;       mds-800 i/o drivers for cp/m 2.0
                ;       (four drive single density version)
                ;
                ;       version 2.0 august, 1979
                ;
0014 =          vers    equ     20      ;version 2.0
                ;
                ;       copyright (c) 1979
                ;       digital research
                ;       box 579, pacific grove
                ;       california, 93950
                ;
4a00                    org     4a00h   ;base of bios in 20k system
3400 =          cpmb    equ     3400h   ;base of cpm ccp
3c06 =          bdos    equ     3c06h   ;base of bdos in 20k system
1600 =          cpml    equ     $-cpmb  ;length (in bytes) of cpm system
002c =          nsects  equ     cpml/128;number of sectors to load
0002 =          offset  equ     2       ;number of disk tracks used by cp
0004 =          cdisk   equ     0004h   ;address of last logged disk
0080 =          buff    equ     0080h   ;default buffer address
000a =          retry   equ     10      ;max retries on disk i/o before e
                ;
                ;       perform following functions
                ;       boot    cold start
                ;       wboot   warm start (save i/o byte)
                ;       (boot and wboot are the same for mds)
                ;       const   console status
                ;               reg-a = 00 if no character ready
                ;               reg-a = ff if character ready
                ;       conin   console character in (result in reg-a)
                ;       conout  console character out (char in reg-c)
                ;       list    list out (char in reg-c)
                ;       punch   punch out (char in reg-c)
                ;       reader  paper tape reader in (result to reg-a)
                ;       home    move to track 00
                ;
                ;       (the following calls set-up the io parameter bloc
                ;       mds, which is used to perform subsequent reads an
                ;       seldsk  select disk given by reg-c (0,1,2...)
                ;       settrk  set track address (0,...76) for sub r/w
                ;       setsec  set sector address (1,...,26)
                ;       setdma  set subsequent dma address (initially 80h
                ;
                ;       read/write assume previous calls to set i/o parms
                ;       read    read track/sector to preset dma address
                ;       write   write track/sector from preset dma addres
                ;
                ;       jump vector for indiviual routines
4a00 c3b34a             jmp     boot
4a03 c3c34a     wboote: jmp     wboot
4a06 c3614b             jmp     const
4a09 c3644b             jmp     conin
4a0c c36a4b             jmp     conout
```

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```
4a0f c36d4b             jmp     list
4a12 c3724b             jmp     punch
4a15 c3754b             jmp     reader
4a18 c3784b             jmp     home
4a1b c37d4b             jmp     seldsk
4a1e c3a74b             jmp     settrk
4a21 c3ac4b             jmp     setsec
4a24 c3bb4b             jmp     setdma
4a27 c3c14b             jmp     read
4a2a c3ca4b             jmp     write
4a2d c3704b             jmp     listst  ;list status
4a30 c3b14b             jmp     sectran
            ;
                        maclib  diskdef ;load the disk definition library
                        disks   4       ;four disks
4a33+=      dpbase      equ     $       ;base of disk parameter blocks
4a33+824a00 dpe0:       dw      xlt0,0000h      ;translate table
4a37+000000             dw      0000h,0000h     ;scratch area
4a3b+6e4c73             dw      dirbuf,dpb0     ;dir buff,parm block
4a3f+0d4dee             dw      csv0,alv0       ;check, alloc vectors
4a43+824a00 dpe1:       dw      xlt1,0000h      ;translate table
4a47+000000             dw      0000h,0000h     ;scratch area
4a4b+6e4c73             dw      dirbuf,dpb1     ;dir buff,parm block
4a4f+3c4d1d             dw      csv1,alv1       ;check, alloc vectors
4a53+824a00 dpe2:       dw      xlt2,0000h      ;translate table
4a57+000000             dw      0000h,0000h     ;scratch area
4a5b+6e4c73             dw      dirbuf,dpb2     ;dir buff,parm block
4a5f+6b4d4c             dw      csv2,alv2       ;check, alloc vectors
4a63+824a00 dpe3:       dw      xlt3,0000h      ;translate table
4a67+000000             dw      0000h,0000h     ;scratch area
4a6b+6e4c73             dw      dirbuf,dpb3     ;dir buff,parm block
4a6f+9a4d7b             dw      csv3,alv3       ;check, alloc vectors
                        diskdef 0,1,26,6,1024,243,64,64,offset
4a73+=      dpb0        equ     $               ;disk parm block
4a73+1a00               dw      26              ;sec per track
4a75+03                 db      3               ;block shift
4a76+07                 db      7               ;block mask
4a77+00                 db      0               ;extnt mask
4a78+f200               dw      242             ;disk size-1
4a7a+3f00               dw      63              ;directory max
4a7c+c0                 db      192             ;alloc0
4a7d+00                 db      0               ;alloc1
4a7e+1000               dw      16              ;check size
4a80+0200               dw      2               ;offset
4a82+=      xlt0        equ     $               ;translate table
4a82+01                 db      1
4a83+07                 db      7
4a84+0d                 db      13
4a85+13                 db      19
4a86+19                 db      25
4a87+05                 db      5
4a88+0b                 db      11
4a89+11                 db      17
4a8a+17                 db      23
4a8b+03                 db      3
```

```
4a8c+09                 db      9
4a8d+0f                 db      15
4a8e+15                 db      21
4a8f+02                 db      2
4a90+08                 db      8
4a91+0e                 db      14
4a92+14                 db      20
4a93+1a                 db      26
4a94+06                 db      6
4a95+0c                 db      12
4a96+12                 db      18
4a97+18                 db      24
4a98+04                 db      4
4a99+0a                 db      10
4a9a+10                 db      16
4a9b+16                 db      22
                        diskdef 1,0
4a73+=          dpb1    equ     dpb0    ;equivalent parameters
001f+=          als1    equ     als0    ;same allocation vector size
0010+=          css1    equ     css0    ;same checksum vector size
4a82+=          xlt1    equ     xlt0    ;same translate table
                        diskdef 2,0
4a73+=          dpb2    equ     dpb0    ;equivalent parameters
001f+=          als2    equ     als0    ;same allocation vector size
0010+=          css2    equ     css0    ;same checksum vector size
4a82+=          xlt2    equ     xlt0    ;same translate table
                        diskdef 3,0
4a73+=          dpb3    equ     dpb0    ;equivalent parameters
001f+=          als3    equ     als0    ;same allocation vector size
0010+=          css3    equ     css0    ;same checksum vector size
4a82+=          xlt3    equ     xlt0    ;same translate table
                ;       endef occurs at end of assembly
                ;
                ;       end of controller - independent code, the remaini
                ;       are tailored to the particular operating environm
                ;       be altered for any system which differs from the
                ;
                ;       the following code assumes the mds monitor exists
                ;       and uses the i/o subroutines within the monitor
                ;
                ;       we also assume the mds system has four disk drive
00fd =          revrt   equ     0fdh    ;interrupt revert port
00fc =          intc    equ     0fch    ;interrupt mask port
00f3 =          icon    equ     0f3h    ;interrupt control port
007e =          inte    equ     0111$1110b;enable rst 0(warm boot),rst 7
                ;
                ;       mds monitor equates
f800 =          mon80   equ     0f800h  ;mds monitor
ff0f =          rmon80  equ     0ff0fh  ;restart mon80 (boot error)
f803 =          ci      equ     0f803h  ;console character to reg-a
f806 =          ri      equ     0f806h  ;reader in to reg-a
f809 =          co      equ     0f809h  ;console char from c to console o
f80c =          po      equ     0f80ch  ;punch char from c to punch devic
f80f =          lo      equ     0f80fh  ;list from c to list device
f812 =          csts    equ     0f812h  ;console status 00/ff to register
```

Appendix G

```
                ;
                ;       disk ports and commands
0078 =          base    equ     78h     ;base of disk command io ports
0078 =          dstat   equ     base    ;disk status (input)
0079 =          rtype   equ     base+1  ;result type (input)
007b =          rbyte   equ     base+3  ;result byte (input)
                ;
0079 =          ilow    equ     base+1  ;iopb low address (output)
007a =          ihigh   equ     base+2  ;iopb high address (output)
                ;
0004 =          readf   equ     4h      ;read function
0006 =          writf   equ     6h      ;write function
0003 =          recal   equ     3h      ;recalibrate drive
0004 =          iordy   equ     4h      ;i/o finished mask
000d =          cr      equ     0dh     ;carriage return
000a =          lf      equ     0ah     ;line feed
                ;
                signon: ;signon message: xxk cp/m vers y.y
4a9c 0d0a0a             db      cr,lf,lf
4a9f 3230               db      '20'    ;sample memory size
4aa1 6b2043f            db      'k cp/m vers '
4aad 322e30             db      vers/10+'0','.',vers mod 10+'0'
4ab0 0d0a00             db      cr,lf,0
                ;
                boot:   ;print signon message and go to ccp
                ;       (note: mds boot initialized iobyte at 0003h)
4ab3 310001             lxi     sp,buff+80h
4ab6 219c4a             lxi     h,signon
4ab9 cdd34b             call    prmsg   ;print message
4abc af                 xra     a       ;clear accumulator
4abd 320400             sta     cdisk   ;set initially to disk a
4ac0 c30f4b             jmp     gocpm   ;go to cp/m
                ;
                ;
                wboot:; loader on track 0, sector 1, which will be skippe
                ;       read cp/m from disk - assuming there is a 128 byt
                ;       start.
                ;
4ac3 318000             lxi     sp,buff ;using dma - thus 80 thru ff ok f
                ;
4ac6 0e0a               mvi     c,retry ;max retries
4ac8 c5                 push    b
                wboot0: ;enter here on error retries
4ac9 010034             lxi     b,cpmb  ;set dma address to start of disk
4acc cdbb4b             call    setdma
4acf 0e00               mvi     c,0     ;boot from drive 0
4ad1 cd7d4b             call    seldsk
4ad4 0e00               mvi     c,0
4ad6 cda74b             call    settrk  ;start with track 0
4ad9 0e02               mvi     c,2     ;start reading sector 2
4adb cdac4b             call    setsec
                ;
                ;       read sectors, count nsects to zero
4ade c1                 pop     b       ;10-error count
4adf 062c               mvi     b,nsects
```

```
                rdsec:  ;read next sector
4ae1 c5                 push    b       ;save sector count
4ae2 cdc14b             call    read
4ae5 c2494b             jnz     booterr ;retry if errors occur
4ae8 2a6c4c             lhld    iod     ;increment dma address
4aeb 118000             lxi     d,128   ;sector size
4aee 19                 dad     d       ;incremented dma address in hl
4aef 44                 mov     b,h
4af0 4d                 mov     c,l     ;ready for call to set dma
4af1 cdbb4b             call    setdma
4af4 3a6b4c             lda     ios     ;sector number just read
4af7 fe1a               cpi     26      ;read last sector?
4af9 da054b             jc      rd1
                ;       must be sector 26, zero and go to next track
4afc 3a6a4c             lda     iot     ;get track to register a
4aff 3c                 inr     a
4b00 4f                 mov     c,a     ;ready for call
4b01 cda74b             call    settrk
4b04 af                 xra     a       ;clear sector number
4b05 3c         rd1:    inr     a       ;to next sector
4b06 4f                 mov     c,a     ;ready for call
4b07 cdac4b             call    setsec
4b0a c1                 pop     b       ;recall sector count
4b0b 05                 dcr     b       ;done?
4b0c c2e14a             jnz     rdsec
                ;
                ;       done with the load, reset default buffer address
                gocpm:  ;(enter here from cold start boot)
                ;       enable rst0 and rst7
4b0f f3                 di
4b10 3e12               mvi     a,12h   ;initialize command
4b12 d3fd               out     revrt
4b14 af                 xra     a
4b15 d3fc               out     intc    ;cleared
4b17 3e7e               mvi     a,inte  ;rst0 and rst7 bits on
4b19 d3fc               out     intc
4b1b af                 xra     a
4b1c d3f3               out     icon    ;interrupt control
                ;
                ;       set default buffer address to 80h
4b1e 018000             lxi     b,buff
4b21 cdbb4b             call    setdma
                ;
                ;       reset monitor entry points
4b24 3ec3               mvi     a,jmp
4b26 320000             sta     0
4b29 21034a             lxi     h,wboote
4b2c 220100             shld    1       ;jmp wboot at location 00
4b2f 320500             sta     5
4b32 21063c             lxi     h,bdos
4b35 220600             shld    6       ;jmp bdos at location 5
4b38 323800             sta     7*8     ;jmp to mon80 (may have been chan
4b3b 2100f8             lxi     h,mon80
4b3e 223900             shld    7*8+1
                ;       leave iobyte set
```

