CP/M System Alteration Guide

for IMSAI CP/M Version 1.31

Contents

Copyright 1976 IMSAI Manufacturing Corporation
14860 Wicks Boulevard
San Leandro, California 94577
Made in the U. S. A.
All rights reserved worldwide.

IMSAI notes on CP/M System Alteration Guide

PREFACE

The Digital Research CP/M System Alteration Guide is written for those who must convert CP/M to support their peripherals before using it on their systems. Since IMSAI CP/M is supplied ready-to-run with standard IMSAI peripherals, most users will not need to read the Alteration Guide. It will, however, be of interest to those who wish to alter or add I/O drivers, and those who wish to increase their understanding of the workings of CP/M.

The following section contains notes about the differences in the IMSAI CP/M; its sections are intended to be read concurrently with the same numbered sections of the Digital Research CP/M System Alteration Guide.

IMSAI Notes on CP/M System Alteration Guide

1. Introduction

IMSAI CP/M has already been modified to work with the standard IMSAI peripherals. Further alteration will be required only if different or additional devices are to be supported.

The next two paragraphs describe the basic differences in memory and diskette organization in the IMSAI system, as these each relate to several sections of the Alteration Guide.

1.1 Memory Organization

In a 16k IMSAI CP/M system of version 1.31 or newer, the BIOS, BDOS, and CCP start at addresses 100H lower than as stated by Digital Research. The whole system is 100H bytes larger, with the added space being in the BIOS. For systems created with the CPM command for larger memories, the addresses increase by 400H for each additional K.

1.2 Diskette Organization

IMSAI CP/M diskettes have a two-sector bootstrap and initialization routine written on sectors 1 and 2 of track 0. The system itself begins at sector 3 of track 1 and is two sectors longer, extending through sector 24 of track 1.

3. Second Level System Generation

IMSAI SYSGEN version 1.31 puts the image of tracks 0 and 1 into the TPA starting at 700H (BOOT routine) with the CCP starting at 800H, the BDOS, at 1100H, and the BIOS, at 1D00H. These addresses are an even 2000H less than those at which a 16K system runs, simplifying a lot of the arithmetic described in the System Alteration Guide.

Source code for two sections of the system, BOOT and BIOS, is supplied on the distribution diskette. If you wish to modify either of these, edit and reassemble them as you would any program. Once this has been done, we suggest the following procedure for creating the modified system:

```
DDT SYSGEN.COM              Load SYSGEN under DDT

G103                        Start SYSGEN -
                    note special start address

GET SYSTEM (Y-N) Y
SOURCE ON A, TYPE RETURN
PUT SYSTEM (Y-N) N
                    System from disk A is now in RAM.

IBIOS.HEX                   If it is desired
RE000                       to replace the BIOS.


IBOOT.HEX                   If it is desired
R700                        to replace BOOT.


G103                        Start SYSGEN again
GET SYSTEM (Y-N) N
PUT SYSTEM (Y-N) Y
DESTINATION ON B, TYPE RETURN
                    System from RAM is now on disk in B
```

The above leaves the old system running and the new system on the diskette in drive B. To run the new system, move the diskette to drive A and bootstrap from it.

The above is for a 16K system. For other memory sizes, first create a system of the desired size with the CPM command and SYSGEN it onto a diskette. Then use a procedure such as the above to incorporate your modified BOOT and/or BIOS into the relocated system. The modified BOOT or BIOS must be assembled for the memory size in which it is to run (assembly parameter MEMT in the current versions). The load bias remains 700H for boot but increases 400H for each addtional K for BIOS.

If you wish to make small alterations only in BIOS or BOOT, or are testing or debugging, minor changes can be made by patching with DDT. The procedure is as shown above, except the alterations are made with the A and/or S commands rather than by loading a file. The same biases are used to translate the addresses shown in the listings to the addresses to be used with the DDT commands.

5. Diskette Organization

See section 1.2.

9. Reserved Locations in Page Zero

As described, plus:

0004H	Contains the drive number of the currently logged disk
0038H-003AH	Are defaulted to a jump to IMSAI BIOS' "NXM" routine (see section 11) but may be changed by program. Note, however, that programs using RST 7 will be impossible to debug with DDT.
0040H-004FH	ARE used by IMSAI BIOS and should NOT be changed by program.

10. The IMSAI BOOT

BOOT resides on sectors 1 and 2 of each CP/M system diskette. BOOT's function is to load and initialize the rest of the system. The source code for BOOT is on file BOOT.ASM on the distribution diskette and a listing is given in the appendix. The programs MBOOT and LBOOT, described in the System Alteration Guide, are not used in IMSAI CP/M.

At either a cold or a warm start, track 0, sector 1 is read into RAM at location 0 and given control. This sector contains the first half of BOOT, which procedes to read the rest of BOOT from track 0, sector 2 to location 80H, then read successive sectors to locations 2800H (in a 16K system) and up until the entire CCP, BDOS, and BIOS have been loaded.

If a disk error occurs during this bootstrap operation, BOOT displays the error code returned by the floppy disk interface in the lights, restores the drive, then retries the operation indefinitely.

After the system has been loaded, BOOT performs system initialization. Both channels of a SIO serial interface board are initialized, so that two terminals may be used on the system. The IMSAI line printer interface (LIF) is initialized. A PIC-8 board, if present, is initialized such that only interrupt 7 will be responded to. (Interrupts are not used by CP/M. This initialization was chosen for the convenience of the user who wishes to use interrupt 7 for RAM-4A memory write protect violation.) The various JMP's required in page 0 are set up. A JMP is also put at 38H to the "NXM" entry point of the IMSAI BIOS. The IOBYTE is set from the switches on a cold start or to its previous value on a warm restart. The sign-on message, whose text is in the BIOS, is printed.

After system initialization, BOOT transfers control to BIOS+0 on a cold start, or BIOS+30H on a warm restart.

11. The IMSAI BIOS

The IMSAI Basic Input-Output System's source code is on file BIOS.ASM on the distribution diskette and a listing is given in the appendix.

The IMSAI BIOS is 100H bytes longer than Digital Research's BIOS and contains considerable space for user additions.

The IMSAI BIOS generally performs the functions described in the System Alteration Guide. The entry vector is located at 3D00H rather than 3E00H in a 16k system. There are two addtional entry points. The first gets control upon completion of a warm reboot and currently JMP's directly to the CCP. The second is the entry to the "NXM" routine.

The NXM routine receives control if a program JMP's to a non-existent memory address or executes an RST 7 without setting up its own JMP at 38H. When this occurs, the BIOS types

```
CRASH pppp mm
```

where pppp is the contents of the top of the stack and mm is the contents of memory location pppp-1. If the fault causing the CRASH typeout was the exection of an RST 7, pppp would be its location, plus 1, and mm would be FF. After the CRASH typeout, the system is rebooted.

The CRASH typeout will also occur if a level 7 interrupt comes from any device, and may be used to indicate a write protect violation on RAM-4A memory boards.

The IOBYTE function is implemented as described, except that a line printer driver is included but drivers for fast paper tape reader and punch are not included.

Disk errors are handled as follows:

"Not Ready" Errors:
Are retried indefinitely, so the system waits if no diskette is present in the drive being accessed.

All Other Errors:
The code returned by the floppy disk interface is displayed in the lights (and remains until another error or until another program uses the lights), the drive is restored, then the operation is retried. After 15 failures, an error return is given to the BDOS which types

```
PERMANENT ERROR DRIVE n
```

then awaits input. If a control-C is typed, the system is rebooted; any other character causes the error to be ignored.

The warm boot entry to the BIOS recieves control from the JMP at BOOT (0). This entry reads the first sector of the BOOT program to location 0, then JMP's to 3 with the current IOBYTE and logged disk values in registers.

In the IMSAI BIOS the drivers for devices "TTY:" and "CRT:" are identical except for the port accessed and one other difference: The "CRT:" driver translates the ASCII code for underscore to rubout. This is a convenience for users with Lear-Siegler ADM-3 terminals, as it eliminates the need to use the shift key when correcting input. Users with other terminals may want to remove this "feature"; the necessary change to BIOS should be evident from the comments in the listing.

Procedures were given above for incorporating a modified BIOS into the system. If you wish to make additions that require more space than is available, another two sectors (100H bytes) are available on track 1 of the disk. To use an enlarged BIOS, you must have the additional RAM above the top of the system and make the following additional changes: increase the assembly parameter LSTDMA in BOOT to cause additional sectors to be read; increase MEMT in SYSGEN (keeping SYSBOTTOM the same); and increase the number of pages specified in any GET and SAVE commands used with system images.

DIGITAL RESEARCH
Post Office Box 579
Pacific Grove, California 93950

CP/M SYSTEM ALTERATION GUIDE

Table of Contents

CP/M System Alteration Guide

1. INTRODUCTION

The standard CP/M system assumes operation on an Intel MDS microcomputer development system, but is designed so that the user can alter a specific set of subroutines which define the hardware operating enviornment. In this way, the user can produce a diskette which operates with a non-standard (but IBM-compatible format) drive controller and/or peripheral devices.

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 the new BIOS into CP/M.

The new BIOS requires some relatively simple software development and testing; the current BIOS, however, is listed in Appendix C, and can be used as a model for the customized package. A skeletal version of the BIOS is given in Appendix D which can form the base 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 is usually 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 E. In order to make the CP/M system work automatically, the user must also supply a cold start loader, similar to the one provided wi CP/M (listed in Appendices A and B). A skeletal form of a cold start loader is given in Appendix F which can serve as a model for your loader.

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 16K 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 - 16K. Values for b in various standard memory sizes are

```
32K:        b = 32K - 16K = 16K = 04000H
```

48K·	b = 48K - 16K = 32K = 08000H
62K:	b = 62K - 16K = 46K = 0B800H
64K:	b = 64K - 16K = 48K = 0C000H

(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 2880H+b. Code GETSYS so that it starts at location 100H (base of the TPA), as shown in the first part of Appendix E.

(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 2880H+b (the operating system actually starts 128 bytes later at 2900H+b).

(4) Review Section 4 and write the PUTSYS program which writes memory starting at 2880H+b 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 E.

(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 C, and write a simple version which performs a similar function for the customized environment. Use the program given in Appendix D 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 distruction of the initialized CP/M system after it is patched.

(8) Referring to Figure 1 in Section 5, note that the BIOS is located between locations 3E00H+b and 3FFFH+b. 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 2880H+b, and check to ensure that it has loaded back properly (clear memory, if possible, before the load). Upon successful load, branch to the CCP module at location 2900H+b. The CCP will call the BDOS, which will call the CBIOS. The CBIOS will be asked to read several sectors on track 2 twice in succession, and, if successful, CP/M will type "A>".

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

```
X       COM
```

(13) Test the erase command by typing

```
ERA X.COM
```

CP/M should respond with the A prompt. When you make it this far, you have an operational system which only requires a bootstrap loader to function completely.

(14) Write a bootstrap loader which is similar to GETSYS, and place it into read-only-memory, or into track 0, 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

™ 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 when the diskette is removed and replaced
> by another diskette, unless the new diskette is read-only.

(18) Load and test the debugger by typing

```
DDT
```

(see the document "CP/M Dynamic Debugging Tool (DDT)" for operating information and examples). Take time to familiarize yourself 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

Copyright (c) 1976
Digital Research

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 second drive, if it exists on your system. 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. If you wish, you may send you name and address to Digital Research, along with a description of your hardware environment and the modifications which you have made. Digital Research will make the information available to other interested parties, and inform them of the prices and availability of your CBIOS.

It should be noted that your system remains file-compatible with all other CP/M systems, 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 may wish to use CP/M facilities in the system regeneration process. In general, we will first get a memory image of CP/M from the first two tracks of an initialized diskette and place this memory image into a named disk file. The disk file can then be loaded, examined, patched, and replaced using the editor, assembler, debugger, and system generation program.