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```
                ;       previously selected disk was b, send parameter to
4b41 3a0400             lda     cdisk   ;last logged disk number
4b44 4f                 mov     c,a     ;send to ccp to log it in
4b45 fb                 ei
4b46 c30034             jmp     cpmb
                ;
                ;       error condition occurred, print message and retry
                booterr:
4b49 c1                 pop     b       ;recall counts
4b4a 0d                 dcr     c
4b4b ca524b             jz      booter0
                ;       try again
4b4e c5                 push    b
4b4f c3c94a             jmp     wboot0
                ;
                booter0:
                ;       otherwise too many retries
4b52 215b4b             lxi     h,bootmsg
4b55 cdd34b             call    prmsg
4b58 c30fff             jmp     rmon80  ;mds hardware monitor
                ;
                bootmsg:
4b5b 3f626f4            db      '?boot',0
                ;
                ;
                const:  ;console status to reg-a
                ;       (exactly the same as mds call)
4b61 c312f8             jmp     csts
                ;
                conin:  ;console character to reg-a
4b64 cd03f8             call    ci
4b67 e67f               ani     7fh     ;remove parity bit
4b69 c9                 ret
                ;
                conout: ;console character from c to console out
4b6a c309f8             jmp     co
                ;
                list:   ;list device out
                ;       (exactly the same as mds call)
4b6d c30ff8             jmp     lo
                ;
                listst:
                        ;return list status
4b70 af                 xra     a
4b71 c9                 ret             ;always not ready
                ;
                punch:  ;punch device out
                ;       (exactly the same as mds call)
4b72 c30cf8             jmp     po
                ;
                reader: ;reader character in to reg-a
                ;       (exactly the same as mds call)
4b75 c306f8             jmp     ri
                ;
                home:   ;move to home position
```

```
               ;       treat as track 00 seek
4b78 0e00              mvi     c,0
4b7a c3a74b            jmp     settrk
               ;
               seldsk: ;select disk given by register c
4b7d 210000            lxi     h,0000h ;return 0000 if error
4b80 79                mov     a,c
4b81 fe04              cpi     ndisks  ;too large?
4b83 d0                rnc             ;leave hl = 0000
               ;
4b84 e602              ani     10b     ;00 00 for drive 0,1 and 10 10 fo
4b86 32664c            sta     dbank   ;to select drive bank
4b89 79                mov     a,c     ;00, 01, 10, 11
4b8a e601              ani     1b      ;mds has 0,1 at 78, 2,3 at 88
4b8c b7                ora     a       ;result 00?
4b8d ca924b            jz      setdrive
4b90 3e30              mvi     a,00110000b     ;selects drive 1 in bank
               setdrive:
4b92 47                mov     b,a     ;save the function
4b93 21684c            lxi     h,iof   ;io function
4b96 7e                mov     a,m
4b97 e6cf              ani     11001111b       ;mask out disk number
4b99 b0                ora     b       ;mask in new disk number
4b9a 77                mov     m,a     ;save it in iopb
4b9b 69                mov     l,c
4b9c 2600              mvi     h,0     ;hl=disk number
4b9e 29                dad     h       ;*2
4b9f 29                dad     h       ;*4
4ba0 29                dad     h       ;*8
4ba1 29                dad     h       ;*16
4ba2 11334a            lxi     d,dpbase
4ba5 19                dad     d       ;hl=disk header table address
4ba6 c9                ret
               ;
               ;
               settrk: ;set track address given by c
4ba7 216a4c            lxi     h,iot
4baa 71                mov     m,c
4bab c9                ret
               ;
               setsec: ;set sector number given by c
4bac 216b4c            lxi     h,ios
4baf 71                mov     m,c
4bb0 c9                ret
               sectran:
                               ;translate sector bc using table at de
4bb1 0600              mvi     b,0     ;double precision sector number i
4bb3 eb                xchg            ;translate table address to hl
4bb4 09                dad     b       ;translate(sector) address
4bb5 7e                mov     a,m     ;translated sector number to a
4bb6 326b4c            sta     ios
4bb9 6f                mov     l,a     ;return sector number in l
4bba c9                ret
               ;
               setdma: ;set dma address given by regs b,c
```

Appendix G

```
4bbb 69              mov     l,c
4bbc 60              mov     h,b
4bbd 226c4c          shld    iod
4bc0 c9              ret
           ;
           read:     ;read next disk record (assuming disk/trk/sec/dma
4bc1 0e04            mvi     c,readf ;set to read function
4bc3 cde04b          call    setfunc
4bc6 cdf04b          call    waitio  ;perform read function
4bc9 c9              ret             ;may have error set in reg-a
           ;
           ;
           write:    ;disk write function
4bca 0e06            mvi     c,writf
4bcc cde04b          call    setfunc ;set to write function
4bcf cdf04b          call    waitio
4bd2 c9              ret             ;may have error set
           ;
           ;
           ;         utility subroutines
           prmsg:    ;print message at h,l to 0
4bd3 7e              mov     a,m
4bd4 b7              ora     a       ;zero?
4bd5 c8              rz
           ;         more to print
4bd6 e5              push    h
4bd7 4f              mov     c,a
4bd8 cd6a4b          call    conout
4bdb e1              pop     h
4bdc 23              inx     h
4bdd c3d34b          jmp     prmsg
           ;
           setfunc:
           ;         set function for next i/o (command in reg-c)
4be0 21684c          lxi     h,iof   ;io function address
4be3 7e              mov     a,m     ;get it to accumulator for maskir
4be4 e6f8            ani     11111000b       ;remove previous command
4be6 b1              ora     c       ;set to new command
4be7 77              mov     m,a     ;replaced in iopb
           ;         the mds-800 controller req's disk bank bit in sec
           ;         mask the bit from the current i/o function
4be8 e620            ani     00100000b       ;mask the disk select bit
4bea 216b4c          lxi     h,ios           ;address the sector selec
4bed b6              ora     m               ;select proper disk bank
4bee 77              mov     m,a             ;set disk select bit on/c
4bef c9              ret
           ;
           waitio:
4bf0 0e0a            mvi     c,retry ;max retries before perm error
           rewait:
           ;         start the i/o function and wait for completion
4bf2 cd3f4c          call    intype  ;in rtype
4bf5 cd4c4c          call    inbyte  ;clears the controller
           ;
4bf8 3a664c          lda     dbank           ;set bank flags
```

```
4bfb b7             ora     a                ;zero if drive 0,1 and nz
4bfc 3e67           mvi     a,iopb and 0ffh ;low address for iopb
4bfe 064c           mvi     b,iopb shr 8     ;high address for iopb
4c00 c20b4c         jnz     iodrl    ;drive bank 1?
4c03 d379           out     ilow             ;low address to controlle
4c05 78             mov     a,b
4c06 d37a           out     ihigh    ;high address
4c08 c3104c         jmp     wait0            ;to wait for complete
               ;
               iodrl:  ;drive bank 1
4c0b d389           out     ilow+10h         ;88 for drive bank 10
4c0d 78             mov     a,b
4c0e d38a           out     ihigh+10h
               ;
4c10 cd594c    wait0:  call    instat           ;wait for completion
4c13 e604           ani     iordy            ;ready?
4c15 ca104c         jz      wait0
               ;
               ;       check io completion ok
4c18 cd3f4c         call    intype           ;must be io complete (00)
               ;       00 unlinked i/o complete,    01 linked i/o comple
               ;       10 disk status changed       11 (not used)
4c1b fe02           cpi     10b              ;ready status change?
4c1d ca324c         jz      wready
               ;
               ;       must be 00 in the accumulator
4c20 b7             ora     a
4c21 c2384c         jnz     werror           ;some other condition, re
               ;
               ;       check i/o error bits
4c24 cd4c4c         call    inbyte
4c27 17             ral
4c28 da324c         jc      wready           ;unit not ready
4c2b 1f             rar
4c2c e6fe           ani     11111110b        ;any other errors?
4c2e c2384c         jnz     werror
               ;
               ;       read or write is ok, accumulator contains zero
4c31 c9             ret
               ;
               wready: ;not ready, treat as error for now
4c32 cd4c4c         call    inbyte           ;clear result byte
4c35 c3384c         jmp     trycount
               ;
               werror: ;return hardware malfunction (crc, track, seek, e
               ;       the mds controller has returned a bit in each pos
               ;       of the accumulator, corresponding to the conditio
               ;       0       - deleted data (accepted as ok above)
               ;       1       - crc error
               ;       2       - seek error
               ;       3       - address error (hardware malfunction)
               ;       4       - data over/under flow (hardware malfunct
               ;       5       - write protect (treated as not ready)
               ;       6       - write error (hardware malfunction)
               ;       7       - not ready
```

Append
G

```
            ;       (accumulator bits are numbered 7 6 5 4 3 2 1 0)
            ;
            ;       it may be useful to filter out the various condit
            ;       but we will get a permanent error message if it i
            ;       recoverable.  in any case, the not ready conditio
            ;       treated as a separate condition for later improve
            trycount:
            ;       register c contains retry count, decrement 'til z
4c38 0d             dcr     c
4c39 c2f24b         jnz     rewait  ;for another try
            ;
            ;       cannot recover from error
4c3c 3e01           mvi     a,1     ;error code
4c3e c9             ret
            ;
            ;       intype, inbyte, instat read drive bank 00 or 10
4c3f 3a664c intype: lda     dbank
4c42 b7             ora     a
4c43 c2494c         jnz     intypl  ;skip to bank 10
4c46 db79           in      rtype
4c48 c9             ret
4c49 db89   intypl: in      rtype+10h       ;78 for 0,1  88 for 2,3
4c4b c9             ret
            ;
4c4c 3a664c inbyte: lda     dbank
4c4f b7             ora     a
4c50 c2564c         jnz     inbytl
4c53 db7b           in      rbyte
4c55 c9             ret
4c56 db8b   inbytl: in      rbyte+10h
4c58 c9             ret
            ;
4c59 3a664c instat: lda     dbank
4c5c b7             ora     a
4c5d c2634c         jnz     instal
4c60 db78           in      dstat
4c62 c9             ret
4c63 db88   instal: in      dstat+10h
4c65 c9             ret
            ;
            ;
            ;
            ;       data areas (must be in ram)
4c66 00     dbank:  db      0       ;disk bank 00 if drive 0,1
                                    ;          10 if drive 2,3
            iopb:   ;io parameter block
4c67 80             db      80h     ;normal i/o operation
4c68 04     iof:    db      readf   ;io function, initial read
4c69 01     ion:    db      1       ;number of sectors to read
4c6a 02     iot:    db      offset  ;track number
4c6b 01     ios:    db      1       ;sector number
4c6c 8000   iod:    dw      buff    ;io address
            ;
            ;
            ;       define ram areas for bdos operation
```