The SYSGEN program, supplied with your diskette, is first used to get a CP/M memory image from the first two tracks. Run the SYSGEN program as shown below

```
SYSGEN                              start the SYSGEN program
*SYSGEN VERSION 1.Ø                 SYSGEN signon message
GET SYSTEM (Y/N)?Y                  Answer yes to GET request
SOURCE ON B, THEN TYPE RETURN
```

at this point, place an initialized diskette into drive B and type a return (if you are operating with a single drive, answer "A" to the GET request, rather than "Y", and place the initialized diskette into drive A before typing the return). The program should respond with:

```
FUNCTION COMPLETE                   Load is complete
PUT SYSTEM (Y/N)?N                  Answer no to PUT request
```

system will automatically reboot at this point, with the memory image loaded into memory starting at location 9ØØH and ending at 2Ø7FH in the transient program area. The memory image for CP/M can then be saved (if you are operating with a single drive, replace your original diskette and reboot). The save operation is accomplished by typing:

```
SAVE 32 CPM.COM                     Save 2ØH = 32 pages of memory
```

The memory image created by the GET function 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 CPM.COM                        Load DDT, then read the CPM
image
```

DDT should respond with

```
            NEXT  PC
            2100  0100
```

You can then use the display and disassembly commands to examine portions of the memory image between 900H and 207FH. 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 16K system, for example, the CCP resides at the CP/M address 2900H, but is placed into memory at 980H by the SYSGEN program. Thus, the negative bias,denoted by n, satisfies

2900H + n = 980H, or n = 980H - 2900H

Assuming two's complement arithmetic, n = 0E080H, which can be checked by

2900H + 0E080H = 10980H = 0980H (ignoring high-order overflow).

Note that for larger systems, n satisfies

(2900H+b) + n = 980H, or
n = 980H - (2900H + b), or
n = 0E080H - b.

The value of n for common CP/M systems is given below

memory size	bias b	negative offset n
16K	0000H	0E080H - 0000H = 0E080H
32K	4000H	0E080H - 4000H = 0A080H
48K	8000H	0E080H - 8000H = 6080H
62K	0B800H	0E080H - 0B800H = 2880H
64K	0C000H	0E080H - 0C000H = 2080H

Assume, for example, that you want to locate the address x within the memory image loaded under DDT in a 16K 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

```
            H2900,E080
```

for example, will produce 98ØH as the sum, which is where the CCP is located in the memory image under DDT.

Use the L command to disassemble portions of your CBIOS located at (3EØØH+b)-n which, when you use the H command, produces an actual address of 1E8ØH. The disassembly command would thus be

```
            L1E8Ø
```

Terminate DDT by typing a control-c or "GØ" in order to prepare the patch program. Your CBIOS, for example, can be modified using the editor, and assembled using ASM, producing a file called CBIOS.HEX which contains the Intel formatted machine code for CBIOS in "hex" format. In order to integrate your new CBIOS, return to DDT by typing

```
            DDT CPM.COM                         Start DDT and load the CPM image
```

Examine the area at 1E8ØH where the previous version of the CBIOS resides. Then type

```
            ICBIOS.HEX                          Ready the "hex" file for loading
```

Assume that your CBIOS is being integrated into a 16K CP/M system, and is thus "org´ed" at location 3EØØH. In order to properly locate the CBIOS in the memory image under DDT, we must apply the negative bias n for a 16K system when loading the hex file. This is accomplished by typing

```
            REØ8Ø                               Read the file with bias ØEØ8ØH
```

Upon completion of the read, re-examine the area where the CBIOS has been loaded (use a "L1E8Ø" command), to ensure that is was loaded properly. When you are satisfied that the patch has been made, return from DDT using a control-c or "GØ" 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 1.Ø                 Signon message from SYSGEN
            GET SYSTEM (Y/N)?N                  Answer no to GET request
            PUT SYSTEM (Y/N)?Y                  Answer yes to PUT request
            DESTINATION ON B, THEN TYPE RETURN
```

Place the test diskette on drive B (if you are operating with a single drive system, answer "A" rather than "Y" to the PUT request, then remove your diskette, and replace by the test diskette), and type a return. The system will be replaced on the test diskette, and the system will automatically boot from drive A.

Test the new CP/M system, and place the Digital Research copyright notice on the diskette, as specified in your Licensing Agreement:

Copyright (c), 1976
Digital Research

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 288ØH
;   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,288ØH     ;SET STACK POINTER TO SCRATCH AREA
       LXI   H, 288ØH     ;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 D for reference purposes, with an assumed origin of 1ØØH. 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 E. 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.

5. DISKETTE ORGANIZATION

The sector allocation for the distribution version of CP/M is given here for reference purposes. The first sector (see Figure 1) contains an optional software boot section. Disk controllers are often set up to bring track Ø, sector 1 into memory at a specific location (often location ØØØØH). The program in this sector, called LBOOT, has the responsibility of bringing the remaining sectors into memory starting at location 29ØØH+b. If your controller does not have a built-in sector load, you can ignore the program in track Ø, sector 1, and begin the load from track Ø sector 2 to location 29ØØH+b.

As an example, the Intel MDS hardware cold start loader brings track Ø, sector 1 into absolute address 3ØØØH. Thus, the distribution version contains two very small programs in track Ø, sector 1:

MBOOT - a storage move program which moves LBOOT into place following the cold start (Appendix A)

LBOOT - the cold start boot loader (Appendix B)

Upon MDS start-up, the 128 byte segment on track Ø, sector 1 is brought into 3000H. The MBOOT program gets control, and moves the LBOOT program from location 301EH down to location 80H in memory, in order to get LBOOT out the the area where CP/M is loaded in a 16K system. Note that the MBOOT program would not be needed if the MDS loaded directly to 80H. In general, the LBOOT program could be located anywhere below the CP/M load location, but is most often located in the area between 000H and 0FFH (below the TPA).

After the move, MBOOT transfers to LBOOT at 80H. LBOOT, in turn, loads the remainder of track 0 and the initialized portion of track 1 to memory, starting at 2900H+b. The user should note that MBOOT and LBOOT are of little use in a non-MDS environment, although it is useful to study them since some of their actions will have to be duplicated in your cold start loader.

Figure 1. Diskette Allocation

Track#	Sector#	Page#	Memory Address	CP/M Module name
00	01		(boot address)	Cold Start Loader
00	02	00	2900H+b	CCP
"	03	"	2980H+b	"
"	04	01	2A00H+b	"
"	05	"	2A80H+b	"
"	06	02	2B00H+b	"
"	07	"	2B80H+b	"
"	08	03	2C00H+b	"
"	09	"	2C80H+b	"
"	10	04	2D00H+b	"
"	11	"	2D80H+b	"
"	12	05	2E00H+b	"
"	13	"	2E80H+b	"
"	14	06	2F00H+b	"
"	15	"	2F80H+b	"
"	16	07	3000H+b	"
"	17	"	3080H+b	"
"	18	08	3100H+b	"
00	19	"	3180H+b	CCP
00	20	09	3200H+b	BDOS
"	21	"	3280H+b	"
"	22	10	3300H+b	"
"	23	"	3380H+b	"
"	24	11	3400H+b	"
"	25	"	3480H+b	"
"	26	12	3500H+b	"
01	01	"	3580H+b	"
"	02	13	3600H+b	"
"	03	"	3680H+b	"
"	04	14	3700H+b	"
"	05	"	3780H+b	"

"	Ø6	15	38ØØH+b	"
"	Ø7	"	388ØH+b	"
"	Ø8	16	39ØØH+b	"
"	Ø9	"	398ØH+b	"
"	1Ø	17	3AØØH+b	"
"	11	"	3A8ØH+b	"
"	12	18	3BØØH+b	"
"	13	"	3B8ØH+b	"
"	14	19	3CØØH+b	"
"	15	"	3C8ØH+b	"
"	16	2Ø	3DØØH+b	"
"	17	"	3D8ØH+b	BDOS
Ø1	18	21	3EØØH+b	BIOS
"	19	"	3E8ØH+b	"
"	2Ø	22	3FØØH+b	"
Ø1	21	"	3F8ØH+b	BIOS
Ø1	22-26			(not currently used)
Ø2-76	Ø1-26			(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" between locations 3EØØH+b and 3E2CH+b, as shown below (see also Appendices, pages C-2 and D-1). The jump vector is a sequence of 15 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.

It should be noted that there is a 16 byte area reserved in page zero (see Section 9) starting at location 4ØH, which is available as a "scratch" area in case the BIOS is implemented in ROM by the user. This scratch area is never accessed by any other CP/M subsystem during operation.

The jump vector at 3EØØH+b takes the form shown below, where the individual jump addresses are given to the left:

```
3EØØH+b     JMP BOOT       ;ARRIVE HERE FROM COLD START LOAD
3EØ3H+b     JMP WBOOT      ;ARRIVE HERE FOR WARM START
3EØ6H+b     JMP CONST      ;CHECK FOR CONSOLE CHAR READY
3EØ9H+b     JMP CONIN      ;READ CONSOLE CHARACTER IN
3EØCH+b     JMP CONOUT     ;WRITE CONSOLE CHARACTER OUT
3EØFH+b     JMP LIST       ;WRITE LISTING CHARACTER OUT
3E12H+b     JMP PUNCH      ;WRITE CHARACTER TO PUNCH DEVICE
3E15H+b     JMP READER     ;READ READER DEVICE
```

```
3E18H+b        JMP HOME            ;MOVE TO TRACK ØØ ON SELECTED DISK
3E1BH+b        JMP SELDSK          ;SELECT DISK DRIVE
3E1EH+b        JMP SETTRK          ;SET TRACK NUMBER
3E21H+b        JMP SETSEC          ;SET SECTOR NUMBER
3E24H+b        JMP SETDMA          ;SET DMA ADDRESS
3E27H+b        JMP READ            ;READ SELECTED SECTOR
3E2AH+b        JMP WRITE           ;WRITE SELECTED SECTOR
```

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, and READER, and diskette I/O performed by calls on HOME, SELDSK, SETTRK, SETSEC, SETDMA, READ, and WRITE.

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 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 are used by PIP, but not the BDOS). 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 should give an appropriate error message so that the system does not "hang" if the device is accessed by PIP or some other user program.

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. 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

CONSOLE field (bits 0,1)
0 - console is assigned to the Teletype 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
3 - user defined console device

READER field (bits 2,3)
0 - READER is the Teletype device
1 - READER is the high-speed reader device (RDR)
2 - user defined reader # 1
3 - user defined reader # 2

PUNCH field (bits 4,5)
0 - PUNCH is the Teletype device
1 - PUNCH is the high speed punch device (PUN)
2 - user defined punch # 1
3 - user defined punch # 2

LIST field (bits 6,7)
0 - LIST is the Teletype device
1 - LIST is the CRT device
2 - LIST is the line printer device
3 - user defined list device

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 TTY: and CRT: devices. If you do not implement the IOBYTE, you cannot access these physical devices through PIP. 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 on 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 called before the read and write operations are performed. Note, however, that the BIOS does not attempt error recovery when a read or write fails, but instead reports the error condition to the BDOS. The BDOS then retries the read or write, assuming the track and sector address remain the same. The HOME subroutine may be called during error recovery, following by a re-seek of the particular track and sector. The HOME subroutine may or may not actually perform the track ØØ seek, depending upon your controller characteristics; the important point is that track ØØ has been selected for the next operation, and is often treated in exactly the same manner as SETTRK with a parameter of ØØ.

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 29ØØH+b for further processing.

WBOOT — The WBOOT entry point gets control when a warm start occurs. A warm start is performed whenever a user program branches to location ØØØØH, 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 Ø,1,2	set to JMP WBOOT for warm starts (ØØØØH: JMP 3EØ3H+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. (ØØØ5H: JMP 32Ø6H+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 29ØØH+b to (re)start the system. Upon entry to the CCP, register C is set to the drive to select after system initialization (normally drive A is selected by setting register C to zero).

CONST Sample the status of the currently assigned console device and return a ØFFH in register A if a character is ready to read, and ØØH in register A if no console characters are ready.

CONIN Read the next console character into register A, and 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 7ØØ 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 ØØ position. If your controller allows access to the track Ø flag from the drive, step the head until the track Ø 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 Ø.

SELDSK Select the disk drive given by register C for further operations, where register C contains Ø for drive A, and 1 for drive B (the standard CP/M distribution version supports a maximum of two drives). If your system has only one drive, you may wish to give an error message at the console, and terminate execution. You can, if you wish, type a message at the console to switch diskettes to simulate a two drive

·--. In this case, you must keep account of the current drive and type an appropriate message when the drive changes.

SETTRK

Register C 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 C can take on values in the range Ø-76 corresponding to valid track numbers.

SETSEC

Register C 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 the read or write operation occurs.

SETDMA

Registers B and C (high order 8 bits in B, low order 8 bits in C) contain the DMA (direct 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 fill 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 uses the 128 byte area starting at the selected DMA address for the memory buffer during the I/O operation.

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 one read based upon these parameters, and returns the following error codes in register A:

Ø	no errors occurred	(bit Ø thru 7 = Ø)
1	Hardware malfunction	(bit Ø = 1)
2	Unit not ready	(bit 1 = 1)
4	Command sequence error	(bit 2 = 1)
8	CRC error	(bit 3 = 1)
16	Seek error	(bit 4 = 1)

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 the return code is non-zero, then CP/M retries the operation to see if the error is recoverable. There is a maximum to 1Ø retries by CP/M before the "PERM ERR DISK d" message is printed at the console. Future versions of CP/M will, however, perform more sophisticated error recovery and thus it will be useful to have the additional error responses.

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 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.

7. A SAMPLE BIOS

The program shown in Appendix D 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 E 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 ØØØØ. 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 Ø, 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

-ta areas are given below for reference purposes.

Locations from to	Contents
0000H - 0002H	Contains a jump instruction to the warm start entry point at location 3E03H+b. This allows a simple programmed restart (JMP 0000H) or manual restart from the front panel.
0003H - 0003H	Contains the Intel standard IOBYTE, which is optionally included in the user´s CBIOS, as described in Section 6.
0004H - 0004H	(not currently used - reserved)
0005H - 0007H	Contains a jump instruction to the BDOS, and serves two purposes: JMP 0005H provides the primary entry point to the BDOS, as described in the manual "CP/M Interface Guide," and LHLD 0006H 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.
0008H - 0027H	(interrupt locations 1 through 5 not used)
0030H - 0037H	(interrupt location 6, not currently used - reserved)
0038H - 003AH	Contains a jump instruction into the DDT program when running in debug mode for programmed breakpoints, but is not otherwise used by CP/M.
003BH - 003FH	(not currently used - reserved)
0040H - 004FH	16 byte area reserved for scratch by CBIOS, but is not used for any purpose in the distribution version of CP/M
0050H - 005BH	(not currently used - reserved)
005CH - 007CH	default file control block produced for a transient program by the Console Command Processor.
007DH - 007FH	(not currently used - reserved)
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 Ø, 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 1ØØH, which is the assumed beginning of all transient programs). The move program can then proceed to move the entire memory image down to location Ø, and pass control to the starting address of the memory load. Note that if the BIOS is overwritten, or if location Ø (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.

```
               ; MDS LOADER MOVE PROGRAM, PLACES COLD START BOOT AT BOOTB
               ;
3000             ORG        3000H      ;WE ARE LOADED HERE ON COLD START
0080 =         BOOTB        EQU        80H        ;START OF COLD BOOT PROGRAM
0080 =         BOOTL        EQU        80H        ;LENGTH OF BOOT
D900 =         MBIAS        EQU        900H-$     ;BIAS TO ADD DURING LOAD
0078 =         BASE         EQU        078H       ;´BASE´ USED BY DISK CONTROLLER
0079 =         RTYPE        EQU        BASE+1     ;RESULT TYPE
007B =         RBYTE        EQU        BASE+3     ;RESULT TYPE
               ;
00FF =         BSW          EQU        0FFH       ;BOOT SWITCH
               ;
               ; CLEAR DISK STATUS
3000 DB79        IN         RTYPE
3002 DB7B        IN         RBYTE
               ;
               COLDSTART:
3004 DBFF        IN         BSW
3006 E602        ANI        2H         ;SWITCH ON?
3008 C20430      JNZ        COLDSTART
               ;
300B 211E30      LXI        H,BOOTV    ;VIRTUAL BASE
300E 0680        MVI        B,BOOTL    ;LENGTH OF BOOT
3010 118000      LXI        D,BOOTB    ;DESTINATION OF BOOT
3013 7E        MOVE:        MOV        A,M
3014 12          STAX       D          ;TRANSFERRED ONE BYTE
3015 23          INX        H
3016 13          INX        D
3017 05          DCR        B
3018 C21330      JNZ        MOVE
301B C38000      JMP        BOOTB      ;TO BOOT SYSTEM
               ;
               BOOTV:       ;BOOT LOADER PLACE HERE AT SYSTEM GENERATION
089E =         LBIAS        EQU        $-80H+MBIAS          ;COLD START BOOT BEGINS AT 80H
301E             END
```

```
                ; MDS COLD START LOADER FOR CP/M
ØØ1Ø =          MSIZE      EQU       16         ;MEMORY SIZE IN KILOBYTES
2ØØØ =          CBASE      EQU       (MSIZE-8)*1Ø24       ;CPM BASE ADDRESS BIAS BEYOND 8K
29ØØ =          BDOSB      EQU       CBASE+9ØØH           ;BASE OF DOS LOAD
32Ø6 =          BDOS       EQU       CBASE+12Ø6H          ;ENTRY TO DOS FOR CALLS
4ØØØ =          BDOSE      EQU       MSIZE*1Ø24           ;END OF DOS LOAD
3EØØ =          BOOT       EQU       BDOSE-2*256          ;COLD START ENTRY POINT
3EØ3 =          RBOOT      EQU       BOOT+3               ;WARM START ENTRY POINT
                ;
ØØ8Ø             ORG       8ØH       ;LOADED DOWN FROM HARDWARE BOOT AT 3ØØØH
                ;
17ØØ =          BDOSL      EQU       BDOSE-BDOSB
ØØØ2 =          NTRKS      EQU       2          ;NUMBER OF TRACKS TO READ
ØØ2E =          BDOSS      EQU       BDOSL/128 ;NUMBER OF SECTORS IN DOS
ØØ19 =          BDOSØ      EQU       25         ;NUMBER OF BDOS SECTORS ON TRACK Ø
ØØ15 =          BDOS1      EQU       BDOSS-BDOSØ          ;NUMBER OF SECTORS ON TRACK 1
                ;
F8ØØ =          MON8Ø      EQU       ØF8ØØH     ;INTEL MONITOR BASE
FFØF =          RMON8Ø     EQU       ØFFØFH     ;RESTART LOCATION FOR MON8Ø
ØØ78 =          BASE       EQU       Ø78H       ;´BASE´ USED BY CONTROLLER
ØØ79 =          RTYPE      EQU       BASE+1     ;RESULT TYPE
ØØ7B =          RBYTE      EQU       BASE+3     ;RESULT BYTE
ØØ7F =          RESET      EQU       BASE+7     ;RESET CONTROLLER
                ;
ØØ78 =          DSTAT      EQU       BASE       ;DISK STATUS PORT
ØØ79 =          LOW        EQU       BASE+1     ;LOW IOPB ADDRESS
ØØ7A =          HIGH       EQU       BASE+2     ;HIGH IOPB ADDRESS
ØØØ3 =          RECAL      EQU       3H         ;RECALIBRATE SELECTED DRIVE
ØØØ4 =          READF      EQU       4H         ;DISK READ FUNCTION
Ø1ØØ =          STACK      EQU       1ØØH       ;USE END OF BOOT FOR STACK
                ;
ØØ8Ø 31ØØØ1      LXI       SP,STACK;IN CASE OF CALL TO MON8Ø
                ; CLEAR THE CONTROLLER
ØØ83 D37F        OUT       RESET     ;LOGIC CLEARED
                ;
                ;
ØØ85 Ø6Ø2        MVI       B,NTRKS   ;NUMBER OF TRACKS TO READ
ØØ87 21B7ØØ      LXI       H,IOPBØ
                ;
                START:
                ;
                ; READ FIRST/NEXT TRACK INTO BDOSB
ØØ8A 7D          MOV       A,L
ØØ8B D379        OUT       LOW
ØØ8D 7C          MOV       A,H
ØØ8E D37A        OUT       HIGH
ØØ9Ø DB78       WAITØ:     IN        DSTAT
ØØ92 E6Ø4        ANI       4
```

```
ØØ94 CA9ØØØ         JZ       WAITØ
                   ;
                   ; CHECK DISK STATUS
ØØ97 DB79           IN       RTYPE
ØØ99 E6Ø3           ANI      11B
ØØ9B FEØ2           CPI      2
ØØ9D D4ØFFF         CNC      RMON8Ø     ;GO TO MONITOR IF 11 OR 1Ø
                   ;
ØØAØ DB7B           IN       RBYTE      ;I/O COMPLETE, CHECK STATUS
                   ; IF NOT READY, THEN GO TO MON8Ø
ØØA2 17             RAL
ØØA3 DCØFFF         CC       RMON8Ø     ;NOT READY BIT SET
ØØA6 1F             RAR                 ;RESTORE
ØØA7 E61E           ANI      1111ØB     ;OVERRUN/ADDR ERR/SEEK/CRC/XXXX
ØØA9 C4ØFFF         CNZ      RMON8Ø     ;TRY ALL OVER AGAIN
                   ;
ØØAC 11Ø7ØØ         LXI      D,IOPBL    ;LENGTH OF IOPB
ØØAF 19             DAD      D          ;ADDRESSING NEXT IOPB
ØØBØ Ø5             DCR      B          ;COUNT DOWN TRACKS
ØØB1 C28AØØ         JNZ      START
                   ;
                   ;
                   ; JMP TO BOOT TO PRINT INITIAL MESSAGE, AND SET UP JMPS
ØØB4 C3ØØ3E         JMP      BOOT
                   ;
                   ; PARAMETER BLOCKS
ØØB7 8Ø            IOPBØ:    DB         8ØH        ;IOCW, NO UPDATE
ØØB8 Ø4             DB       READF      ;READ FUNCTION
ØØB9 19             DB       BDOSØ      ;# SECTORS TO READ ON TRACK Ø
ØØBA ØØ             DB       Ø          ;TRACK Ø
ØØBB Ø2             DB       2          ;START WITH SECTOR 2 ON TRACK Ø
ØØBC ØØ29           DW       BDOSB      ;START AT BASE OF BDOS
ØØØ7 =             IOPBL     EQU        $-IOPBØ
                   ;
ØØBE 8Ø            IOPB1:    DB         8ØH
ØØBF Ø4             DB       READF
ØØCØ 15             DB       BDOS1      ;SECTORS TO READ ON TRACK 1
ØØC1 Ø1             DB       1          ;TRACK 1
ØØC2 Ø1             DB       1          ;SECTOR 1
ØØC3 8Ø35           DW       BDOSB+BDOSØ*128      ;BASE OF SECOND READ
                   ;
ØØC5                END
```

```
                ; MDS I/O DRIVERS FOR CP/M
                ; VERSION 1.0  SEPT, 1976
                ;
                ; COPYRIGHT (C) 1976
                ; DIGITAL RESEARCH
                ; BOX 579, PACIFIC GROVE CA.
                ;
                ;
                ;
0010 =          MSIZE     EQU     16         ;MEMORY SIZE IN KILOBYTES
000A =          VERS      EQU     10         ;CPM VERSION NUMBER
3E00 =          PATCH     EQU     MSIZE*1024-2*256   ;BASE OF THIS MODULE (ABOVE DOS)
                ;
3E00             ORG      PATCH
2000 =          CBASE     EQU     (MSIZE-8)*1024     ;BIAS FOR SYSTEMS LARGER THAN 8K
2900 =          CPMB      EQU     CBASE+900H         ;BASE OF CPM (CONSOLE PROCESSOR ENTRY)
3206 =          BDOS      EQU     CBASE+1206H        ;BASIC DOS (RESIDENT PORTION)
1500 =          CPML      EQU     $-CPMB     ;LENGTH (IN BYTES) OF CPM SYSTEM
002A =          NSECTS    EQU     CPML/128   ;NUMBER OF SECTORS TO LOAD
0080 =          LBIAS     EQU     980H-CPMB ;LOADER BIAS VALUE USED IN SYSGEN
0002 =          OFFSET    EQU     2          ;NUMBER OF DISK TRACKS USED BY CP/M
0080 =          BUFF      EQU     80H        ;DEFAULT BUFFER ADDRESS
                ;
                ; 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 BLOCK FOR THE
                ; MDS, WHICH IS USED TO PERFORM SUBSEQUENT READS AND WRITES)
                ; SELDSK    SELECT DISK GIVEN BY REG-C (0,1,2...)
                ; SETTRK    SET TRACK ADDRESS (0,...76) FOR SUBSEQUENT READ/WRITE
                ; SETSEC    SET SECTOR ADDRESS (1,...,26) FOR SUBSEQUENT READ/WRITE
                ; SETDMA    SET SUBSEQUENT DMA ADDRESS (INITIALLY 80H)
                ;
                ; (READ AND WRITE ASSUME PREVIOUS CALLS TO SET UP THE IO PARAMETERS)
                ; READ      READ TRACK/SECTOR TO PRESET DMA ADDRESS
                ; WRITE     WRITE TRACK/SECTOR FROM PRESET DMA ADDRESS
                ;
```

```
                     UMP VECTOR FOR INDIVIUAL ROUTINES
3EØØ C3443E          JMP        BOOT
3EØ3 C3543E        WBOOTE:      JMP        WBOOT
3EØ6 C3Ø73F          JMP        CONST
3EØ9 C3ØA3F          JMP        CONIN
3EØC C31Ø3F          JMP        CONOUT
3EØF C3293F          JMP        LIST
3E12 C32C3F          JMP        PUNCH
3E15 C32F3F          JMP        READER
3E18 C3323F          JMP        HOME
3E1B C3413F          JMP        SELDSK
3E1E C35A3F          JMP        SETTRK
3E21 C35F3F          JMP        SETSEC
3E24 C3643F          JMP        SETDMA
3E27 C36A3F          JMP        READ
3E2A C3733F          JMP        WRITE
                   ;
                   ;
                   ; END OF CONTROLLER - INDEPENDENT CODE, THE REMAINING SUBROUTINES
                   ; ARE TAILORED TO THE PARTICULAR OPERATING ENVIRNOMENT, AND MUST
                   ; BE ALTERED FOR ANY SYSTEM WHICH DIFFERS FROM THE INTEL MDS.
                   ;
                   ; THE FOLLOWING CODE ASSUMES THE MDS MONITOR EXISTS AT ØF8ØØH
                   ; AND USES THE I/O SUBROUTINES WITHIN THE MONITOR
                   ;