```
                        endef
4c6e+=      begdat   equ     $
4c6e+       dirbuf:  ds      128     ;directory access buffer
4cee+       alvØ:    ds      31
4dØd+       csvØ:    ds      16
4d1d+       alv1:    ds      31
4d3c+       csv1:    ds      16
4d4c+       alv2:    ds      31
4d6b+       csv2:    ds      16
4d7b+       alv3:    ds      31
4d9a+       csv3:    ds      16
4daa+=      enddat   equ     $
Ø13c+=      datsiz   equ     $-begdat
4daa                 end
```

Appendix G

APPENDIX C: A SKELETAL CBIOS

```
                ;       skeletal cbios for first level of cp/m 2.0 altera
                ;
0014 =          msize   equ     20      ;cp/m version memory size in kilo
                ;
                ;       "bias" is address offset from 3400h for memory sy
                ;       than 16k (referred to as "b" throughout the text)
                ;
0000 =          bias    equ     (msize-20)*1024
3400 =          ccp     equ     3400h+bias      ;base of ccp
3c06 =          bdos    equ     ccp+806h        ;base of bdos
4a00 =          bios    equ     ccp+1600h       ;base of bios
0004 =          cdisk   equ     0004h   ;current disk number 0=a,...,15=p
0003 =          iobyte  equ     0003h   ;intel i/o byte
                ;
4a00                    org     bios    ;origin of this program
002c =          nsects  equ     ($-ccp)/128     ;warm start sector count
                ;
                ;       jump vector for individual subroutines
4a00 c39c4a             jmp     boot            ;cold start
4a03 c3a64a wboote:     jmp     wboot           ;warm start
4a06 c3114b             jmp     const           ;console status
4a09 c3244b             jmp     conin           ;console character in
4a0c c3374b             jmp     conout          ;console character out
4a0f c3494b             jmp     list            ;list character out
4a12 c34d4b             jmp     punch           ;punch character out
4a15 c34f4b             jmp     reader          ;reader character out
4a18 c3544b             jmp     home            ;move head to home positi
4a1b c35a4b             jmp     seldsk          ;select disk
4a1e c37d4b             jmp     settrk          ;set track number
4a21 c3924b             jmp     setsec          ;set sector number
4a24 c3ad4b             jmp     setdma          ;set dma address
4a27 c3c34b             jmp     read            ;read disk
4a2a c3d64b             jmp     write           ;write disk
4a2d c34b4b             jmp     listst          ;return list status
4a30 c3a74b             jmp     sectran         ;sector translate
                ;
                ;       fixed data tables for four-drive standard
                ;       ibm-compatible 8" disks
                ;       disk parameter header for disk 00
4a33 734a00 dpbase:     dw      trans,0000h
4a37 000000             dw      0000h,0000h
4a3b f04c8d             dw      dirbf,dpblk
4a3f ec4d70             dw      chk00,all00
                ;       disk parameter header for disk 01
4a43 734a00             dw      trans,0000h
4a47 000000             dw      0000h,0000h
4a4b f04c8d             dw      dirbf,dpblk
4a4f fc4d8f             dw      chk01,all01
                ;       disk parameter header for disk 02
4a53 734a00             dw      trans,0000h
4a57 000000             dw      0000h,0000h
4a5b f04c8d             dw      dirbf,dpblk
4a5f 0c4eae             dw      chk02,all02
```

```
                 ;          disk parameter header for disk 03
4a63 734a00                 dw      trans,0000h
4a67 000000                 dw      0000h,0000h
4a6b f04c8d                 dw      dirbf,dpblk
4a6f 1c4ecd                 dw      chk03,all03
                 ;
                 ;          sector translate vector
4a73 01070d      trans:     db      1,7,13,19           ;sectors 1,2,3,4
4a77 19050b                 db      25,5,11,17          ;sectors 5,6,7,8
4a7b 170309                 db      23,3,9,15           ;sectors 9,10,11,12
4a7f 150208                 db      21,2,8,14           ;sectors 13,14,15,16
4a83 141a06                 db      20,26,6,12          ;sectors 17,18,19,20
4a87 121804                 db      18,24,4,10          ;sectors 21,22,23,24
4a8b 1016                   db      16,22               ;sectors 25,26
                 ;
                 dpblk:     ;disk parameter block, common to all disks
4a8d 1a00                   dw      26                  ;sectors per track
4a8f 03                     db      3                   ;block shift factor
4a90 07                     db      7                   ;block mask
4a91 00                     db      0                   ;null mask
4a92 f200                   dw      242                 ;disk size-1
4a94 3f00                   dw      63                  ;directory max
4a96 c0                     db      192                 ;alloc 0
4a97 00                     db      0                   ;alloc 1
4a98 1000                   dw      16                  ;check size
4a9a 0200                   dw      2                   ;track offset
                 ;
                 ;          end of fixed tables
                 ;
                 ;          individual subroutines to perform each function
                 boot:      ;simplest case is to just perform parameter initi
4a9c af                     xra     a                   ;zero in the accum
4a9d 320300                 sta     iobyte              ;clear the iobyte
4aa0 320400                 sta     cdisk               ;select disk zero
4aa3 c3ef4a                 jmp     gocpm               ;initialize and go to cp/
                 ;
                 wboot:     ;simplest case is to read the disk until all sect
4aa6 318000                 lxi     sp,80h              ;use space below buffer f
4aa9 0e00                   mvi     c,0                 ;select disk 0
4aab cd5a4b                 call    seldsk
4aae cd544b                 call    home                ;go to track 00
                 ;
4ab1 062c                   mvi     b,nsects            ;b counts # of sectors to
4ab3 0e00                   mvi     c,0                 ;c has the current track
4ab5 1602                   mvi     d,2                 ;d has the next sector to
                 ;          note that we begin by reading track 0, sector 2 s
                 ;          contains the cold start loader, which is skipped
4ab7 210034                 lxi     h,ccp               ;base of cp/m (initial lo
                 load1:     ;load one more sector
4aba c5                     push    b       ;save sector count, current track
4abb d5                     push    d       ;save next sector to read
4abc e5                     push    h       ;save dma address
4abd 4a                     mov     c,d     ;get sector address to register c
4abe cd924b                 call    setsec  ;set sector address from register
4ac1 c1                     pop     b       ;recall dma address to b,c
```

```
4ac2 c5                 push    b          ;replace on stack for later recal
4ac3 cdad4b             call    setdma     ;set dma address from b,c
                ;
                ;       drive set to 0, track set, sector set, dma addres
4ac6 cdc34b             call    read
4ac9 fe00               cpi     00h        ;any errors?
4acb c2a64a             jnz     wboot      ;retry the entire boot if an erro
                ;
                ;       no error, move to next sector
4ace e1                 pop     h          ;recall dma address
4acf 118000             lxi     d,128      ;dma=dma+128
4ad2 19                 dad     d          ;new dma address is in h,l
4ad3 d1                 pop     d          ;recall sector address
4ad4 c1                 pop     b          ;recall number of sectors remaini
4ad5 05                 dcr     b          ;sectors=sectors-1
4ad6 caef4a             jz      gocpm      ;transfer to cp/m if all have bee
                ;
                ;       more sectors remain to load, check for track chan
4ad9 14                 inr     d
4ada 7a                 mov     a,d        ;sector=27?, if so, change tracks
4adb fe1b               cpi     27
4add daba4a             jc      load1      ;carry generated if sector<27
                ;
                ;       end of current track, go to next track
4ae0 1601               mvi     d,1        ;begin with first sector of next
4ae2 0c                 inr     c          ;track=track+1
                ;
                ;       save register state, and change tracks
4ae3 c5                 push    b
4ae4 d5                 push    d
4ae5 e5                 push    h
4ae6 cd7d4b             call    settrk     ;track address set from register
4ae9 e1                 pop     h
4aea d1                 pop     d
4aeb c1                 pop     b
4aec c3ba4a             jmp     load1      ;for another sector
                ;
                ;       end of load operation, set parameters and go to c
                gocpm:
4aef 3ec3               mvi     a,0c3h     ;c3 is a jmp instruction
4af1 320000             sta     0          ;for jmp to wboot
4af4 21034a             lxi     h,wboote           ;wboot entry point
4af7 220100             shld    1          ;set address field for jmp at 0
                ;
4afa 320500             sta     5          ;for jmp to bdos
4afd 21063c             lxi     h,bdos     ;bdos entry point
4b00 220600             shld    6          ;address field of jump at 5 to bd
                ;
4b03 018000             lxi     b,80h      ;default dma address is 80h
4b06 cdad4b             call    setdma
                ;
4b09 fb                 ei                 ;enable the interrupt system
4b0a 3a0400             lda     cdisk      ;get current disk number
4b0d 4f                 mov     c,a        ;send to the ccp
4b0e c30034             jmp     ccp        ;go to cp/m for further processin
```

```
               ;
               ;
               ;        simple i/o handlers (must be filled in by user)
               ;        in each case, the entry point is provided, with s
               ;        to insert your own code
               ;
               const:   ;console status, return 0ffh if character ready,
4b11                    ds      10h      ;space for status subroutine
4b21 3e00               mvi     a,00h
4b23 c9                 ret
               ;
               conin:   ;console character into register a
4b24                    ds      10h      ;space for input routine
4b34 e67f               ani     7fh      ;strip parity bit
4b36 c9                 ret
               ;
               conout:  ;console character output from register c
4b37 79                 mov     a,c      ;get to accumulator
4b38                    ds      10h      ;space for output routine
4b48 c9                 ret
               ;
               list:    ;list character from register c
4b49 79                 mov     a,c      ;character to register a
4b4a c9                 ret              ;null subroutine
               ;
               listst:  ;return list status (0 if not ready, 1 if ready)
4b4b af                 xra     a        ;0 is always ok to return
4b4c c9                 ret
               ;
               punch:   ;punch character from register c
4b4d 79                 mov     a,c      ;character to register a
4b4e c9                 ret              ;null subroutine
               ;
               ;
               reader:  ;read character into register a from reader devic
4b4f 3e1a               mvi     a,1ah    ;enter end of file for now (repla
4b51 e67f               ani     7fh      ;remember to strip parity bit
4b53 c9                 ret
               ;
               ;
               ;        i/o drivers for the disk follow
               ;        for now, we will simply store the parameters away
               ;        in the read and write subroutines
               ;
               home:    ;move to the track 00 position of current drive
               ;        translate this call into a settrk call with param
4b54 0e00               mvi     c,0      ;select track 0
4b56 cd7d4b             call    settrk
4b59 c9                 ret              ;we will move to 00 on first read
               ;
               seldsk:  ;select disk given by register c
4b5a 210000             lxi     h,0000h ;error return code
4b5d 79                 mov     a,c
4b5e 32ef4c             sta     diskno
4b61 fe04               cpi     4        ;must be between 0 and 3
```