                   ; WE ALSO ASSUME THE MDS SYSTEM HAS TWO DISK DRIVES AVAILABLE
ØØØ2 =             NDISKS      EQU       2          ;NUMBER OF DRIVES AVAILABLE
ØØFD =             REVRT       EQU       ØFDH       ;INTERRUPT REVERT PORT
ØØFC =             INTC        EQU       ØFCH       ;INTERRUPT MASK PORT
ØØF3 =             ICON        EQU       ØF3H       ;INTERRUPT CONTROL PORT
ØØ7E =             INTE        EQU       Ø111$111ØB          ;ENABLE RST Ø(WARM BOOT), RST 7 (MONIT
                   ;
                   ; MDS MONITOR EQUATES
F8ØØ =             MON8Ø       EQU       ØF8ØØH     ;MDS MONITOR
FFØF =             RMON8Ø      EQU       ØFFØFH     ;RESTART MON8Ø (DISK SELECT ERROR)
F8Ø3 =             CI          EQU       ØF8Ø3H     ;CONSOLE CHARACTER TO REG-A
F8Ø6 =             RI          EQU       ØF8Ø6H     ;READER IN TO REG-A
F8Ø9 =             CO          EQU       ØF8Ø9H     ;CONSOLE CHAR FROM C TO CONSOLE OUT
F8ØC =             PO          EQU       ØF8ØCH     ;PUNCH CHAR FROM C TO PUNCH DEVICE
F8ØF =             LO          EQU       ØF8ØFH     ;LIST FROM C TO LIST DEVICE
F812 =             CSTS        EQU       ØF812H     ;CONSOLE STATUS ØØ/FF TO REGISTER A
                   ;
                   ; DISK PORTS AND COMMANDS
ØØ78 =             BASE        EQU       78H        ;BASE OF DISK COMMAND IO PORTS
ØØ78 =             DSTAT       EQU       BASE       ;DISK STATUS (INPUT)
ØØ79 =             RTYPE       EQU       BASE+1     ;RESULT TYPE (INPUT)
ØØ7B =             RBYTE       EQU       BASE+3     ;RESULT BYTE (INPUT)
                   ;
ØØ79 =             LOW         EQU       BASE+1     ;IOPB LOW ADDRESS (OUTPUT)
ØØ7A =             HIGH        EQU       BASE+2     ;IOPB HIGH ADDRESS (OUTPUT)
```

```
                ;
ØØØ4 =          READF       EQU       4H        ;READ FUNCTION
ØØØ6 =          WRITF       EQU       6H        ;WRITE FUNCTION
ØØØ3 =          RECAL       EQU       3H        ;RECALIBRATE DRIVE
ØØØ4 =          IORDY       EQU       4H        ;I/O FINISHED MASK
ØØØD =          CR          EQU       ØDH       ;CARRIAGE RETURN
ØØØA =          LF          EQU       ØAH       ;LINE FEED
                ;
                SIGNON:     ;SIGNON MESSAGE: XXK CP/M VERS Y.Y
3E2D ØDØAØA       DB        CR,LF,LF
3E3Ø 3136         DB        MSIZE/1Ø+´Ø´,MSIZE MOD 1Ø + ´Ø´
3E32 4B2Ø435Ø2F   DB        ´K CP/M VERS ´
3E3E 312E3Ø       DB        VERS/1Ø+´Ø´,´.´,VERS MOD 1Ø+´Ø´
3E41 ØDØAØØ       DB        CR,LF,Ø
                ;
                BOOT:       ;PRINT SIGNON MESSAGE AND GO TO DOS
3E44 318ØØØ       LXI       SP,BUFF
3E47 212D3E       LXI       H,SIGNON
3E4A CD7C3F       CALL      PRMSG     ;PRINT MESSAGE
3E4D AF           XRA       A         ;CLEAR ACCUMULATOR
3E4E 32ED3F       STA       DISKT     ;SELECT DISK Ø ON ENTRY
3E51 C3A63E       JMP       GOCPM     ;GO TO CP/M
                ;
                ;
                WBOOT:;     LOADER ON TRACK Ø, SECTOR 1, WHICH WILL BE SKIPPED FOR WARM
                ; READ CP/M FROM DISK - ASSUMING THERE IS A 128 BYTE COLD START
                ; START.
                ;
3E54 318ØØØ       LXI       SP,BUFF   ;USING DMA - THUS 8Ø THRU FF AVAILABLE FOR STACK
3E57 3AEC3F       LDA       DISKN     ;CURRENTLY LOGGED DISK, RETURN TO DISKN IF NOT Ø
3E5A 32ED3F       STA       DISKT     ;STORE INTO DISK TEMP SINCE WE BOOT OFF OF Ø
                ;
3E5D ØEØA         MVI       C,1Ø      ;MAX 1Ø RETRIES
3E5F C5           PUSH      B
                WBOOTØ:     ;ENTER HERE ON ERROR RETRIES
3E6Ø Ø1ØØ29       LXI       B,CPMB    ;SET DMA ADDRESS TO START OF DISK SYSTEM
3E63 CD643F       CALL      SETDMA
3E66 ØEØ2         MVI       C,2       ;START READING SECTOR 2
3E68 CD5F3F       CALL      SETSEC
3E6B ØEØØ         MVI       C,Ø       ;START READING TRACK Ø
3E6D CD5A3F       CALL      SETTRK
3E7Ø ØEØØ         MVI       C,Ø       ;START WITH DISK Ø
3E72 CD413F       CALL      SELDSK    ;CHANGES DISKN TO Ø
                ;
                ; READ SECTORS, COUNT NSECTS TO ZERO
3E75 C1           POP       B         ;1Ø-ERROR COUNT
3E76 Ø62A         MVI       B,NSECTS
                RDSEC:      ;READ NEXT SECTOR
3E78 C5           PUSH      B         ;SAVE SECTOR COUNT
3E79 CD6A3F       CALL      READ
```

```
 E7C C2EØ3E      JNZ       BOOTERR    ;RETRY IF ERRORS OCCUR
3E7F 2AF33F      LHLD      IOD        ;INCREMENT DMA ADDRESS
3E82 118ØØØ      LXI       D,128      ;SECTOR SIZE
3E85 19          DAD       D          ;INCREMENTED DMA ADDRESS IN HL
3E86 44          MOV       B,H
3E87 4D          MOV       C,L        ;READY FOR CALL TO SET DMA
3E88 CD643F      CALL      SETDMA
3E8B 3AF23F      LDA       IOS        ;SECTOR NUMBER JUST READ
3E8E FE1A        CPI       26         ;READ LAST SECTOR?
3E9Ø DA9C3E      JC        RD1
                ; MUST BE SECTOR 26, ZERO AND GO TO NEXT TRACK
3E93 3AF13F      LDA       IOT        ;GET TRACK TO REGISTER A
3E96 3C          INR       A
3E97 4F          MOV       C,A        ;READY FOR CALL
3E98 CD5A3F      CALL      SETTRK
3E9B AF          XRA       A          ;CLEAR SECTOR NUMBER
3E9C 3C         RD1:       INR        A          ;TO NEXT SECTOR
3E9D 4F          MOV       C,A        ;READY FOR CALL
3E9E CD5F3F      CALL      SETSEC
3EA1 C1          POP       B          ;RECALL SECTOR COUNT
3EA2 Ø5          DCR       B          ;DONE?
3EA3 C2783E      JNZ       RDSEC
                ;
                ; DONE WITH THE LOAD, RESET DEFAULT BUFFER ADDRESS
                GOCPM:     ;(ENTER HERE FROM COLD START BOOT)
                ; ENABLE RSTØ AND RST7
3EA6 F3          DI
3EA7 3E12        MVI       A,12H      ;INITIALIZE COMMAND
3EA9 D3FD        OUT       REVRT
3EAB AF          XRA       A
3EAC D3FC        OUT       INTC       ;CLEARED
3EAE 3E7E        MVI       A,INTE     ;RSTØ AND RST7 BITS ON
3EBØ D3FC        OUT       INTC
3EB2 AF          XRA       A
3EB3 D3F3        OUT       ICON       ;INTERRUPT CONTROL
                ;
                ; SET DEFAULT BUFFER ADDRESS TO 8ØH
3EB5 Ø18ØØØ      LXI       B,BUFF
3EB8 CD643F      CALL      SETDMA
                ;
                ; RESET MONITOR ENTRY POINTS
3EBB 3EC3        MVI       A,JMP
3EBD 32ØØØØ      STA       Ø
3ECØ 21Ø33E      LXI       H,WBOOTE
3EC3 22Ø1ØØ      SHLD      1          ;JMP WBOOT AT LOCATION ØØ
3EC6 32Ø5ØØ      STA       5
3EC9 21Ø632      LXI       H,BDOS
3ECC 22Ø6ØØ      SHLD      6          ;JMP BDOS AT LOCATION 5
3ECF 3238ØØ      STA       7*8        ;JMP TO MON8Ø (MAY HAVE BEEN CHANGED BY DDT)
3ED2 21ØØF8      LXI       H,MON8Ø
```

```
3ED5 223900      SHLD      7*8+1
               ; LEAVE IOBYTE SET
               ; PREVIOUSLY SELECTED DISK WAS B, SEND PARAMETER TO CPM
3ED8 3AED3F      LDA       DISKT
3EDB 4F          MOV       C,A       ;LOOKS LIKE A SINGLE PARAMETER TO CPM
3EDC FB          EI
3EDD C3ØØ29      JMP       CPMB
               ;
               ; ERROR CONDITION OCCURRED, PRINT MESSAGE AND RETRY
               BOOTERR:
3EEØ C1          POP       B         ;RECALL COUNTS
3EE1 ØD          DCR       C
3EE2 CAE93E      JZ        BOOTERØ
               ; TRY AGAIN
3EE5 C5          PUSH      B
3EE6 C36Ø3E      JMP       WBOOTØ
               ;
               BOOTERØ:
               ; OTHERWISE TOO MANY RETRIES
3EE9 21F23E      LXI       H,BOOTMSG
3EEC CD893F      CALL      ERROR
3EEF C3543E      JMP       WBOOT     ;FOR ANOTHER TRY
               ;
               BOOTMSG:
3EF2 2A43414E4E DB         ´*CANNOT BOOT SYSTEM*´,Ø
               ;
               ;
               CONST:      ;CONSOLE STATUS TO REG-A
               ; (EXACTLY THE SAME AS MDS CALL)
3FØ7 C312F8      JMP       CSTS
               ;
               CONIN:      ;CONSOLE CHARACTER TO REG-A
3FØA CDØ3F8      CALL      CI
3FØD E67F        ANI       7FH       ;REMOVE PARITY BIT
3FØF C9          RET
               ;
               CONOUT:     ;CONSOLE CHARACTER FROM C TO CONSOLE OUT
               ; SAME AS MDS CALL, BUT WAIT FOR SLOW CONSOLES ON LINE FEED
3F1Ø 79          MOV       A,C       ;GET CHARACTER TO ACCUM
3F11 FEØA        CPI       LF        ;END OF LINE?
3F13 F5          PUSH      PSW       ;SAVE CONDITION FOR LATER
3F14 CDØ9F8      CALL      CO        ;SEND THE CHARACTER (MAY BE LINE FEED)
3F17 F1          POP       PSW
3F18 CØ          RNZ                 ;RETURN IF IT WASN´T A LINE FEED
               ;
               ; WAIT 13 CHARACTER TIMES (AT 24ØØ BAUD) FOR LINE FEED TO HAPPEN
               ; (THIS WORKS OUT TO ABOUT 5Ø MILLISECS)
3F19 Ø632        MVI       B,5Ø      ;NUMBER OF MILLISECS TO WAIT
3F1B ØEB6      T1:         MVI       C,182     ;COUNTER TO CONTROL 1 MILLISEC LOOP
3F1D ØD        T2:         DCR       C         ;1 CYCLE = .5 USEC
```

```
3F1E C21D3F        JNZ      T2         ;1Ø CYCLES= 5.5 USEC
                  ;                     ------------
                  ;                      =    5.5 USEC PER LOOP*  182 = 1ØØ1 USEC
3F21 Ø5            DCR      B
3F22 C21B3F        JNZ      T1         ;FOR ANOTHER LOOP
3F25 C9            RET
                  ;
                  ;
3F26 C3Ø9F8        JMP      CO
                  ;
                  LIST:       ;LIST DEVICE OUT
                  ; (EXACTLY THE SAME AS MDS CALL)
3F29 C3ØFF8        JMP      LO
                  ;
                  PUNCH:      ;PUNCH DEVICE OUT
                  ; (EXACTLY THE SAME AS MDS CALL)
3F2C C3ØCF8        JMP      PO
                  ;
                  READER:     ;READER CHARACTER IN TO REG-A
                  ; (EXACTLY THE SAME AS MDS CALL)
3F2F C3Ø6F8        JMP      RI
                  ;
                  HOME:       ;MOVE TO HOME POSITION
                  ; USE RECALIBRATION IN CASE SEEK ERRORS HAVE OCCURRED
3F32 ØEØ3          MVI      C,RECAL    ;SET TO RECALIBRATE
3F34 CD9A3F        CALL     SETFUNC    ;SET IO FUNCTION
3F37 CDA33F        CALL     WAITIO     ;RECALIBRATE THE CURRENT DRIVE
3F3A 21ØØØØ        LXI      H,Ø        ;SET TRACK TO ØØ FOR SUBSEQUENT OPERATIONS
3F3D 22F13F        SHLD     IOT        ;SELECT TRACK ØØ
3F4Ø C9            RET                 ;MAY HAVE ERROR SET UPON RETURN
                  ;
                  SELDSK:     ;SELECT DISK GIVEN BY REGISTER C
                  ; CP/M HAS CHECKED FOR DISK SELECT Ø OR 1, BUT WE MAY HAVE
                  ; A SINGLE DRIVE MDS SYSTEM, SO CHECK AGAIN AND GIVE ERROR
                  ; BY CALLING MON8Ø
3F41 79            MOV      A,C
3F42 FEØ2          CPI      NDISKS     ;TOO LARGE?
3F44 D4ØFFF        CNC      RMON8Ø     ;GIVES #ADDR MESSAGE AT CONSOLE
3F47 32EC3F        STA      DISKN      ;SELECT DISK N
                  ;
3F4A 17            RAL
3F4B 17            RAL
3F4C 17            RAL
3F4D 17            RAL
3F4E E61Ø          ANI      1ØØØØB     ;UNIT NUMBER IN POSITION
3F5Ø 4F            MOV      C,A        ;SAVE IT
3F51 21EF3F        LXI      H,IOF      ;IO FUNCTION
3F54 7E            MOV      A,M
3F55 E6CF          ANI      11ØØ1111B ;MASK OUT DISK NUMBER
3F57 B1            ORA      C          ;MASK IN NEW DISK NUMBER
```