```
4b63 dØ              rnc                    ;no carry if 4,5,...
            ;        disk number is in the proper range
4b64                 ds       1Ø        ;space for disk select
            ;        compute proper disk parameter header address
4b6e 3aef4c          lda      diskno
4b71 6f              mov      l,a       ;l=disk number Ø,1,2,3
4b72 26ØØ            mvi      h,Ø       ;high order zero
4b74 29              dad      h         ;*2
4b75 29              dad      h         ;*4
4b76 29              dad      h         ;*8
4b77 29              dad      h         ;*16 (size of each header)
4b78 11334a          lxi      d,dpbase
4b7b 19              dad      d         ;hl=.dpbase(diskno*16)
4b7c c9              ret
            ;
            settrk: ;set track given by register c
4b7d 79              mov      a,c
4b7e 32e94c          sta      track
4b81                 ds       1Øh       ;space for track select
4b91 c9              ret
            ;
            setsec: ;set sector given by register c
4b92 79              mov      a,c
4b93 32eb4c          sta      sector
4b96                 ds       1Øh       ;space for sector select
4ba6 c9              ret
            ;
            sectran:
                     ;translate the sector given by bc using the
                     ;translate table given by de
4ba7 eb              xchg               ;hl=.trans
4ba8 Ø9              dad      b         ;hl=.trans(sector)
4ba9 6e              mov      l,m       ;l = trans(sector)
4baa 26ØØ            mvi      h,Ø       ;hl= trans(sector)
4bac c9              ret                ;with value in hl
            ;
            setdma: ;set dma address given by registers b and c
4bad 69              mov      l,c       ;low order address
4bae 6Ø              mov      h,b       ;high order address
4baf 22ed4c          shld     dmaad     ;save the address
4bb2                 ds       1Øh       ;space for setting the dma addres
4bc2 c9              ret
            ;
            read:    ;perform read operation (usually this is similar
            ;        so we will allow space to set up read command, th
            ;        common code in write)
4bc3                 ds       1Øh       ;set up read command
4bd3 c3e64b          jmp      waitio    ;to perform the actual i/o
            ;
            write:   ;perform a write operation
4bd6                 ds       1Øh       ;set up write commanu
            ;
            waitio: ;enter here from read and write to perform the ac
            ;        operation.  return a ØØh in register a if the ope
            ;        properly, and Ø1h if an error occurs during the r
```

```
                ;
                ;       in this case, we have saved the disk number in 'd
                ;                       the track number in 'track' (Ø-76
                ;                       the sector number in 'sector' (1-
                ;                       the dma address in 'dmaad' (Ø-655
4be6                    ds      256     ;space reserved for i/o drivers
4ce6 3eØ1               mvi     a,1     ;error condition
4ce8 c9                 ret             ;replaced when filled-in
                ;
                ;       the remainder of the cbios is reserved uninitiali
                ;       data area, and does not need to be a part of the
                ;       system memory image (the space must be available,
                ;       however, between "begdat" and "enddat").
                ;
4ce9            track:  ds      2       ;two bytes for expansion
4ceb            sector: ds      2       ;two bytes for expansion
4ced            dmaad:  ds      2       ;direct memory address
4cef            diskno: ds      1       ;disk number Ø-15
                ;
                ;       scratch ram area for bdos use
4cfØ =          begdat  equ     $       ;beginning of data area
4cfØ            dirbf:  ds      128     ;scratch directory area
4d7Ø            all0Ø:  ds      31      ;allocation vector Ø
4d8f            allØ1:  ds      31      ;allocation vector 1
4dae            allØ2:  ds      31      ;allocation vector 2
4dcd            allØ3:  ds      31      ;allocation vector 3
4dec            chkØØ:  ds      16      ;check vector Ø
4dfc            chkØ1:  ds      16      ;check vector 1
4eØc            chkØ2:  ds      16      ;check vector 2
4e1c            chkØ3:  ds      16      ;check vector 3
                ;
4e2c =          enddat  equ     $       ;end of data area
Ø13c =          datsiz  equ     $-begdat;size of data area
4e2c                    end
```

Appendix G

```
                ;       combined getsys and putsys programs from Sec 4.
                ;       Start the programs at the base of the TPA

0100                    org     0100h

0014 =          msize   equ     20              ; size of cp/m in Kbytes

                ; "bias" is the amount to add to addresses for > 20k
                ;       (referred to as "b" throughout the text)

0000 =          bias    equ     (msize-20)*1024
3400 =          ccp     equ     3400h+bias
3c00 =          bdos    equ     ccp+0800h
4a00 =          bios    equ     ccp+1600h

                ;       getsys programs tracks 0 and 1 to memory at
                ;       3880h + bias

                ;       register                usage
                ;         a             (scratch register)
                ;         b             track count (0...76)
                ;         c             sector count (1...26)
                ;         d,e           (scratch register pair)
                ;         h,l           load address
                ;         sp            set to stack address

                gstart:                                 ; start of getsys
0100 318033             lxi     sp,ccp-0080h            ; convenient plac
0103 218033             lxi     h,ccp-0080h             ; set initial loa
0106 0600               mvi     b,0                     ; start with trac
                rd$trk:                                 ; read next track
0108 0e01               mvi     c,1                     ; each track star
                rd$sec:
010a cd0003             call    read$sec                ; get the next se
010d 118000             lxi     d,128                   ; offset by one s
0110 19                 dad     d                       ;   (hl=hl+128)
0111 0c                 inr     c                       ; next sector
0112 79                 mov     a,c                     ; fetch sector nu
0113 fe1b               cpi     27                      ;   and see if la
0115 da0a01             jc      rdsec                   ; <, do one more

                ; arrive here at end of track, move to next track

0118 04                 inr     b                       ; track = track+1
0119 78                 mov     a,b                     ; check for last
011a fe02               cpi     2                       ; track = 2 ?
011c da0801             jc      rd$trk                  ; <, do another

                ; arrive here at end of load, halt for lack of anything b

011f fb                 ei
0120 76                 hlt
```

```
                ;       putsys program, places memory image starting at
                ;       3880h + bias back to tracks 0 and 1
                ;       start this program at the next page boundary

0200                    org     ($+0100h) and 0ff00h

                put$sys:
0200 318033             lxi     sp,ccp-0080h            ; convenient plac
0203 218033             lxi     h,ccp-0080h             ; start of dump
0206 0600               mvi     b,0                     ; start with trac
                wr$trk:
0208 0e01               mvi     c,1                     ; start with sect
                wr$sec:
020a cd0004             call    write$sec               ; write one secto
020d 118000             lxi     d,128                   ; length of each
0210 19                 dad     d                       ; <hl>=<hl> + 128
0211 0c                 inr     c                       ; <c> = <c> + 1
0212 79                 mov     a,c                     ; see if
0213 fe1b               cpi     27                      ;   past end of t
0215 da0a02             jc      wr$sec                  ; no, do another

                ;  arrive here at end of track, move to next track

0218 04                 inr     b                       ; track = track+1
0219 78                 mov     a,b                     ; see if
021a fe02               cpi     2                       ;   last track
021c da0802             jc      wr$trk                  ; no, do another

                ;       done with putsys, halt for lack of anything bette

021f fb                 ei
0220 76                 hlt


                ; user supplied subroutines for sector read and write

                ;       move to next page boundary

0300                    org     ($+0100h) and 0ff00h

                read$sec:
                        ; read the next sector
                        ; track in <b>,
                        ; sector in <c>
                        ; dmaaddr in <hl>

0300 c5                 push    b
0301 e5                 push    h

                ; user defined read operation goes here
0302                    ds      64

0342 e1                 pop     h
0343 c1                 pop     b
```

Appendix G

```
0344 c9             ret

0400                org     ($+0100h) and 0ff00h    ; another page bo

            write$sec:

                    ; same parameters as read$sec

0400 c5             push    b
0401 e5             push    h

            ; user defined write operation goes here
0402                ds      64

0442 el             pop     h
0443 cl             pop     b
0444 c9             ret

            ; end of getsys/putsys program

0445                end
```

APPENDIX E: A SKELETAL COLD START LOADER

```
            ; this is a sample cold start loader which, when modified
            ; resides on track 00, sector 01 (the first sector on the
            ; diskette).  we assume that the controller has loaded
            ; this sector into memory upon system start-up (this pro-
            ; gram can be keyed-in, or can exist in read/only memory
            ; beyond the address space of the cp/m version you are
            ; running).  the cold start loader brings the cp/m system
            ; into memory at "loadp" (3400h + "bias").  in a 20k
            ; memory system, the value of "bias" is 0000h, with large
            ; values for increased memory sizes (see section 2). afte
            ; loading the cp/m system, the clod start loader branches
            ; to the "boot" entry point of the bios, which begins at
            ; "bios" + "bias."  the cold start loader is not used un-
            ; til the system is powered up again, as long as the bios
            ; is not overwritten.  the origin is assumed at 0000h, an
            ; must be changed if the controller brings the cold start
            ; loader into another area, or if a read/only memory area
            ; is used.

0000                    org     0                   ; base of ram in cp/m

0014 =          msize   equ     20                  ; min mem size in kbytes

0000 =          bias    equ     (msize-20)*1024     ; offset from 20k system
3400 =          ccp     equ     3400h+bias          ; base of the ccp
4a00 =          bios    equ     ccp+1600h           ; base of the bios
0300 =          biosl   equ     0300h               ; length of the bios
4a00 =          boot    equ     bios
1900 =          size    equ     bios+biosl-ccp      ; size of cp/m system
0032 =          sects   equ     size/128            ; # of sectors to load

                ;       begin the load operation

                cold:
0000 010200             lxi     b,2                 ; b=0, c=sector 2
0003 1632               mvi     d,sects             ; d=# sectors to load
0005 210034             lxi     h,ccp               ; base transfer address

                lsect:  ; load the next sector

                ;       insert inline code at this point to
                ;       read one 128 byte sector from the
                ;       track given in register b, sector
                ;       given in register c,
                ;       into the address given by <hl>
                ;
                ; branch to location "cold" if a read error occurs
```

```
                ;       ************************************************
                ;       *
                ;       *       user supplied read operation goes here...
                ;       *
                ;       ************************************************

0008 c36b00             jmp     past$patch      ; remove this when patche
000b                    ds      60h

                past$patch:
                ; go to next sector if load is incomplete
006b 15                 dcr     d               ; sects=sects-1
006c ca004a             jz      boot            ; head for the bios

                ;       more sectors to load
                ;
                ; we aren't using a stack, so use <sp> as scratch registe
                ;       to hold the load address increment

006f 318000             lxi     sp,128          ; 128 bytes per sector
0072 39                 dad     sp              ; <hl> = <hl> + 128

0073 0c                 inr     c               ; sector = sector + 1
0074 79                 mov     a,c
0075 fe1b               cpi     27              ; last sector of track?
0077 da0800             jc      lsect           ; no, go read another

                ; end of track, increment to next track

007a 0e01               mvi     c,1             ; sector = 1
007c 04                 inr     b               ; track = track + 1
007d c30800             jmp     lsect           ; for another group
0080                    end                     ; of boot loader
```

```
;         CP/M 2.0 disk re-definition library
;
;         Copyright (c) 1979
;         Digital Research
;         Box 579
;         Pacific Grove, CA
;         93950
;
;         CP/M logical disk drives are defined using the
;         macros given below, where the sequence of calls
;         is:
;
;         disks   n
;         diskdef parameter-list-0
;         diskdef parameter-list-1
;         ...
;         diskdef parameter-list-n
;         endef
;
;         where n is the number of logical disk drives attached
;         to the CP/M system, and parameter-list-i defines the
;         characteristics of the ith drive (i=0,1,...,n-1)
;
;         each parameter-list-i takes the form
;                 dn,fsc,lsc,[skf],bls,dks,dir,cks,ofs,[0]
;         where
;         dn      is the disk number 0,1,...,n-1
;         fsc     is the first sector number (usually 0 or 1)
;         lsc     is the last sector number on a track
;         skf     is optional "skew factor" for sector translate
;         bls     is the data block size (1024,2048,...,16384)
;         dks     is the disk size in bls increments (word)
;         dir     is the number of directory elements (word)
;         cks     is the number of dir elements to checksum
;         ofs     is the number of tracks to skip (word)
;         [0]     is an optional 0 which forces 16K/directory en
;
;         for convenience, the form
;                 dn,dm
;         defines disk dn as having the same characteristics as
;         a previously defined disk dm.
;
;         a standard four drive CP/M system is defined by
;                 disks   4
;                 diskdef 0,1,26,6,1024,243,64,64,2
;         dsk     set     0
;                 rept    3
;         dsk     set     dsk+1
;                 diskdef %dsk,0
;                 endm
;                 endef
;
;         the value of "begdat" at the end of assembly defines t
```

```
;       beginning of the uninitialize ram area above the bios,
;       while the value of "enddat" defines the next location
;       following the end of the data area.  the size of this
;       area is given by the value of "datsiz" at the end of t
;       assembly.  note that the allocation vector will be qui
;       large if a large disk size is defined with a small blo
;       size.
;
dskhdr  macro   dn
;;      define a single disk header list
dpe&dn: dw      xlt&dn,0000h    ;translate table
        dw      0000h,0000h     ;scratch area
        dw      dirbuf,dpb&dn   ;dir buff,parm block
        dw      csv&dn,alv&dn   ;check, alloc vectors
        endm
;
disks   macro   nd
;;      define nd disks
ndisks  set     nd      ;;for later reference
dpbase  equ     $       ;base of disk parameter blocks
;;      generate the nd elements
dsknxt  set     0
        rept    nd
        dskhdr  %dsknxt
dsknxt  set     dsknxc+1
        endm
        endm
;
dpbhdr  macro   dn
dpb&dn  equ     $                       ;disk parm block
        endm
;
ddb     macro   data,comment
;;      define a db statement
        db      data                    comment
        endm
;
ddw     macro   data,comment
;;      define a dw statement
        dw      data                    comment
        endm
;
gcd     macro   m,n
;;      greatest common divisor of m,n
;;      produces value gcdn as result
;;      (used in sector translate table generation)
gcdm    set     m       ;;variable for m
gcdn    set     n       ;;variable for n
gcdr    set     0       ;;variable for r
        rept    65535
gcdx    set     gcdm/gcdn
gcdr    set     gcdm - gcdx*gcdn
        if      gcdr = 0
        exitm
        endif
```

```
gcdm    set     gcdn
gcdn    set     gcdr
        endm
        endm
;
diskdef macro   dn,fsc,lsc,skf,bls,dks,dir,cks,ofs,k16
;;      generate the set statements for later tables
        if      nul lsc
;;      current disk dn same as previous fsc
dpb&dn  equ     dpb&fsc ;equivalent parameters
als&dn  equ     als&fsc ;same allocation vector size
css&dn  equ     css&fsc ;same checksum vector size
xlt&dn  equ     xlt&fsc ;same translate table
        else
secmax  set     lsc-(fsc)       ;;sectors 0...secmax
sectors set     secmax+1;;number of sectors
als&dn  set     (dks)/8 ;;size of allocation vector
        if      ((dks) mod 8) ne 0
als&dn  set     als&dn+1
        endif
css&dn  set     (cks)/4 ;;number of checksum elements
;;      generate the block shift value
blkval  set     bls/128 ;;number of sectors/block
blkshf  set     0       ;;counts right 0's in blkval
blkmsk  set     0       ;;fills with 1's from right
        rept    16      ;;once for each bit position
        if      blkval=1
        exitm
        endif
;;      otherwise, high order 1 not found yet
blkshf  set     blkshf+1
blkmsk  set     (blkmsk shl 1) or 1
blkval  set     blkval/2
        endm
;;      generate the extent mask byte
blkval  set     bls/1024        ;;number of kilobytes/block
extmsk  set     0       ;;fill from right with 1's
        rept    16
        if      blkval=1
        exitm
        endif
;;      otherwise more to shift
extmsk  set     (extmsk shl 1) or 1
blkval  set     blkval/2
        endm
;;      may be double byte allocation
        if      (dks) > 256
extmsk  set     (extmsk shr 1)
        endif
;;      may be optional [0] in last position
        if      not nul k16
extmsk  set     k16
        endif
;;      now generate directory reservation bit vector
dirrem  set     dir     ;;# remaining to process
```

```
dirbks  set     bls/32  ;;number of entries per block
dirblk  set     0       ;;fill with 1's on each loop
        rept    16
        if      dirrem=0
        exitm
        endif
;;      not complete, iterate once again
;;      shift right and add 1 high order bit
dirblk  set     (dirblk shr 1) or 8000h
        if      dirrem > dirbks
dirrem  set     dirrem-dirbks
        else
dirrem  set     0
        endif
        endm
        dpbhdr  dn      ;;generate equ $
        ddw     %sectors,<;sec per track>
        ddb     %blkshf,<;block shift>
        ddb     %blkmsk,<;block mask>
        ddb     %extmsk,<;extnt mask>
        ddw     %(dks)-1,<;disk size-1>
        ddw     %(dir)-1,<;directory max>
        ddb     %dirblk shr 8,<;alloc0>
        ddb     %dirblk and 0ffh,<;alloc1>
        ddw     %(cks)/4,<;check size>
        ddw     %ofs,<;offset>
;;      generate the translate table, if requested
        if      nul skf
xlt&dn  equ     0                   ;no xlate table
        else
        if      skf = 0
xlt&dn  equ     0                   ;no xlate table
        else
;;      generate the translate table
nxtsec  set     0       ;;next sector to fill
nxtbas  set     0       ;;moves by one on overflow
        gcd     %sectors,skf
;;      gcdn = gcd(sectors,skew)
neltst  set     sectors/gcdn
;;      neltst is number of elements to generate
;;      before we overlap previous elements
nelts   set     neltst  ;;counter
xlt&dn  equ     $                   ;translate table
        rept    sectors ;;once for each sector
        if      sectors < 256
        ddb     %nxtsec+(fsc)
        else
        ddw     %nxtsec+(fsc)
        endif
nxtsec  set     nxtsec+(skf)
        if      nxtsec >= sectors
nxtsec  set     nxtsec-sectors
        endif
nelts   set     nelts-1
        if      nelts = 0
```

```
nxtbas  set     nxtbas+1
nxtsec  set     nxtbas
nelts   set     neltst
        endif
        endm
        endif   ;;end of nul fac test
        endif   ;;end of nul bls test
        endm
;
defds   macro   lab,space
lab:    ds      space
        endm
;
lds     macro   lb,dn,val
        defds   lb&dn,%val&dn
        endm
;
endef   macro
;;      generate the necessary ram data areas
begdat  equ     $
dirbuf: ds      128     ;directory access buffer
dsknxt  set     0
        rept    ndisks  ;;once for each disk
        lds     alv,%dsknxt,als
        lds     csv,%dsknxt,css
dsknxt  set     dsknxt+1
        endm
enddat  equ     $
datsiz  equ     $-begdat
;;      db 0 at this point forces hex record
        endm
```

APPENDIX G: BLOCKING AND DEBLOCKING ALGORITHMS.

```
;*****************************************************
;*                                                   *
;*      Sector Deblocking Algorithms for CP/M 2.0    *
;*                                                   *
;*****************************************************
;
;       utility macro to compute sector mask
smask   macro   hblk
;;      compute log2(hblk), return @x as result
;;      (2 ** @x = hblk on return)
@y      set     hblk
@x      set     0
;;      count right shifts of @y until = 1
        rept    8
        if      @y = 1
        exitm
        endif
;;      @y is not 1, shift right one position
@y      set     @y shr 1
@x      set     @x + 1
        endm
        endm
;
;*****************************************************
;*                                                   *
;*          CP/M to host disk constants              *
;*                                                   *
;*****************************************************
blksiz  equ     2048            ;CP/M allocation size
hstsiz  equ     512             ;host disk sector size
hstspt  equ     20              ;host disk sectors/trk
hstblk  equ     hstsiz/128      ;CP/M sects/host buff
cpmspt  equ     hstblk * hstspt ;CP/M sectors/track
secmsk  equ     hstblk-1        ;sector mask
        smask   hstblk          ;compute sector mask
secshf  equ     @x              ;log2(hstblk)
;
;*****************************************************
;*                                                   *
;*          BDOS constants on entry to write         *
;*                                                   *
;*****************************************************
wrall   equ     0               ;write to allocated
wrdir   equ     1               ;write to directory
wrual   equ     2               ;write to unallocated
;
;*****************************************************
;*                                                   *
;*      The BDOS entry points given below show the   *
;*      code which is relevant to deblocking only.   *
;*                                                   *
;*****************************************************
;
```

```
;       DISKDEF macro, or hand coded tables go here
dpbase  equ     $               ;disk param block base
;
boot:
wboot:
        ;enter here on system boot to initialize
        xra     a               ;0 to accumulator
        sta     hstact          ;host buffer inactive
        sta     unacnt          ;clear unalloc count
        ret
;
seldsk:
        ;select disk
        mov     a,c             ;selected disk number
        sta     sekdsk          ;seek disk number
        mov     l,a             ;disk number to HL
        mvi     h,0
        rept    4               ;multiply by 16
        dad     h
        endm
        lxi     d,dpbase        ;base of parm block
        dad     d               ;hl=.dpb(curdsk)
        ret
;
settrk:
        ;set track given by registers BC
        mov     h,b
        mov     l,c
        shld    sektrk          ;track to seek
        ret
;
setsec:
        ;set sector given by register c
        mov     a,c
        sta     seksec          ;sector to seek
        ret
;
setdma:
        ;set dma address given by BC
        mov     h,b
        mov     l,c
        shld    dmaadr
        ret
;
sectran:
        ;translate sector number BC
        mov     h,b
        mov     l,c
        ret
;
```

```
;*****************************************************
;*                                                   *
;*      The READ entry point takes the place of      *
;*      the previous BIOS defintion for READ.        *
;*                                                   *
;*****************************************************
read:
        ;read the selected CP/M sector
        mvi     a,1
        sta     readop          ;read operation
        sta     rsflag          ;must read data
        mvi     a,wrual
        sta     wrtype          ;treat as unalloc
        jmp     rwoper          ;to perform the read
;
;*****************************************************
;*                                                   *
;*      The WRITE entry point takes the place of     *
;*      the previous BIOS defintion for WRITE.       *
;*                                                   *
;*****************************************************
write:
        ;write the selected CP/M sector
        xra     a               ;0 to accumulator
        sta     readop          ;not a read operation
        mov     a,c             ;write type in c
        sta     wrtype
        cpi     wrual           ;write unallocated?
        jnz     chkuna          ;check for unalloc
;
;       write to unallocated, set parameters
        mvi     a,blksiz/128    ;next unalloc recs
        sta     unacnt
        lda     sekdsk          ;disk to seek
        sta     unadsk          ;unadsk = sekdsk
        lhld    sektrk
        shld    unatrk          ;unatrk = sectrk
        lda     seksec
        sta     unasec          ;unasec = seksec
;
chkuna:
        ;check for write to unallocated sector
        lda     unacnt          ;any unalloc remain?
        ora     a
        jz      alloc           ;skip if not
;
;       more unallocated records remain
        dcr     a               ;unacnt = unacnt-1
        sta     unacnt
        lda     sekdsk          ;same disk?
        lxi     h,unadsk
        cmp     m               ;sekdsk = unadsk?
        jnz     alloc           ;skip if not
;
;       disks are the same
```

```
         lxi     h,unatrk
         call    sektrkcmp          ;sektrk = unatrk?
         jnz     alloc              ;skip if not
;
;        tracks are the same
         lda     seksec             ;same sector?
         lxi     h,unasec
         cmp     m                  ;seksec = unasec?
         jnz     alloc              ;skip if not
;
;        match, move to next sector for future ref
         inr     m                  ;unasec = unasec+1
         mov     a,m                ;end of track?
         cpi     cpmspt             ;count CP/M sectors
         jc      noovf              ;skip if no overflow
;
;        overflow to next track
         mvi     m,0                ;unasec = 0
         lhld    unatrk
         inx     h
         shld    unatrk             ;unatrk = unatrk+1
;
noovf:
         ;match found, mark as unnecessary read
         xra     a                  ;0 to accumulator
         sta     rsflag             ;rsflag = 0
         jmp     rwoper             ;to perform the write
;
alloc:
         ;not an unallocated record, requires pre-read
         xra     a                  ;0 to accum
         sta     unacnt             ;unacnt = 0
         inr     a                  ;1 to accum
         sta     rsflag             ;rsflag = 1
;
;*****************************************************
;*                                                   *
;*       Common code for READ and WRITE follows      *
;*                                                   *
;*****************************************************
rwoper:
         ;enter here to perform the read/write
         xra     a                  ;zero to accum
         sta     erflag             ;no errors (yet)
         lda     seksec             ;compute host sector
         rept    secshf
         ora     a                  ;carry = 0
         rar                        ;shift right
         endm
         sta     sekhst             ;host sector to seek
;
;        active host sector?
         lxi     h,hstact           ;host active flag
         mov     a,m
         mvi     m,1                ;always becomes 1
```