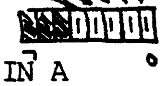
```
3F58 77             MOV      M,A         ;SAVE IT IN IOPB
3F59 C9             RET
                   ;
                   ;
                   SETTRK:     ;SET TRACK ADDRESS GIVEN BY C
3F5A 21F13F         LXI      H,IOT
3F5D 71             MOV      M,C
3F5E C9             RET
                   ;
                   SETSEC:     ;SET SECTOR NUMBER GIVEN BY C
3F5F 21F23F         LXI      H,IOS
3F62 71             MOV      M,C
3F63 C9             RET
                   ;
                   SETDMA:     ;SET DMA ADDRESS GIVEN BY REGS B,C
3F64 69             MOV      L,C
3F65 6Ø             MOV      H,B
3F66 22F33F         SHLD     IOD
3F69 C9             RET
                   ;
                   READ:       ;READ NEXT DISK RECORD (ASSUMING DISK/TRK/SEC/DMA SET)
3F6A ØEØ4           MVI      C,READF     ;SET TO READ FUNCTION
3F6C CD9A3F         CALL     SETFUNC
3F6F CDA33F         CALL     WAITIO      ;PERFORM READ FUNCTION
3F72 C9             RET                  ;MAY HAVE ERROR SET IN REG-A
                   ;
                   ;
                   WRITE:      ;DISK WRITE FUNCTION
3F73 ØEØ6           MVI      C,WRITF
3F75 CD9A3F         CALL     SETFUNC     ;SET TO WRITE FUNCTION
3F78 CDA33F         CALL     WAITIO
3F7B C9             RET                  ;MAY HAVE ERROR SET
                   ;
                   ;
                   ; UTILITY SUBROUTINES
                   PRMSG:      ;PRINT MESSAGE AT H,L TO Ø
3F7C 7E             MOV      A,M
3F7D B7             ORA      A           ;ZERO?
3F7E C8             RZ
                   ; MORE TO PRINT
3F7F E5             PUSH     H
3F8Ø 4F             MOV      C,A
3F81 CDØ9F8         CALL     CO
3F84 E1             POP      H
3F85 23             INX      H
3F86 C37C3F         JMP      PRMSG
                   ;
                   ERROR:      ;ERROR MESSAGE ADDRESSES BY H,L
3F89 CD7C3F         CALL     PRMSG
                   ; ERROR MESSAGE WRITTEN, WAIT FOR RESPONSE FROM CONSOLE
```

```
  8C CDØA3F      CALL      CONIN
3F8F ØEØD        MVI       C,CR      ;CARRIAGE RETURN
3F91 CD1Ø3F      CALL      CONOUT
3F94 ØEØA        MVI       C,LF      ;LINE FEED
3F96 CD1Ø3F      CALL      CONOUT
3F99 C9          RET                 ;MAY BE RETURNING FOR ANOTHER RETRY
               ;
               SETFUNC:
               ; SET FUNCTION FOR NEXT I/O (COMMAND IN REG-C)
3F9A 21EF3F      LXI       H,IOF     ;IO FUNCTION ADDRESS
3F9D 7E          MOV       A,M       ;GET IT TO ACCUMULATOR FOR MASKING
3F9E E6F8        ANI       11111ØØØB ;REMOVE PREVIOUS COMMAND
3FAØ B1          ORA       C         ;SET TO NEW COMMAND
3FA1 77          MOV       M,A       ;REPLACED IN IOPB
3FA2 C9          RET
               ;
               WAITIO:
               ; START THE I/O FUNCTION AND WAIT FOR COMPLETION
3FA3 DB79        IN        RTYPE
3FA5 DB7B        IN        RBYTE     ;CLEARS THE CONTROLLER
               ;
3FA7 3EEE        MVI       A,IOPB AND ØFFH     ;LOW ADDRESS FOR IOPB
3FA9 D379        OUT       LOW                 ;TO THE CONTROLLER
3FAB 3E3F        MVI       A,IOPB SHR 8        ;HIGH ADDRESS FOR IOPB
3FAD D37A        OUT       HIGH                ;TO THE CONTROLLER, STARTS OPERATION
               ;
3FAF DB78      WAITØ:      IN        DSTAT               ;WAIT FOR COMPLETION
3FB1 E6Ø4        ANI       IORDY               ;READY?
3FB3 CAAF3F      JZ        WAITØ
               ;
               ; CHECK IO COMPLETION OK
3FB6 DB79        IN        RTYPE               ;MUST BE I/O COMPLETE (ØØ) UNLINKED
               ; ØØ UNLINKED I/O COMPLETE,     Ø1 LINKED I/O COMPLETE (NOT USED)
               ; 1Ø DISK STATUS CHANGED        11 (NOT USED)
3FB8 FEØ2        CPI       1ØB                 ;READY STATUS CHANGE?
3FBA CACF3F      JZ        WREADY
               ;
               ; MUST BE ØØ IN THE ACCUMULATOR
3FBD B7          ORA       A
3FBE C2D53F      JNZ       WERROR              ;SOME OTHER CONDITION, RETRY
               ;
               ; CHECK I/O ERROR BITS
3FC1 DB7B        IN        RBYTE
3FC3 17          RAL
3FC4 DACF3F      JC        WREADY              ;UNIT NOT READY
3FC7 1F          RAR
3FC8 E6FE        ANI       1111111ØB ;ANY OTHER ERRORS?  (DELETED DATA OK)
3FCA C2D53F      JNZ       WERROR
               ;
               ; READ OR WRITE IS OK, RETURN ZERO FLAG
```

```
3FCD AF          XRA      A          ;ACCUMULATOR CLEARED, FLAGS SET
3FCE C9          RET
                ;
                WREADY:   ;RETURN NOT READY INDICATOR
3FCF DB7B        IN       RBYTE      ;CLEAR RESULT BYTE
                ;
                WREADØ:
3FD1 AF          XRA      A
3FD2 F6Ø2        ORI      1ØB
3FD4 C9          RET
                ;
                WERROR:   ;RETURN HARDWARE MALFUNCTION (CRC, TRACK, SEEK, ETC.)
                ; CP/M EXPECTS THE FOLLOWING RETURN CODES
```

bit positions

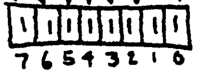
```
                ; Ø         - HARDWARE MALFUNCTION
                ; 1         - UNIT NOT READY (RETURNED ABOVE)
                ; 2         - COMMAND SEQUENCE ERROR
                ; 3         - CRC ERROR
                ; 4         - SEEK ERROR
                ;
```



```
                ; THE MDS CONTROLLER HAS RETURNED THE FOLLOWING IN A
```

bit position

```
                ; Ø         - DELETED DATA (ACCEPTED AS OK ABOVE)
                ; 1         - CRC ERROR
                ; 2         - SEEK ERROR
                ; 3         - ADDRESS ERROR (HARDWARE MALFUNCTION)
                ; 4         - DATA OVER/UNDER FLOW (HARDWARE MALFUNCTION)
                ; 5         - WRITE PROTECT (TREATED AS NOT READY)
                ; 6         - WRITE ERROR (HARDWARE MALFUNCTION)
                ; 7         - NOT READY
                ;
```



```
3FD5 47          MOV      B,A        ;SAVE CONDITION
3FD6 E62Ø        ANI      ØØ1ØØØØØB ;WRITE PROTECTED?
3FD8 C2D13F      JNZ      WREADØ     ;TREATED AS NOT READY STATUS
3FDB 78          MOV      A,B
3FDC E6Ø6        ANI      ØØØØØ11ØB ;CRC OR SEEK?
3FDE C2E63F      JNZ      WERRØ
                ; NO, RETURN HARDWARE MALFUNCTION
3FE1 3EØ1        MVI      A,1
3FE3 C3EA3F      JMP      WERR1
                ;
                ; CRC OR SEEK ERROR
3FE6 17         WERRØ:    RAL
3FE7 17          RAL
3FE8 E618        ANI      11ØØØB     ;INTO PROPER POSITION
3FEA B7         WERR1:    ORA        A          ;SET FLAGS
3FEB C9          RET
                ;
                ;
                ;
                ; DATA AREAS (MUST BE IN RAM)
3FEC ØØ         DISKN:    DB         Ø          ;CURRENT DISK
```

```
3FED 00        DISKT:    DB        0         ;TEMP FOR CURRENT DISK DURING WARM START
               IOPB:     ;IO PARAMETER BLOCK
3FEE 80          DB      80H       ;NORMAL I/O OPERATION
3FEF 04        IOF:      DB        READF     ;IO FUNCTION, INITIAL READ
3FF0 01        ION:      DB        1         ;NUMBER OF SECTORS TO READ
3FF1 02        IOT:      DB        OFFSET    ;TRACK NUMBER
3FF2 01        IOS:      DB        1         ;SECTOR NUMBER
3FF3 8000      IOD:      DW        BUFF      ;IO ADDRESS
               ;
               ;
3FF5             END
```

```
                ; SKELETAL CBIOS FOR FIRST LEVEL OF CP/M ALTERATION
                ;
                ; NOTE :  MSIZE DETERMINES WHERE THIS CBIOS IS LOCATED
ØØ1Ø =          MSIZE       EQU      16         ;CP/M VERSION MEMORY SIZE IN KILOBYTES
3EØØ =          PATCH       EQU      MSIZE*1Ø24-2*256   ;START OF THE CBIOS PATCH
                ;
                ; WE WILL USE PART OF THE 1Ø BYTE SCRATCH AREA AHEAD
                ; OF THE CBIOS FOR HOLDING THE VALUES OF:
                ;           TRACK   =  LAST SELECTED TRACK
                ;           SECTOR  =  LAST SELECTED SECTOR
                ;           DMAAD   =  LAST SELECTED DMA ADDRESS
                ;           DISKNO  =  LAST SELECTED DISK NUMBER
                ; (NOTE THAT ALL ARE BYTE VALUES EXCEPT FOR DMAAD)
                ;
3DF6 =          SCRAT       EQU      PATCH-1Ø  ;START OF 1Ø BYTE SCRATCH AREA
3DF6 =          TRACK       EQU      SCRAT              ;CURRENTLY SELECTED TRACK
3DF7 =          SECTOR      EQU      SCRAT+1            ;CURRENTLY SELECTED SECTOR
3DF8 =          DMAAD       EQU      SCRAT+2            ;CURRENT DMA ADDRESS
3DFC =          DISKNO      EQU      DMAAD+4   ;CURRENT DISK NUMBER
                ;
                ;
3EØØ              ORG       PATCH    ;ORGIN OF THIS PROGRAM
ØØØØ =          CBASE       EQU      (MSIZE-16)*1Ø24    ;BIAS FOR SYSTEMS LARGER THAN 16K
29ØØ =          CPMB        EQU      CBASE+29ØØH        ;BASE OF CP/M (= BASE OF CCP)
32Ø6 =          BDOS        EQU      CBASE+32Ø6H        ;BASE OF RESIDENT PORTION OF CP/M
15ØØ =          CPML        EQU      $-CPMB             ;LENGTH OF THE CP/M SYSTEM IN BYTES
ØØ2A =          NSECTS      EQU      CPML/128  ;NUMBER OF SECTORS TO LOAD ON WARM START
                ;
                ; JUMP VECTOR FOR INDIVIDUAL SUBROUTINES
3EØØ C32D3E       JMP       BOOT               ;COLD START
                WBOOTE:
3EØ3 C33Ø3E       JMP       WBOOT              ;WARM START
3EØ6 C3993E       JMP       CONST              ;CONSOLE STATUS
3EØ9 C3AC3E       JMP       CONIN              ;CONSOLE CHARACTER IN
3EØC C3BF3E       JMP       CONOUT             ;CONSOLE CHARACTER OUT
3EØF C3D13E       JMP       LIST               ;LIST CHARACTER OUT
3E12 C3D33E       JMP       PUNCH              ;PUNCH CHARACTER OUT
3E15 C3D53E       JMP       READER             ;READER CHARACTER OUT
3E18 C3DA3E       JMP       HOME               ;MOVE HEAD TO HOME POSITION
3E1B C3EØ3E       JMP       SELDSK             ;SELECT DISK
3E1E C3F53E       JMP       SETTRK             ;SET TRACK NUMBER
3E21 C3ØA3F       JMP       SETSEC             ;SET SECTOR NUMBER
3E24 C31F3F       JMP       SETDMA             ;SET DMA ADDRESS
3E27 C3353F       JMP       READ               ;READ DISK
3E2A C3483F       JMP       WRITE              ;WRITE DISK
                ;
                ;
                ; INDIVIDUAL SUBROUTINES TO PERFORM EACH FUNCTION
                BOOT:      ;SIMPLEST CASE IS TO JUST PERFORM PARAMETER INITIALIZATION
3E2D C3793E      JMP       GOCPM             ;INITIALIZE AND GO TO CP/M
                ;
                WBOOT:     ;SIMPLEST CASE IS TO READ THE DISK UNTIL ALL SECTORS LOADED
3E30 318000      LXI       SP,80H            ;USE SPACE BELOW BUFFER FOR STACK
3E33 0E00        MVI       C,0               ;SELECT DISK 0
3E35 CDE03E      CALL      SELDSK
3E38 CDDA3E      CALL      HOME              ;GO TO TRACK 00
                ;
3E3B 062A        MVI       B,NSECTS  ;B COUNTS THE NUMBER OF SECTORS TO LOAD
3E3D 0E00        MVI       C,0               ;C HAS THE CURRENT TRACK NUMBER
3E3F 1602        MVI       D,2               ;D HAS THE NEXT SECTOR TO READ
                ; NOTE THAT WE BEGIN BY READING TRACK 0, SECTOR 2 SINCE SECTOR 1
                ; CONTAINS THE COLD START LOADER, WHICH IS SKIPPED IN A WARM START
3E41 210029      LXI       H,CPMB            ;BASE OF CP/M (INITIAL LOAD POINT)
                LOAD1:     ;LOAD ONE MORE SECTOR
3E44 C5          PUSH      B        ;SAVE SECTOR COUNT, CURRENT TRACK
3E45 D5          PUSH      D        ;SAVE NEXT SECTOR TO READ
3E46 E5          PUSH      H        ;SAVE DMA ADDRESS
3E47 4A          MOV       C,D      ;GET SECTOR ADDRESS TO REGISTER C
3E48 CD0A3F      CALL      SETSEC   ;SET SECTOR ADDRESS FROM REGISTER C
3E4B C1          POP       B        ;RECALL DMA ADDRESS TO B,C
3E4C C5          PUSH      B        ;REPLACE ON STACK FOR LATER RECALL
3E4D CD1F3F      CALL      SETDMA   ;SET DMA ADDRESS FROM B,C
                ;
                ; DRIVE SET TO 0, TRACK SET, SECTOR SET, DMA ADDRESS SET
3E50 CD353F      CALL      READ
3E53 FE00        CPI       00H      ;ANY ERRORS?
3E55 C2303E      JNZ       WBOOT    ;RETRY THE ENTIRE BOOT IF AN ERROR OCCURS
                ;
                ; NO ERROR, MOVE TO NEXT SECTOR
3E58 E1          POP       H        ;RECALL DMA ADDRESS
3E59 118000      LXI       D,128    ;DMA=DMA+128
3E5C 19          DAD       D        ;NEW DMA ADDRESS IS IN H,L
3E5D D1          POP       D        ;RECALL SECTOR ADDRESS
3E5E C1          POP       B        ;RECALL NUMBER OF SECTORS REMAINING, AND CURRENT TRK
3E5F 05          DCR       B        ;SECTORS=SECTORS-1
3E60 CA793E      JZ        GOCPM    ;TRANSFER TO CP/M IF ALL HAVE BEEN LOADED
                ;
                ; MORE SECTORS REMAIN TO LOAD, CHECK FOR TRACK CHANGE
3E63 14          INR       D
3E64 7A          MOV       A,D      ;SECTOR=27?, IF SO, CHANGE TRACKS
3E65 FE1B        CPI       27
3E67 DA443E      JC        LOAD1    ;CARRY GENERATED IF SECTOR<27
                ;
                ; END OF CURRENT TRACK, GO TO NEXT TRACK
3E6A 1601        MVI       D,1      ;BEGIN WITH FIRST SECTOR OF NEXT TRACK
3E6C 0C          INR       C        ;TRACK=TRACK+1
                ;
                ; SAVE REGISTER STATE, AND CHANGE TRACKS
```

```
3E6D C5          PUSH      B
3E6E D5          PUSH      D
3E6F E5          PUSH      H
3E7Ø CDF53E      CALL      SETTRK     ;TRACK ADDRESS SET FROM REGISTER C
3E73 E1          POP       H
3E74 D1          POP       D
3E75 C1          POP       B
3E76 C3443E      JMP       LOAD1      ;FOR ANOTHER SECTOR
                ;
                ; END OF LOAD OPERATION, SET PARAMETERS AND GO TO CP/M
                GOCPM:
3E79 3EC3        MVI       A,ØC3H     ;C3 IS A JMP INSTRUCTION
3E7B 32ØØØØ      STA       Ø          ;FOR JMP TO WBOOT
3E7E 21Ø33E      LXI       H,WBOOTE   ;WBOOT ENTRY POINT
3E81 22Ø1ØØ      SHLD      1          ;SET ADDRESS FIELD FOR JMP AT Ø
                ;
3E84 32Ø5ØØ      STA       5          ;FOR JMP TO BDOS
3E87 21Ø632      LXI       H,BDOS     ;BDOS ENTRY POINT
3E8A 22Ø6ØØ      SHLD      6          ;ADDRESS FIELD OF JUMP AT 5 TO BDOS
                ;
3E8D Ø18ØØØ      LXI       B,8ØH      ;DEFAULT DMA ADDRESS IS 8ØH
3E9Ø CD1F3F      CALL      SETDMA
                ;
3E93 FB          EI                   ;ENABLE THE INTERRUPT SYSTEM
                ; FUTURE VERSIONS OF CCP WILL SELECT THE DISK GIVEN BY REGISTER
                ; C UPON ENTRY, HENCE ZERO IT IN THIS VERSION OF THE BIOS FOR
                ; FUTURE COMPATIBILITY.
3E94 ØEØØ        MVI       C,Ø        ;SELECT DISK ZERO AFTER INITIALIZATION
3E96 C3ØØ29      JMP       CPMB       ;GO TO CP/M FOR FURTHER PROCESSING
                ;
                ;
                ; SIMPLE I/O HANDLERS (MUST BE FILLED IN BY USER)
                ; IN EACH CASE, THE ENTRY POINT IS PROVIDED, WITH SPACE RESERVED
                ; TO INSERT YOUR OWN CODE
                ;
                CONST:      ;CONSOLE STATUS, RETURN ØFFH IF CHARACTER READY, ØØH IF NOT
3E99             DS        1ØH        ;SPACE FOR STATUS SUBROUTINE
3EA9 3EØØ        MVI       A,ØØH
3EAB C9          RET
                ;
                CONIN:      ;CONSOLE CHARACTER INTO REGISTER A
3EAC             DS        1ØH        ;SPACE FOR INPUT ROUTINE
3EBC E67F        ANI       7FH        ;STRIP PARITY BIT
3EBE C9          RET
                ;
                CONOUT: ;CONSOLE CHARACTER OUTPUT FROM REGISTER C
3EBF 79          MOV       A,C        ;GET TO ACCUMULATOR
3ECØ             DS        1ØH        ;SPACE FOR OUTPUT ROUTINE
3EDØ C9          RET
                ;
```

```
                 LIST:      ;LIST CHARACTER FROM REGISTER C
3ED1 79           MOV       A,C         ;CHARACTER TO REGISTER A
3ED2 C9           RET                   ;NULL SUBROUTINE
                 ;
                 PUNCH:     ;PUNCH CHARACTER FROM REGISTER C
3ED3 79           MOV       A,C         ;CHARACTER TO REGISTER A
3ED4 C9           RET                   ;NULL SUBROUTINE
                 ;
                 ;
                 READER: ;READ CHARACTER INTO REGISTER A FROM READER DEVICE
3ED5 3E1A         MVI       A,1AH       ;ENTER END OF FILE FOR NOW (REPLACE LATER)
3ED7 E67F         ANI       7FH         ;REMEMBER TO STRIP PARITY BIT
3ED9 C9           RET
                 ;
                 ;
                 ; I/O DRIVERS FOR THE DISK FOLLOW
                 ; FOR NOW, WE WILL SIMPLY STORE THE PARAMETERS AWAY FOR USE
                 ; IN THE READ AND WRITE SUBROUTINES
                 ;
                 HOME:      ;MOVE TO THE TRACK ØØ POSITION OF CURRENT DRIVE
                 ; TRANSLATE THIS CALL INTO A SETTRK CALL WITH PARAMETER ØØ
3EDA ØEØØ         MVI       C,Ø         ;SELECT TRACK Ø
3EDC CDF53E       CALL      SETTRK
3EDF C9           RET                   ;WE WILL MOVE TO ØØ ON FIRST READ/WRITE
                 ;
                 SELDSK:    ;SELECT DISK GIVEN BY REGISTER C
3EEØ 79           MOV       A,C
3EE1 32FC3D       STA       DISKNO