```
        ora     a               ;was it already?
        jz      filhst          ;fill host if not
;
;       host buffer active, same as seek buffer?
        lda     sekdsk
        lxi     h,hstdsk        ;same disk?
        cmp     m               ;sekdsk = hstdsk?
        jnz     nomatch
;
;       same disk, same track?
        lxi     h,hsttrk
        call    sektrkcmp       ;sektrk = hsttrk?
        jnz     nomatch
;
;       same disk, same track, same buffer?
        lda     sekhst
        lxi     h,hstsec        ;sekhst = hstsec?
        cmp     m
        jz      match           ;skip if match
;
nomatch:
        ;proper disk, but not correct sector
        lda     hstwrt          ;host written?
        ora     a
        cnz     writehst        ;clear host buff
;
filhst:
        ;may have to fill the host buffer
        lda     sekdsk
        sta     hstdsk
        lhld    sektrk
        shld    hsttrk
        lda     sekhst
        sta     hstsec
        lda     rsflag          ;need to read?
        ora     a
        cnz     readhst         ;yes, if 1
        xra     a               ;0 to accum
        sta     hstwrt          ;no pending write
;
match:
        ;copy data to or from buffer
        lda     seksec          ;mask buffer number
        ani     secmsk          ;least signif bits
        mov     l,a             ;ready to shift
        mvi     h,0             ;double count
        rept    7               ;shift left 7
        dad     h
        endm
;       hl has relative host buffer address
        lxi     d,hstbuf
        dad     d               ;hl = host address
        xchg                    ;now in DE
        lhld    dmaadr          ;get/put CP/M data
        mvi     c,128           ;length of move
```

```
        lda     readop          ;which way?
        ora     a
        jnz     rwmove          ;skip if read
;
;       write operation, mark and switch direction
        mvi     a,1
        sta     hstwrt          ;hstwrt = 1
        xchg                    ;source/dest swap
;
rwmove:
        ;C initially 128, DE is source, HL is dest
        ldax    d               ;source character
        inx     d
        mov     m,a             ;to dest
        inx     h
        dcr     c               ;loop 128 times
        jnz     rwmove
;
;       data has been moved to/from host buffer
        lda     wrtype          ;write type
        cpi     wrdir           ;to directory?
        lda     erflag          ;in case of errors
        rnz                     ;no further processing
;
;       clear host buffer for directory write
        ora     a               ;errors?
        rnz                     ;skip if so
        xra     a               ;0 to accum
        sta     hstwrt          ;buffer written
        call    writehst
        lda     erflag
        ret
;
;*****************************************************
;*                                                   *
;*      Utility subroutine for 16-bit compare        *
;*                                                   *
;*****************************************************
sektrkcmp:
        ;HL = .unatrk or .hsttrk, compare with sektrk
        xchg
        lxi     h,sektrk
        ldax    d               ;low byte compare
        cmp     m               ;same?
        rnz                     ;return if not
;       low bytes equal, test high 1s
        inx     d
        inx     h
        ldax    d
        cmp     m       ;sets flags
        ret
;
```

```
;*****************************************************
;*                                                   *
;*      WRITEHST performs the physical write to      *
;*      the host disk, READHST reads the physical    *
;*      disk.                                        *
;*                                                   *
;*****************************************************
writehst:
        ;hstdsk = host disk #, hsttrk = host track #,
        ;hstsec = host sect #. write "hstsiz" bytes
        ;from hstbuf and return error flag in erflag.
        ;return erflag non-zero if error
        ret
;
readhst:
        ;hstdsk = host disk #, hsttrk = host track #,
        ;hstsec = host sect #. read "hstsiz" bytes
        ;into hstbuf and return error flag in erflag.
        ret
;
;*****************************************************
;*                                                   *
;*      Unitialized RAM data areas                   *
;*                                                   *
;*****************************************************
;
sekdsk: ds      1               ;seek disk number
sektrk: ds      2               ;seek track number
seksec: ds      1               ;seek sector number
;
hstdsk: ds      1               ;host disk number
hsttrk: ds      2               ;host track number
hstsec: ds      1               ;host sector number
;
sekhst: ds      1               ;seek shr secshf
hstact: ds      1               ;host active flag
hstwrt: ds      1               ;host written flag
;
unacnt: ds      1               ;unalloc rec cnt
unadsk: ds      1               ;last unalloc disk
unatrk: ds      2               ;last unalloc track
unasec: ds      1               ;last unalloc sector
;
erflag: ds      1               ;error reporting
rsflag: ds      1               ;read sector flag
readop: ds      1               ;1 if read operation
wrtype: ds      1               ;write operation type
dmaadr: ds      2               ;last dma address
hstbuf: ds      hstsiz          ;host buffer
;
```