3EE4              DS        1ØH         ;SPACE FOR DISK SELECTION ROUTINE
3EF4 C9           RET
                 ;
                 SETTRK:    ;SET TRACK GIVEN BY REGISTER C
3EF5 79           MOV       A,C
3EF6 32F63D       STA       TRACK
3EF9              DS        1ØH         ;SPACE FOR TRACK SELECT
3FØ9 C9           RET
                 ;
                 SETSEC:    ;SET SECTOR GIVEN BY REGISTER C
3FØA 79           MOV       A,C
3FØB 32F73D       STA       SECTOR
3FØE              DS        1ØH         ;SPACE FOR SECTOR SELECT
3F1E C9           RET
                 ;
                 SETDMA:    ;SET DMA ADDRESS GIVEN BY REGISTERS B AND C
3F1F 69           MOV       L,C         ;LOW ORDER ADDRESS
3F2Ø 6Ø           MOV       H,B         ;HIGH ORDER ADDRESS
3F21 22F83D       SHLD      DMAAD       ;SAVE THE ADDRESS
3F24              DS        1ØH         ;SPACE FOR SETTING THE DMA ADDRESS
3F34 C9           RET
                 ;
```

```
                READ:       ;PERFORM READ OPERATION (USUALLY THIS IS SIMILAR TO WRITE
                ; SO WE WILL ALLOW SPACE TO SET UP READ COMMAND, THEN USE
                ; COMMON CODE IN WRITE)
3F35             DS         1ØH        ;SET UP READ COMMAND
3F45 C3583F      JMP        WAITIO     ;TO PERFORM THE ACTUAL I/O
                ;
                WRITE:      ;PERFORM A WRITE OPERATION
3F48             DS         1ØH        ;SET UP WRITE COMMAND
                ;
                WAITIO:     ;ENTER HERE FROM READ AND WRITE TO PERFORM THE ACTUAL I/O
                ; OPERATION.  RETURN A ØØH IN REGISTER A IF THE OPERATION COMPLETES
                ; PROPERLY, AND Ø1H IF AN ERROR OCCURS DURING THE READ OR WRITE
                ;
                ; IN THIS CASE, WE HAVE SAVED THE DISK NUMBER IN 'DISKNO' (Ø,1)
                ;                             THE TRACK NUMBER IN 'TRACK' (Ø-76)
                ;                             THE SECTOR NUMBER IN 'SECTOR' (1-26)
                ;                             THE DMA ADDRESS IN 'DMAAD' (Ø-65535)
                ; ALL REMAINING SPACE FROM $ THROUGH MSIZE*1Ø24-1 IS AVAILABLE:
ØØA7 =          LEFT        EQU        (MSIZE*1Ø24-1)-$    ;SPACE REMAINING IN CBIOS
                ;
3F58 3EØ1        MVI        A,1        ;ERROR CONDITION
3F5A C9          RET                   ;REPLACED WHEN FILLED-IN
3F5B             END
```

```
               ; COMBINED GETSYS AND PUTSYS PROGRAMS FROM SECTION 4
               ;
               ; START THE PROGRAMS AT THE BASE OF THE TRANSIENT PROGRAM AREA
0100            ORG       100H
0010 =         MSIZE      EQU       16        ;SIZE OF MEMORY IN KILOBYTES
               ; BIAS IS THE AMOUNT TO ADD TO ADDRESSES FOR SYSTEMS LARGER THAN 16K
               ; (REFERRED TO AS 'B' THROUGHOUT THE TEXT)
0000 =         BIAS       EQU       (MSIZE-16)*1024
               ;
               ; GETSYS PROGRAM - READ TRACKS 0 AND 1 TO MEMORY AT 2880H+BIAS
               ; REGISTER            USE
               ;   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 THE GETSYS PROGRAM
0100 318028     LXI       SP,2880H+BIAS       ;SET STACK POINTER TO SCRATCH AREA
0103 218028     LXI       H,2880H+BIAS        ;SET BASE LOAD ADDRESS
0106 0600       MVI       B,0                 ;START WITH TRACK 00
               RDTRK:                                   ;READ FIRST (NEXT) TRACK
0108 0E01       MVI       C,1                 ;READ STARTING WITH SECTOR 1
               RDSEC:
010A CD0003     CALL      READSEC             ;READ NEXT SECTOR
010D 118000     LXI       D,128               ;CHANGE LOAD ADDRESS TO NEXT 1/2 PAGE
0110 19         DAD       D                   ;HL=HL+128 TO NEXT ADDRESS
0111 0C         INR       C                   ;SECTOR=SECTOR+1
0112 79         MOV       A,C                 ;CHECK FOR END OF TRACK
0113 FE1B       CPI       27
0115 DA0A01     JC        RDSEC               ;CARRY GENERATED IF C<27
               ;
               ; 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 TRACK
011A FE02       CPI       2                   ;TRACK=2?
011C DA0801     JC        RDTRK               ;CARRY GENERATED IF TRACK < 2
               ;
               ; ARRIVE HERE AT END OF LOAD, HALT FOR NOW
011F FB         EI
0120 76         HLT
               ;
               ; PUTSYS PROGRAM - PLACE MEMORY STARTING AT 2880H+BIAS BACK TO TRACKS
               ; 0 AND 1.  START THIS PROGRAM ON THE NEXT PAGE
0200            ORG       ($+100H) AND 0FF00H
               ; REGISTER                      USE
               ;   A                           (SCRATCH REGISTER)
               ;   B                           TRACK COUNT (0,1)
               ;   C                           SECTOR COUNT (1...26)
               ;   D,E                         (SCRATCH REGISTER PAIR)
               ;   H,L                         DUMP ADDRESS
               ;   SP                          SET TO STACK ADDRESS
               ;
               PSTART:              ;START OF THE PUTSYS PROGRAM
0200 318028     LXI       SP,2880H+BIAS        ;SET STACK POINTER TO SCRATCH AREA
0203 218028     LXI       H,2880H+BIAS         ;SET BASE DUMP ADDRESS
0206 0600       MVI       B,0                  ;START WITH TRACK 0
               WRTRK:                                    ;WRITE FIRST (NEXT) TRACK
0208 0E01       MVI       C,1                  ;START WRITING AT SECTOR 1
               WRSEC:                                    ;WRITE FIRST (NEXT) SECTOR
020A CD8003     CALL      WRITESEC  ;PERFORM THE WRITE
020D 118000     LXI       D,128                ;MOVE DUMP ADDRESS TO NEXT 1/2 PAGE
0210 19         DAD       D                    ;HL=HL+128
0211 0C         INR       C                    ;SECTOR=SECTOR+1
0212 79         MOV       A,C                  ;CHECK FOR END OF TRACK
0213 FE1B       CPI       27                   ;SECTOR=27?
0215 DA0A02     JC        WRSEC                ;CARRY GENERATED IF SECTOR < 27
               ;
               ; ARRIVE HERE AT END OF TRACK, MOVE TO NEXT TRACK
0218 04         INR       B                    ;TRACK=TRACK+1
0219 78         MOV       A,B                  ;TEST FOR LAST TRACK
021A FE02       CPI       2                    ;TRACK=2?
021C DA0802     JC        WRTRK                ;CARRY GENERATED IF TRACK < 2
               ;
               ; ARRIVE HERE AT END OF DUMP, HALT FOR NOW
021F FB         EI
0220 76         HLT
               ;
               ;
               ; USER-SUPPLIED SUBROUTINES FOR SECTOR READ AND SECTOR WRITE
               ;
               ; MOVE TO NEXT PAGE FOR READSEC AND WRITESEC
0300            ORG       ($+100H) AND 0FF00H
               ;
               READSEC:             ;READ THE NEXT SECTOR
               ; TRACK TO READ IS IN REGISTER B
               ; SECTOR TO READ IS IN REGISTER C
               ; BRANCH TO LABEL GSTART IF ERROR OCCURS
               ; READ 128 BYTES OF DATA TO ADDRESS GIVEN BY H,L
0300 C5         PUSH      B
0301 E5         PUSH      H
               ; ** PLACE READ OPERATION HERE **
0302 E1         POP       H
0303 C1         POP       B
0304 C9         RET
               ;
               ; MOVE TO NEXT 1/2 PAGE FOR WRITESEC SUBROUTINE
```

```
0380            ORG     ($ AND 0FF00H) + 80H
              WRITESEC:             ;WRITE THE NEXT SECTOR
              ; TRACK TO WRITE IS IN REGISTER B
              ; SECTOR TO WRITE IS IN REGISTER C
              ; BRANCH TO LABEL PSTART IF ERROR OCCURS
              ; WRITE 128 BYTES OF DATA FROM ADDRESS GIVEN BY H,L
0380 C5         PUSH    B
0381 E5         PUSH    H
              ; ** PLACE WRITE OPERATION HERE **
0382 E1         POP     H
0383 C1         POP     B
0384 C9         RET
              ;
              ; END OF GETSYS/PUTSYS PROGRAM
0385            END
```

```
                ; THIS IS A SAMPLE COLD START LOADER WHICH, WHEN MODIFIED, RESIDES
                ; ON TRACK ØØ, SECTOR Ø1 (THE FIRST SECTOR ON THE DISKETTE).  WE
                ; ASSUME THAT THE CONTROLLER HAS LOADED THIS SECTOR INTO MEMORY
                ; UPON SYSTEM STARTUP (THIS PROGRAM CAN BE KEYED-IN, OR EXIST IN
                ; A PAGE OF 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´ (NOMINALLY 29ØØH) + ´BIAS´ WHERE
                ; THE BIAS VALUE ACCOUNTS FOR MEMORY SYSTEMS LARGER THAN 16K, AND
                ; CP/M VERSIONS WHICH HANDLE THE LARGER MEMORY SPACE.  IN A 16K
                ; SYSTEM, THE VALUE OF BIAS IS ØØØØH.  AFTER LOADING THE CP/M SYS-
                ; TEM, THE COLD START LOADER BRANCHES TO THE ´BOOT´ ENTRY POINT OF
                ; THE BIOS, WHICH BEGINS AT ´BIOS´ + ´BIAS´.  THE COLD START LOADER
                ; IS NOT USED AGAIN UNTIL THE SYSTEM IS POWERED UP AGAIN, AS LONG
                ; AS THE BIOS IS NOT OVERWRITTEN.
                ;
                ; THE ORGIN IS Ø, ASSUMING THE CONTROLLER LOADS THE COLD START
                ; PROGRAM AT THE BASE OF MEMORY.  THIS ORIGIN MUST BE IN HIGH
                ; MEMORY (BEYOND THE END OF THE BIOS) IF THE COLD START LOADER
                ; IS IMPLEMENTED IN READ-ONLY-MEMORY.
ØØØØ              ORG       ØØØØH     ;BASE OF MEMORY
ØØ1Ø =          MSIZE       EQU       16        ;MEMORY SIZE IN KILOBYTES
ØØØØ =          BIAS        EQU       (MSIZE-16)*1Ø24     ;BIAS TO ADD TO LOAD ADDRESSES
29ØØ =          LOADP       EQU       29ØØH     ;LOAD POINT FOR CP/M SYSTEM
3EØØ =          BIOS        EQU       3EØØH     ;BASIC I/O SYSTEM (2 PAGES = 512 BYTES)
3EØØ =          BOOT        EQU       BIOS      ;COLD START ENTRY POINT IN BIOS
17ØØ =          SIZE        EQU       BIOS+512-LOADP      ;SIZE OF THE CP/M SYSTEM TO LOAD
ØØ2E =          SECTS       EQU       SIZE/128  ;NUMBER OF SECTORS TO LOAD
                ;
                ; BEGIN THE LOAD OPERATION
ØØØØ Ø1Ø2ØØ     COLD:       LXI       B,2                 ;CLEAR B TO Ø, SET C TO SECTOR 2
ØØØ3 162E         MVI       D,SECTS   ;NUMBER OF SECTORS TO LOAD IS IN D
ØØØ5 21ØØ29       LXI       H,LOADP+BIAS                  ;LOAD POINT IN H,L
                ;
                LSECT:      ;LOAD NEXT SECTOR
                ; INSERT INLINE CODE AT THIS POINT TO READ ONE 128 BYTE SECTOR
                ; FROM TRACK GIVEN BY REGISTER B,
                ;     SECTOR GIVEN BY REGISTER C,
                ; INTO ADDRESS GIVEN BY REGISTER PAIR H,L
                ; BRANCH TO LOCATION ´COLD´ IF A READ ERROR OCCURS
                ;
                ; *********************************************************
                ; USER SUPPLIED READ OPERATION GOES HERE
                ; *********************************************************
                ; (SPACE IS RESERVED FOR YOUR PATCH)
ØØØ8 C36BØØ       JMP       PASTPATCH ;REMOVE THIS JUMP WHEN PATCHED
ØØØB              DS        6ØH
                ;
                PASTPATCH:
```

```
                ; GO TO NEXT SECTOR IF LOAD IS INCOMPLETE
006B 15           DCR      D                   ;SECTS=SECTS-1
006C CA003E       JZ       BOOT+BIAS           ;GO TO BOOT LOADER AT 3E00H+BIAS
                ;
                ; MORE SECTORS TO LOAD
                ; USE SP FOR SCRATCH REGISTER TO HOLD LOAD ADDRESS INCREMENT
006F 318000       LXI      SP,128
0072 39           DAD      SP                  ;HL=HL+128 TO NEXT LOAD ADDRESS
                ;
0073 0C           INR      C                   ;SECTOR=SECTOR+1
0074 79           MOV      A,C                 ;MOVE SECTOR COUNT TO A FOR COMPARE
0075 FE1B         CPI      27                  ;END OF CURRENT TRACK?
0077 DA0800       JC       LSECT               ;CARRY GENERATED IF SECTOR < 27
                ;
                ; END OF TRACK, MOVE TO NEXT TRACK
007A 0E01         MVI      C,1                 ;SECTOR=1
007C 04           INR      B                   ;TRACK=TRACK+1
007D C30800       JMP      LSECT               ;FOR ANOTHER SECTOR
                ;
0080              END
```