```
;*****************************************************
;*                                                   *
;*      The ENDEF macro invocation goes here         *
;*                                                   *
;*****************************************************
        end
```

APPENDIX H

ADDENDUMS

APPENDIX H-1

HARDWARE ADDENDUMS

APPENDIX H-2

SOFTWARE ADDENDUMS

APPENDIX J

CUSTOMER INFORMATION

APPENDIX J-1

SERVICING PROCEDURES

SERVICING PROCEDURES

Your SuperBrain II Video Terminal is warranted to the original purchaser for 90 days from date of shipment. This warranty covers the adjustment or replacement, F.O.B. Intertec's plant in Columbia, South Carolina, of any part or parts which in Intertec's judgment shall disclose to have been originally defective. A complete statement of your warranty rights is contained on the inside back cover of this manual.

To qualify for receipt of future technical documentation updates, please complete the Warranty Registration Form (contained in this section) and return it to Intertec Data Systems within 10 days of receipt of this equipment. Be sure to include the serial number of the specific terminal you are registering. The serial number of your terminal can be found on the right hand side of the rear I/O panel (looking from the rear). A Customer Comment Card is also enclosed for your convenience if you desire to make comments regarding the overall operation and/or adaptability of the SuperBrain II to your particular application.

IF SERVICE IS EVER REQUIRED:

If you should ever encounter difficulties with the use or operation of this terminal, contact the supplier from whom the unit was purchased for instructions regarding the proper servicing techniques. Service procedures differ from dealer to dealer, but most Intertec authorized service dealers can provide local, on-site servicing of this equipment on a per-call or maintenance contract basis. Plus, a wide variety of service programs are available directly from the factory, including extended warranty, a module exchange program, and on-site maintenance from a wide variety of locations within the U.S.

Contact our Customer Services Department at the factory for rates and availability if you desire to participate in one of these programs. **If you are not covered under one of the programs described above and service cannot be made available through your local supplier, contact Intertec's Customer Services Department at (803) 798-9100. Be prepared to give the following information when you call:**

1. The serial number of the defective equipment. If you are returning individual modules to the factory for repair, it will be necessary to have the serial number of the individual modules also. The serial number of the entire terminal may be found on the right hand side of the rear I/O panel (looking from the rear). Module serial numbers are listed on white stickers placed in conspicuous locations on each major module or subassembly of the terminal. **NOTE:** Individual modules **cannot** be returned to the factory for repair unless you originally purchased your unit from the factory. If your unit was purchased through a Dealer or OEM vendor, and you desire factory repair, then the entire terminal must be returned.

2. The name and location of the Dealer and/or Agent from whom the unit was purchased.

3. A complete description of the alleged failure (including the nature and cause of the failure if readily available).

The Customer Services Department will issue you a Return Material Authorization Number (RMA Number) which will be valid for a period of 30 days. This RMA Number will be your official authorization to return equipment to IDSC for repair only. The Customer Services Department will also give you an estimate, if requested, of the time it should take to process and repair your equipment. Turnaround time on repairs varies depending on workloads and availability of parts, but normally your equipment will be repaired and returned to you within 10 working days of its receipt. If your repair is urgent, you may authorize a special $50 Emergency Repair fee and have your equipment repaired and returned within no more than 48 hours of its receipt at our Service Center. Ask the Customer Services Department for more information about this program.

SERVICING PROCEDURES (continued)

IMPORTANT: Any equipment returned to Intertec without an RMA Number will result in the equipment being refused and possible cancellation of your SuperBrain II warranty. Also if your RMA Number expires, you must request a new number. Equipment arriving at Intertec bearing an expired RMA Number will also be refused.

After securing an RMA Number from the Customer Services Department, return the specified modules and/or complete terminals to Intertec, freight prepaid, at the address below. **NOTE: The RMA Number must be plainly marked and visible on your shipping label to prevent the equipment from being refused at Intertec's Receiving Department.**

ATTN: SUPERBRAIN SERVICE CENTER
Intertec Data Systems Corporation
2300 Broad River Road
Columbia, South Carolina 29210

To aid our technicians in troubleshooting and correcting your reported malfunction, please complete an Intertec Equipment Malfunction Report (contained in this section) and enclose it with the equipment you intend to return to the factory.

Be sure a declared value equal to the price of the unit is shown on the Bill of Lading, Express Receipt or Air Freight Bill, whichever is applicable. Risk of loss or damage to equipment during the time it is in transit either to or from Intertec's facilities is your sole responsibility. A declared value must be placed on your Bill of Lading to insure substantiation of your freight claim if shipping damage or loss is incurred.

All equipment returned to an Intertec Service Center must be freight prepaid. Equipment not prepaid on arrival at Intertec's Receiving Department cannot be accepted. Upon repair of equipment under warranty, it will be returned to you freight prepaid, via UPS or equivalent ground transportation. All repaired equipment not covered by warranty will be returned, F.O.B. the factory in Columbia, South Carolina, via UPS or equivalent ground transportation unless you specify otherwise.

INSTRUCTIONS FOR HANDLING LOST OR DAMAGED EQUIPMENT

The goods described on your Packing Slip were delivered to the Transportation Company at Intertec's premises in complete and good condition. If any of the goods called for on this Packing Slip are short or damaged, you must file a claim WITH THE TRANSPORTATION COMPANY FOR THE AMOUNT OF THE DAMAGE AND/OR LOSS.

IF LOSS OR DAMAGE IS EVIDENT AT TIME OF DELIVERY:

If any of the goods called for on your Packing Slip are short or damaged at the time of delivery, ACCEPT THEM, **but insist that the Freight Agent make a damaged or short notation on your Freight Bill or Express Receipt and sign it.**

IF DAMAGE OR LOSS IS CONCEALED AND DISCOVERED AT A LATER DATE:

If any concealed loss or damage is discovered, notify your local Freight Agent or Express Agent AT ONCE and request him to make an inspection. This is absolutely necessary. Unless you do this, the Transportation Company will not consider your claim for loss or damage valid. If the agent refuses to make an inspection, you should draw up an affidavit to the effect that you notified him on a certain date and that he failed to make the necessary inspection.

SERVICING PROCEDURES (continued)

After you have ascertained the extent of the loss or damage, **ORDER THE REPLACEMENT PARTS OR COMPLETE NEW UNITS FROM THE FACTORY.** We will ship them to you **and bill you for the cost.** This new invoice will then be a part of your claim for reimbursement from the Transportation Company. This, together with other papers, will properly support your claim.

IMPORTANT: The claims adjustment procedure for UPS shipments varies somewhat from the procedure listed above for regular motor and air freight shipments. *If your equipment was shipped via UPS and sustained either damage or loss, the UPS representative in your area* **must** *initiate the claim by inspecting the goods and assigning a freight claim number to the damaged equipment.* The representative will attach a "Call Tag" to the outside of the equipment box which will be your authorization to return the merchandise to our factory for claim adjustment. Upon receipt of this damaged equipment, we will perform the necessary repairs, process the appropriate paperwork with UPS and return the equipment to you. Please allow time for processing of any type claim. Normal time for proper processing of a UPS claim is 15-30 working days.

Remember, it is extremely important that you **do not give the Transportation Company a clear receipt if damage or shortages are evident upon delivery.** It is equally important that you call for an inspection if the loss or damage is discovered later. **DO NOT, UNDER ANY CIRCUMSTANCES, ORDER THE TRANSPORTATION COMPANY TO RETURN SHIPMENT TO OUR FACTORY OR REFUSE SHIPMENT UNLESS WE HAVE AUTHORIZED SUCH RETURN.**

ADDITIONAL TECHNICAL DOCUMENTATION

Detailed technical documentation (i.e., schematics) describing the operation of the SuperBrain II Video Terminal and the electrical interconnection of its various modules is available at nominal cost directly from Intertec Data Systems Corporation. However, due to the confidentiality of this technical information, it will be necessary to sign and return the Documentation Non-Disclosure Agreement (appearing on the next page) denoting your concurrence with its terms and conditions.

The handling and processing costs of SuperBrain II technical documentation is $50. Due to the large amount of requests being processed and the relatively small handling costs involved, *we* **must** *request that you* **enclose payment** *($50) upon return of your Non-Disclosure Agreement.* Normally the documents will be mailed to you within 15 to 30 days after receipt of your payment and a signed copy of the Agreement. (IMPORTANT: The technical documentation will be mailed to the address listed at the top of the Non-Disclosure Agreement.) For prompt processing of your documentation request, please forward your signed agreement and payment to:

Customer Services Department
Intertec Data Systems Corporation
2300 Broad River Road
Columbia, South Carolina 29210

NOTE: Formal technical documentation for the SuperBrain II will be sent to you normally within 10-15 days of receipt of your payment and signed Non-Disclosure Agreement.

IMPORTANT: *Payment* **must** *accompany your Non-Disclosure Agreement. Agreements sent to us without payment will be discarded without notice.*

INTERTEC DATA SYSTEMS

SUPERBRAIN II DOCUMENTATION NON-DISCLOSURE AGREEMENT

IDS-350B

®Corporate Headquarters: 2300 Broad River Road, Columbia, South Carolina 29210 • 803/798-9100 • TWX: 810-666-2115

THIS AGREEMENT MADE BETWEEN INTERTEC DATA SYSTEMS CORPORATION AND THE ORGANIZATION AND/OR PERSONS LISTED AT THE RIGHT AND BECOMES EFFECTIVE ON THE DATE SPECIFIED BELOW.

(PLEASE PRINT CLEARLY. DOCUMENTS WILL BE MAILED TO THE ADDRESS AT RIGHT)

YOUR COMPANY NAME ______________________

ADDRESS ______________________

CITY & STATE ______________________

TELEPHONE ______________________

YOUR NAME ______________________

For and in consideration of receiving confidential documentation on the SuperBrain II™ line of terminals manufactured by INTERTEC DATA SYSTEMS CORPORATION (hereinafter called INTERTEC) at the date hereof, the undersigned hereby agrees with INTERTEC as follows:

(1) The undersigned acknowleges that formulae, programs, manufacturing processes, devices, techniques, plans, methods, drawings, blueprints, reproductions, data tables, calculations and components were designed and developed by INTERTEC at great expense and over lengthy periods of time, and the same are secret and confidential, are unique and constitute the exclusive property and trade secrets of INTERTEC, and that any use of such property and trade secrets by the undersigned other than for the sole benefit of INTERTEC would be wrongful, tortiuous and would cause irreparable injury to INTERTEC.

(2) The undersigned shall not at any time, without the express written consent of the Board of Directors of INTERTEC, publish, disclose, use or divulge to any person, firm or corporation, directly or indirectly, or use for his own benefit or the benefit of any person, firm, or use other than to effect repair of INTERTEC manufacturing equipment, and property above described, trade secrets or confidential information of INTERTEC, its subsidiaries and its affiliates learned or obtained by its subsidiaries and its affiliates learned or obtained by him from INTERTEC, including, but not limited to the information and things set forth in paragraph 1 hereinabove.

(3) This agreement shall be binding upon the undersigned, his personal representatives, successors and assigns, and shall run to the benefit of INTERTEC, its successors and assigns.

(4) Upon termination of the association of the undersigned with INTERTEC or its subsidiaries, the undersigned shall promptly deliver to INTERTEC all drawings, blueprints, reproductions, manuals, letters, notes, notebooks, reports, data, tables, calculations or copies thereof, components, programs, and any and all other secret and confidential property of INTERTEC, its subsidiaries and affiliates, including, but not limited to, all of the property set forth in paragraph 1 hereinabove which are in the possession or under the control of the undersigned.

(5) The undersigned hereby acknowledges and agrees that in the event of any violation hereof, INTERTEC shall be authorized and entitled to obtain from any court of competent jurisdiction preliminary and permanent injunctive relief as well as equitable accounting of all profits or benefits arising out of such violation which rights or remedies shall be cumulative and in addition to any rights or remedies to which INTERTEC may be entitled and that the undersigned shall further be directly liable for any and all reasonable attorney's fees incurred by INTERTEC to enforce this Agreement against the undersigned in a court of law.

(6) The foregoing understanding shall apply to any subsequent meeting and/or communications between INTERTEC and the above mentioned organization relating to the same subject manner, unless modified in writing as to any such subsequent meetings and/or communications.

We would appreciate your signing and returning to us, prior to the release of INTERTEC product documentation, the original copy of this agreement denoting your concurrence with the foregoing provisions.

AGREED TO: ______________________

(YOUR NAME OR COMPANY - PLEASE PRINT)

YOUR SIGNATURE: ______________________

In addition to the terms listed above, I further certify that I am duly authorized to sign this document on behalf of the organization and/or persons requesting that this imformation be supplied by INTERTEC.

YOUR NAME: ______________________

YOUR TITLE: ______________________

TODAY'S DATE: ______________________

INTERTEC DATA SYSTEMS CORPORATION

SIGNATURE: ______________________

FOR OFFICE USE ONLY

DATE RCV'D ________ PROCESSED BY: ________

OTHER RELEASES	DATE	INVOICE NO.

INTERTEC DATA SYSTEMS
® Corporate Headquarters: 2300 Broad River Road, Columbia, South Carolina 29210 • 803/798-9100 • TWX: 810-666-2115

BE SURE TO INCLUDE YOUR SERIAL NUMBER HERE.
SERIAL NO. ____________

SUPERBRAIN II LIMITED WARRANTY REGISTRATION FORM

IMPORTANT: This form should be completed within ten days of receipt of your SuperBrain II Video Computer System and returned to Intertec at the following address:

Intertec Data Systems Corporation
2300 Broad River Road
Columbia, South Carolina 29210

Attn: Warranty Registration Department

All warranty liability is limited to that expressed in most recent edition of the SuperBrain II Video Computer User's Manual as published by Intertec Data Systems Corporation.

****

Date Received: ____________	Purchased from: ____________
Company: ____________	____________
Name: ____________	Address ____________
Title: ____________	City: ____________
Address ____________	Telephone: ( ) ____________
City: ____________	Sales Agent: ____________
Country: ____________	Order Placed On: ____________
Telephone: ( ) ____________	Price Paid: ____________

****

Where did you first hear about the SuperBrain? From a ☐ Magazine ☐ Dealer ☐ Friend

____

Why did you decide to purchase the SuperBrain? ☐ Features ☐ Price ☐ Appearance

____

____

Was the Dealer and/or Sales Agent knowlegeable about the SuperBrain? ☐ YES ☐ NO

Please explain.

____

____

____

Questions on the reverse side must be completed to validate your warranty

Were you introduced to any other Intertec products? ☐ YES ☐NO (if yes, please indicate other products which were mentioned.)____________________

Are you aware of other Intertec products? ☐ YES ☐ NO (If yes, which ones?)

What other microcumputer related products will you be purchasing in the next 12 months?

☐ Video Terminals ☐ Printers (matrix) ☐ Printers (character) ☐ Disk Systems ☐ Other

What is your application for the SuperBrain? ☐ Business ☐ Scientific ☐ Educational ☐ Other

What are your comments in general concerning the overall operation of the SuperBrain?

☐ Outstanding ☐ Excellent ☐ Good ☐ Average ☐ Unsatisfactory

Would you like to be placed on our mailing lists? ☐ YES ☐ NO

May we use your name as a favorable reference for other customers in your area desiring to purchase a SuperBrain? ☐ YES ☐ NO

Thank you for purchasing the SuperBrain II Video Computer System. If we may be of further assistance to you, please contact our Customer Service Department at the address on the reverse side of this form.

INTERTEC DATA SYSTEMS
® Corporate Headquarters: 2300 Broad River Road, Columbia, South Carolina 29210 • 803/798-9100 • TWX: 810-666-2115

EQUIPMENT MALFUNCTION REPORT

IDS - 505A

THIS EQUIPMENT PURCHASED FROM: ______________________________

Dealer Name: ______________________ Address ______________________

City & State______________________ Telephone Area ( ) ______________

Dear Customer:

We are trying to manufacture the most reliable product possible. You would do us a great courtesy by completing this form should you experience any failures. Enclose this form with the equipment you intend to return to the dealer or factory for service. (Additional copies of this form available upon request.)

1. Type Unit ______________________ Serial No.______________

   Module (if applicable) ______________________

2. Component failed (if available, include Name and Number) ______________

3. Description of failure (include cause of failure if readily available) ______________

   ____

   ____

   ____

4. Approximate hours/days of operation to failure ______________

5. Failure occurred during:

   ☐ Initial Inspection ☐ Customer Installation ☐ Field Use

6. Personal Comment:

   ____

   ____

   ____

Your Name ______________________ Address ______________________

City & State______________ Zip______________ Phone( ) ______________

Date ______________ Signed ______________________

Return this form and equipment to your local dealer or to the factory at the address below.

ATTN: SUPERBRAIN SERVICE CENTER
Intertec Data Systems Corporation
2300 Broad River Road
Columbia, South Carolina 29210

APPENDIX J-2

GENERAL INFORMATION FOR SUPERBRAIN II USERS

INTERTEC DATA SYSTEMS
® Corporate Headquarters: 2300 Broad River Road, Columbia, South Carolina 29210 • 803/798-9100 • TWX: 810-666-2115

CUSTOMER COMMENT CARD

Our past and present customers are directly responsible for the evolution of the SuperBrain as you see it presented in this manual. Before Intertec began research and development on the SuperBrain, an extensive user survey was conducted to ascertain optimum video computer price/performance ratios to enable us to capture a major portion of the video computer market. In order that we continue with our commitment to excellence in engineering, production and marketing, we would appreciate your comments below regarding your overall opinion of the SuperBrain. All comments are given careful consideration in future product design and become the property of Intertec Data Corporation.

(1) What are your comments concerning the overall appearance of the SuperBrain? (You may want to comment on color, size and construction.)

____

____

____

____

(2) What are your comments (in general) concerning the overall operation of the unit?

____

____

____

____

(3) What features about the unit do you like best?

____

____

____

____

(4) What features about the unit do you like least?

____

____

____

____

Please see additional questions on the reverse side

(5) Briefly describe your application for the SuperBrain.

____

____

____

____

(6) What other microcomputer systems do you feel are comparable to the SuperBrain in both price and performance?

____

____

____

____

(7) What changes and/or modifications to the SuperBrain could be made to render it more suited to your application?

____

____

____

____

(8) Your candid comments regarding the operation of and application for the SuperBrain are greatly appreciated. Address your comments and/or suggestions to:

PRODUCT SERVICES MANAGER
Intertec Data Systems
2300 Broad River Road
Columbia, South Carolina 29210

(9) If you desire to be contacted by our service, marketing or technical staff regarding these comments, please give us your complete name, address and phone number below. (This information is optional.)

Company Name______________________________

Address ______________________________

City, State & Zip______________________________

Contact: ______________________________

Phone: AREA (   )______________________ EXT __________

I would like to be contacted by your: ☐ Marketing ☐ Technical ☐ Service Department

INTERTEC DATA SYSTEMS

DOCUMENT REVIEW FORM

®Corporate Headquarters: 2300 Broad River Road, Columbia, South Carolina 29210 • 803/798-9100 • TWX: 810-666-2115

In order to insure that you are provided with a document that will satisfy all of your information requirements as well as one that is error free and easy to use, we would like to ask you to supply us with any comments, suggestions, or errors you have found. The space below is provided for this input. Return the completed form to:

ATTN: TECHNICAL SERVICES MANAGER
Intertec Data Systems Corporation
2300 Broad River Road
Columbia, South Carolina 29210

STATEMENT OF LIMITED WARRANTY

For ninety (90) days from the date of shipment from our manufacturing plant at 2300 Broad River Road, Columbia, South Carolina, Intertec warrants, to the original purchaser only, that its products, excluding software products, will be free of defective parts or components and agrees to replace or repair any defective component which, in Intertec's judgement, shall disclose to have been originally defective. Intertec neither offers nor implies any warranty whatsoever on any software products. Furthermore, Intertec's obligations under this limited warranty are subject to the following conditions:

LIMITED WARRANTY REPAIRS

Unless authorized by written statement from Intertec, all repairs must be done by Intertec at our plant in Columbia, South Carolina. Return of any and all parts and/or equipment must be freight prepaid and accompanied by an Intertec Return Material Authorization number which must be clearly visible on the customer's shipping label. Return of parts or equipment contrary to this policy shall result in the material being refused, and the customer being invoiced for any replacement parts, if any were previously issued, at Intertec's standard prices.

When making repairs or replacing parts in accordance with this limited warranty, Intertec reserves the right to alter and/or modify specifications of this equipment.

Upon completion of the repairs, Intertec will return the equipment, freight prepaid, directly to the customer from whom it was sent via UPS or equivalent ground transportation.

Authorization to return equipment for repair can be obtained by writing Intertec at the address stated herein or by calling our Customer Service Department at 803/798-9100.

In the event Intertec shall authorize repair of its equipment, in writing, by an authorized repair agent, then Customer shall bear all shipping, packing, inspection and insurance costs necessary to effectuate repairs under this warranty.

EXCLUSIONS

The Limited Warranty provided by Intertec Data Systems Corporation does hot include:

(a) Any damage or defect caused by injuries received in shipment or any damage caused by unauthorized repairs or adjustments. The risk of loss or damage to the equipment shall pass to the Customer upon delivery by Intertec to the carrier at Intertec's premises.

(b) Repair, damage or increase in service time caused by failure to continually provide a suitable installation environment including, but not limited to, the failure to provide, or the failure of, adequate electrical power, air-conditioning, or humidity control.

(c) Repair, damage or increase in service time caused by accident or disaster, which shall include, but not be limited to, fire, flood, water, wind, lightning, transportation neglect, misuse and alterations, which shall include, but not be limited to, any deviation from the original physical, mechanical or electrical design of the product.

(d) Any statements made about the equipment by salesman, dealers or agents unless such statements are in a written document signed by an officer of Intertec Data Systems Corporation. Such statements do not constitute warranties, shall not be relied on by the buyer, and are not part of the contract for sale.

(e) Any damage arising out of any application for its products other than for normal commercial and industrial use, unless such application is, upon request, specifically approved in writing by Intertec. Intertec products are sophisticated data processing units and are not sold or distributed for personal, family or household purposes.

This Class A equipment generates, uses, and can radiate radio frequency energy and if not installed and used in accordance with the instructions manual, may cause interference to radio communications. As temporarily permitted by regulation it has not been tested for compliance with the limits for Class A computing devices pursuant to Subpart I of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference. Operation of this equipment in a residential area is likely to cause interference in which case the user at his own expense will be required to take whatever measures may be required to correct the interference.

(f) Software, including either source code, object code, or any computer program used in connection with our equipment, whether purchased directly from Intertec or from an independent source.

WAIVER OF ALL EXPRESS OR IMPLIED WARRANTIES

Our limited warranty to repair or replace defective parts or components for ninety (90) days after date of shipment from our Columbia plant is being offered in lieu of all express or implied warranties.

INTERTEC MAKES NO EXPRESS WARRANTY OTHER THAN THE LIMITED WARRANTY SET FORTH ABOVE, CONCERNING THIS PRODUCT OR ITS COMPONENTS, NOR DO WE IMPLIEDLY WARRANT ITS MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

All statements, technical information and recommendations contained in this document and related documents are based on tests we believe to be reliable, but the accuracy or completeness thereof is not guaranteed.

THE FOREGOING LIMITED WARRANTIES ARE IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, EXCEPT AS TO CONSUMER GOODS IN WHICH CASE THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE APPLY ONLY FOR THE PERIOD OF THE LIMITED WARRANTY.

PURCHASERS OF CONSUMER PRODUCTS SHOULD NOTE THAT SOME STATES DO NOT ALLOW FOR THE EXCLUSION OF CONSEQUENTIAL DAMAGES OR THE LIMITATION OR THE DURATION OF IMPLIED WARRANTIES SO THE ABOVE EXCLUSION AND LIMITATION MAY NOT BE APPLICABLE.

THIS LIMITED WARRANTY GIVES THE PURCHASER SPECIFIC LEGAL RIGHTS, AND THE PURCHASER MAY ALSO HAVE OTHER RIGHTS WHICH MAY VARY FROM STATE TO STATE.

LIMITATION OF REMEDIES

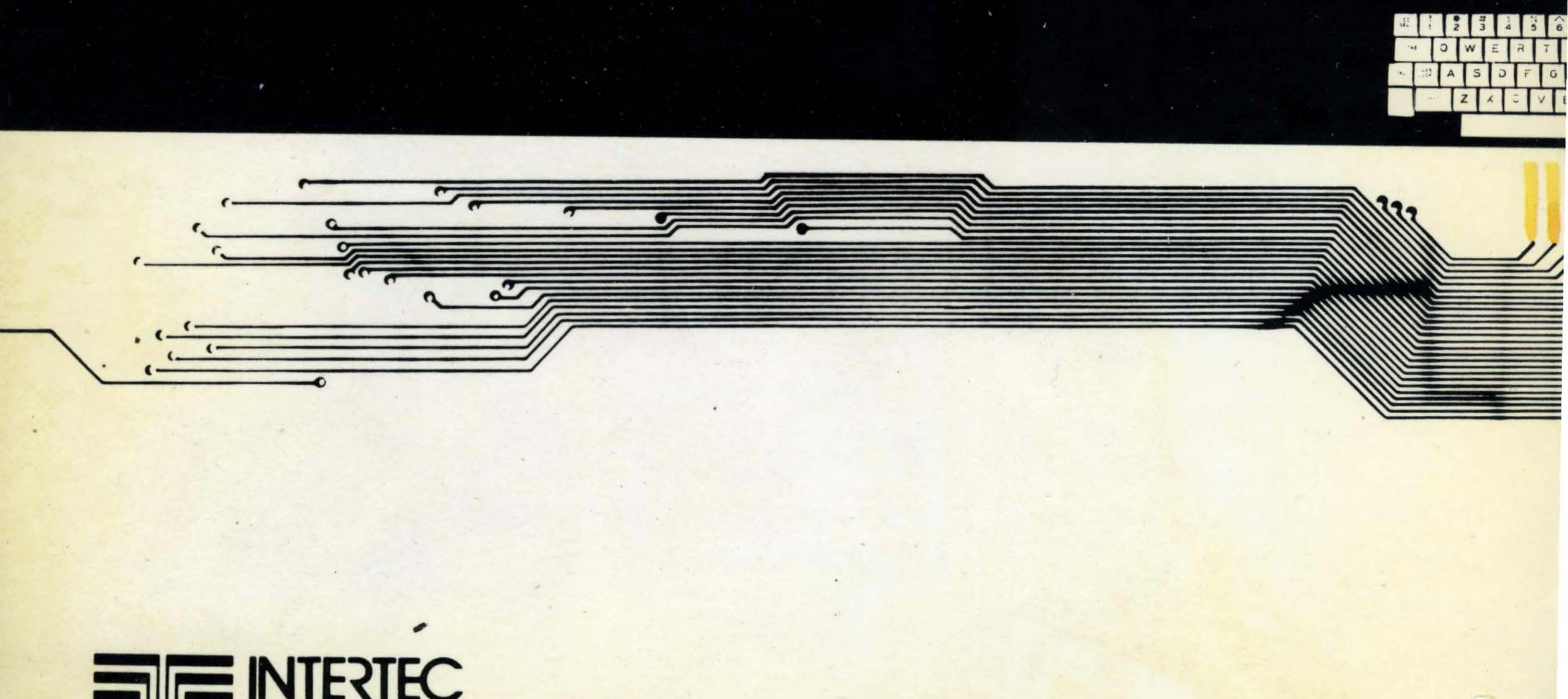
INTERTEC SHALL NOT BE LIABLE FOR ANY INJURY, LOSS OR DAMAGE, DIRECT OR CONSEQUENTIAL, TO PERSONS OR PROPERTY CAUSED EITHER DIRECTLY OR INDIRECTLY BY THE USE OR INABILITY TO USE ITS PRODUCT AND/OR DOCUMENTS. SUCH LIMITATION IN LIABILITY SHALL REMAIN IN FULL FORCE AND EFFECT EVEN WHEN INTERTEC MAY HAVE BEEN ADVISED OF THE POSSIBILITY OF SUCH INJURIES, LOSSES OR DAMAGES.

Before purchasing or using, the Customer shall determine the suitability of Intertec's products and documents for his intended use and assumes all risk and liability whatsoever in connection therewith.

THE LIMITED WARRANTY TO REPLACE OR REPAIR PARTS OR COMPONENTS FOR (90) DAYS IS THE EXCLUSIVE REMEDY PROVIDED TO THE CUSTOMER AND THE LIABILITY OF INTERTEC WITH RESPECT TO ANY OTHER CONTRACT, SALE OR ANYTHING DONE IN CONNECTION THEREWITH, WHETHER IN CONTRACT, IN TORT, UNDER ANY WARRANTY, OR OTHERWISE, SHALL NOT EXCEED THE PRICE OF THE PART OR COMPONENT ON WHICH SUCH LIABILITY IS BASED.

Rights under this warranty are not assignable without the express prior consent, in writing, of Intertec Data Systems Corporation and, regarding the terms of such consent in writing, such assignee shall have no greater rights than his assignor.

In the event the Customer has any problem or complaints arising out of any breach of our limited warranty, including a failure to make repairs in accordance with this warranty, or unsuccessful repair attempts by an authorized repair facility, the Customer is encouraged to inform Intertec, in writing, of his or her problem or complaint. Any such writing should be addressed to Intertec Data Systems Corporation at 2300 Broad River Road, Columbia, South Carolina 29210, and should be marked with the phrase "Warranty Claim."



INTERTEC DATA SYSTEMS®

CORPORATE HEADQUARTERS • 2300 BROAD RIVER ROAD • COLUMBIA, SOUTH CAROLINA 29210 • 803/798-9100