APPENDIX 1

IMSAI BOOT PROGRAM LISTING

```
                ;BOOT.ASM  VER 1.31 REV 0   JRB  12/13/76
                ;
                ; IMSAI CP/M BOOTSTRAP ROUTINE
                ;
                ;THIS PROGRAM RESIDES ON TRACK 0, SECTOR 1 AND 2 OF
                ;ALL CP/M SYSTEM DISKS AND IS READ INTO RAM AT
                ;LOCATION 0 AND EXECUTED FOR BOTH COLD AND WARM
                ;START BOOTSTRAPS.


                ; COPYRIGHT (C) 1976,
                ;       IMSAI MANUFACTURING CORP.
                ;       14860 WICKS BLVD, SAN LEANDRO, CA  94577, USA



                ;
                ; SYSTEM RAM EQUATES
                ;
0000 =          BBASE   EQU  0                  ;WHERE THIS PROGRAM RUNS
0080 =          BBASE2  EQU  80H                ;WHERE SECTOR 2 OF THIS PROGRAM RUNS
4000 =          MEMT    EQU  4000H              ;TOP OF MEMORY, BEFORE RELOCATION BY CPM PROGRAM
2800 =          SYSBOTTOM EQU MEMT-1800H        ;FIRST LOCATION OCCUPIED BY SYSTEM
3106 =          ENTRYPOINT EQU MEMT-4*1024+256+6   ;WHERE SYSTEM CALLS ENTER SYSTEM
3D00 =          BIOS    EQU  MEMT-300H          ;WHERE BASIC I/O SYSTEM ENTRIES ARE
3D00 =          BOOTR   EQU  BIOS               ;WHERE COLD BOOT EXITS TO
3D03 =          WBOOT   EQU  BIOS+3             ;WHERE TO GO TO INITIATE WARM BOOT
                                                ;(IE TO GET THIS PROGRAM READ IN AND ENTERED)
3D0C =          CONOUT  EQU  BIOS+0CH           ;ROUTINE TO OUTPUT CHARACTER TO CONSOLE
3D2D =          NXM     EQU  BIOS+02DH          ;WHERE RESTART 7 SHOULD GO
3D30 =          WBOOTR  EQU  BIOS+030H          ;WHERE WARM BOOT RETURNS TO
0040 =          FIFSTRING EQU 40H               ;WHERE TO PRESET FIF STRING PTR 0 TO FOR BIOS
3D33 =          MESSAGE EQU  BIOS+33H           ;LOCATION OF SIGN-ON MSG TEXT IN BIOS
                                                ;N. B. ABOVE MUST MATCH VALUES USED IN BIOS !;
0005 =          ENTRYJMP EQU 5          ;WHERE TO PUT JMP ENTRYPOINT
0000 =          WBOOTJMP EQU 0          ;WHERE TO PUT JMP REBOOT
0003 =          IOBYTE  EQU  3          ;LOCATION OF IO STATUS BYTE

                ;
```

```
                        ;
                        ; SYSTEM DISK LAYOUT EQUATES
                        ;
0000 =                  FTRK     EQU  0           ;FIRST TRACK TO READ
0001 =                  LTRK     EQU  1           ;LAST TRACK TO READ
0001 =                  NSECTB4SYSTEM EQU 1       ;NUMBER OF SECTORS TO SKIP BEFORE READING SYSTEM:
                                                  ;THE ONE SECTOR CONTAINING THIS PROGRAM
                                                  ;SECOND SECTOR OF THIS PROGRAM IS TREATED
                                                  ;AS PART OF SYSTEM EXCEPT IT IS REDIRECTED TO 80H
                        ;AFTER SECTOR 2 SECTORS ON DISK ARE READ INTO MEMORY IN ORDER,
                        ;STOPPING AT MEMT.
                        ;
                        ; I/O DEVICE CONFIGURATION EQUATES
                        ;
00FD =                  DISK     EQU  0FDH        ;FLOPPY DISK PORT
                        ;
00F7 =                  PIC8     EQU  0F7H        ;PRI INT CNTRL BOARD. INITIALIZED, NOT USED.
                        ;
0000 =                  SIOBD    EQU  0           ;BASE PORT # OF SIO BOARD
0003 =                  SIOS1    EQU  SIOBD+3     ;STATUS PORT OF IMSAI SERIAL I/O BOARD TO INITIALIZE
0005 =                  SIOS2    EQU  SIOBD+5     ;STATUS PORT OF TOTHER...
0008 =                  SIOC     EQU  SIOBD+8     ;CONTROL PORT FOR SIO BOARD (BOTH CHANNELS)
                        ;
00F6 =                  PRINTER  EQU  0F6H        ;IMSAI PTR-300^@LINE^@PRINTER PORT
0080 =                  PINIT    EQU  80H         ;COMMAND TO INIT LINE PRINTER
0082 =                  POFF     EQU  82H         ;COMMAND TO TURN MOTOR OFF AND FORM FEED
                        ;
                        ;MISCELLANEOUS
                        ;
0000 =                  SPTR     EQU  0           ;FIF STRING POINTER USED BY BIOS AND BOOT
000C =                  FF       EQU  0CH         ;ASCII FORM FEED CHARACTER




                        ;
```

```
                ;
                ;     THE BOOTSTRAP PORTION OF THIS PROGRAM READS
                ;EVERY NTH SECTOR ON ONE DISK REVOLUTION FOR SPEED,
                ;INTO APPROPRIATE MEMORY LOCATIONS.  DISC CONTAINS
                ;DIRECT MEMORY IMAGE.
                ;       TO MAKE ITS ADDRESS INCREMENTING SCHEME WORK,
                ;THE PROGRAM MUST LOOP OVER AN INTEGRAL NUMBER OF TRACKS.
                ;       HOWEVER, THE PROGRAM DOES NO IO FOR SECTORS
                ;AT BEGINNING OF FIRST TRACK OR END OF LAST TRACK WHICH
                ;DO NOT CONTAIN INFORMATION TO BE READ.
                ;
                ;FLASH!; ANOTHER KLUDGE !; THE SYSTEM INITIALIZER TURNS OOUT TO BE
                ;TOO BIG FOR ONE SECTOR AND THE DISK READER IS A VERY TIGHT FIT.
                ;THE MINIMUM MEMORY MODIFICATION TO READ TRACK 0, SECTOR 2 INTO
                ;LOCATION 80H AS THE REST OF THE INITIALIZER TURNS OUT TO BE
                ;TO ALTER THE RAM ADDRESS FOR THE LOWEST
                ;SECTOR READ.  HENCE THE FOLLOWING 2 EQUATES ARE AS THOUGH
                ;THE SYSTEM STARTS 128 BYTES LOWER IN RAM THAN IT DOES.
                ;
2700 =          FSTDMA  EQU  SYSBOTTOM-NSECTB4SYSTEM*128-128
                                        ;WHERE 1ST SECTOR WOULD BE READ
                                        ;IF IT WERE TO BE READ
2780 =          FSTRDMA EQU  SYSBOTTOM-128      ;FIRST LOCATION TO REALLY READ INTO
                                        ;EXCEPT SEE FLASH NOTE ABOVE
4000 =          LSTDMA  EQU  MEMT       ;FIRST LOCATION BEYOND END OF PROGRAM
                ;
                ;PARAMETERS FOR SKEWING SCHEME
0005 =          SKEW    EQU  5          ;READ EVERY 5FH SECTOR. CHANGE WITH
                                        ;CARE!; 7 ALSO WORKS.
001B =          ETSCT   EQU  27         ;ENDTEST SECTOR NUMBER.  27  WORKS
                                        ;FOR 5 AND 7, BUT OTHER SKEWS MAY
                                        ;CHANGE THIS !
                ;
001A =          NSCTPT  EQU  26         ;NUMBER OF SECTORS PER TRACK
                                        ;N.B. IF THIS CHANGES, REVIEW SKEW AND ETSECT!
0001 =          FSCT    EQU  1          ;NUMBER OF FIRST SECTOR
0080 =          SCTSIZ  EQU  128        ;SIZE OF SECTORS


0100 =          STACK   EQU  100H       ;WHERE TO PUT STACK

                ;
```

```
               ;
0000                   ORG   BBASE

                       ;************************************************
                       ;* WARNING TO ANYONE ALTERING FOLLOWING CODE:   *
                       ;* THERE IS SOMETHING ORG'D AT 40H A FEW LINES  *
                       ;* DOWN. IF YOU INSERT INSTRUCTIONS BEFORE      *
                       ;* IT, YOU MUST MOVE SOME INSTRUCTIONS          *
                       ;* FROM ABOVE TO BELOW IT                       *
                       ;************************************************

               ;
               ; ENTRY VECTOR
               ;
0000 16FF              MVI   D,0FFH     ;COLD START, ENTERED BY HARDWARE BOOT
0002 21                DB   21H         ;LXI H,  OP CODE: SKIP OVER MVI D,0
0003                   ORG   BBASE+3
0003 1600      WBOOTE: MVI   D,0        ;WARM START. BIOS JMPS HERE AFTER READING SECTOR
                                        ;1, TRACK 0.  B AND C CONTAIN VALUES TO
                                        ;PRESERVE !!
                       ;FLAG IN D IS PRESERVED THRU DISK READ:
                       ;NON-0 FOR COLD START, 0 FOR WARM START.


               ; ***************************************************************
               ;
               ;
               ;       ROUTINE TO READ SYSTEM OFF DISK
               ;
               ;
               ; REGISTER USE
               ;       A       SCRATCH
               ;       BC      WARM START PARAMETERS TO SAVE
               ;       D       WARM/COLD FLAG
               ;       E       SECTOR NUMBER
               ;       HL      RAM ADDRESS/SCRATCH
               ;       SP      SCRATCH/RAM ADDRESS
               ;   STACK IS NOT AVAILABLE UNTIL READ IS COMPLETE:
               ;   A SECTOR IS READ IN OVER IT.
               ;       N. B. DO NOT CLOBBER B, C, OR D !
               ;
```

```
                   ;
                   ; INITITIALIZE TO READ OFF DISK
                   ;
0005 3E10                  MVI  A,10H+SPTR ;"SET STRING PTR"
0007 D3FD                  OUT  DISK
0009 3E40                  MVI  A,FIFSTRING AND OFFH
000B D3FD                  OUT  DISK       ;SET LO STRING ADDRESS
000D AF                    XRA  A          ;MVI A,FIFSTRING SHR 8 AND OFFH
000E D3FD                  OUT  DISK       ;SET HI STRING ADDRESS
                   ;
                   ; INIT RAM ADDRESS IN HL
                   ;
0010 210027                LXI  H,FSTDMA
                   ;
                   ; TOP OF READ TRACKS LOOP
                   ;
0013 3EFC          R0:     MVI  A,(FSCT-SKEW) AND OFFH     ;FIRST SECTOR
                   ;
                   ; TOP OF READ SECTORS LOOP
                   ;
0015 C605          R1:     ADI SKEW        ;COMPUTE NEXT SECTOR
0017 5F                    MOV  E,A        ;SAVE SECTOR NUMBER FOR PROGRAM
0018 324400                STA  BSECT      ;STORE SECTOR FOR FLOPPY INTERFACE
001B 224500                SHLD BBUFAD     ;SET MEMORY ADDRESS FOR DISC
                   ;DON'T READ IF OUT OF ADDR RANGE, BUT CONTINUE LOOPING
001E F9                    SPHL            ;RAM ADDRESS TO SP UNTIL INCREMENTED BELOW
001F 218027                LXI  H,FSTRDMA  ;THIS MUST BE POSITIVE FOR RELOCATION
                           ;NEGATE HL
0022 AF                       XRA A
0023 95                       SUB L
0024 6F                       MOV L,A
0025 3E00                     MVI A,0
0027 9C                       SBB H
0028 67                       MOV H,A
0029 39                    DAD  SP
002A D26A00                JNC  OK ;ADDR TOO LOW: PROVISION FOR THIS PROGRAM TO BE ON 1ST SCTR
                           ;FLASH KLUDGE!; IF ADDRESS IS EXACTLY LOWEST, READ
                           ;TO 80H INSTEAD. THIS GETS 2ND HALF OF THIS PROGRAM.
002D 7D                    MOV  A,L
002E B4                    ORA  H
002F C23800                JNZ  R1A
0032 218000                LXI  H,BBASE2
0035   1500                SHLD BBUFAD
                   R1A:
```

```
0038 210040            LXI  H,LSTDMA
                       ;AGAIN, NEGATE HL
003B AF                   XRA A
003C 95                   SUB L
003D C34700                JMP  BOOT1
                   ;
                   ; PRE-INITIALIZED FIF COMMAND STRING
                   ;
                   ; STUCK IN THIS REDICULOUS PLACE CAUSE IT'S WHERE BIOS
                   ; USES IT, AND IT SAVES THE FEW BYTES OF CODE IT TAKES
                   ; TO SET STRING POINTER AGAIN IN BOOT.
                   ;
0040                      ORG FIFSTRING
0040 21            BCMD:    DB  21H          ;READ SECTOR, UNIT 0 COMMAND
0041 00            BSTAT:   DB 0             ;STATUS BYTE
0042 0000          BTRK:    DB 0,FTRK        ;TRACK
0044 01            BSECT:   DB 1             ;SECTOR
0045 0027          BBUFAD:  DW FSTDMA        ;BUFFER ADDRESS

                   BOOT1:   ;NOW, BACK TO WHAT WE WERE DOING

0047 6F                   MOV L,A          ;FINISH NEGATING HL
0048 3E00                 MVI A,0
004A 9C                   SBB H
004B 67                   MOV H,A
004C 39                DAD  SP
004D DA6A00            JC   OK          ;JMP IF ADDRESS TOO HI:
                                        ;THIS IS TO ALLOW FOR SYSTEM LENGTH
                                        ;BEING OTHER THAN WHOLE # OF TRACK LENGTHS

               ;READ THIS SECTOR
0050 AF        R2:     XRA  A           ;HERE TO RETRY AFTER ERROR
0051 214100            LXI  H,BSTAT     ;POINT STATUS BYTE
0054 77                MOV  M,A         ;ZERO STATUS BYTE
                       ;N. B. A=0 IS ALSO COMMAND FOR DISK
0055 D3FD              OUT  DISK        ;DO IT !
0057 86        WAIT:   ADD  M           ;TOP OF WAIT LOOP
0058 CA5700            JZ WAIT          ;WAIT FOR FIF TO STORE NON-0 STATUS
005B FE01              CPI  1           ;TEST FOR EXACT GOOD RETURN
005D CA6A00            JZ   OK          ;GO INCREMENT TO NEXT SECTOR
               ;
               ;DISPLAY ERROR CODE IN LIGHTS
0060 2F                CMA             ;LIGHTS DISPLAY COMPLEMENT
0061 D3FF              OUT  0FFH
0063 3E21              MVI  A,21H      ;RESTORE THE DRIVE - IT HELPS
0065 D3FD              OUT  DISK
0067 C35000            JMP  R2         ;TRY AGAIN,. AND AGAIN
               OK:
               ;
               ; INCREMENT ADDRESSES WITH SKEW
               ;
               ;NEXT SECTOR: MOVE UP "SKEW" SECTORS, AND ADJUST
               ;MEMORY ADDRESS CORRESPONDINGLY
006A 7B                MOV A,E         ;SECTOR NUMBER TO A
                                       ;("SKEW" IS ADDED TO THIS AT TOP OF LOOP)
006B 218002            LXI  H,SKEW*SCTSIZ ;MEM ADDR INCREMENT
               ;END OF PASS THRU THIS TRACK TEST
006E FE16              CPI  NSCTPT+FSCT-SKEW
0070 FA7B00            JM   DADSP      ;GO UPDATE HL THEN READ. SECTOR IS IN A
               ;END OF TRACK TEST
                       ;CPI  ETSCT-SKEW        ;TEST ON MAGIC NUMBER
                               ;N.B. MAGIC NUMBER IS SAME AS NUMBER JUST TESTED ON !
0073 CA7F00            JZ NXTTRK       ;IF DONE THIS TRACK, GO INCREMENT TRACK
               ;RECYCLE THRU THIS TRACK, GETTING A DIFFERENT GROUP
               ; OF SPACED SECTORS
0076 DE1A              SBI  NSCTPT     ;UNCREMENT SECTOR #
0078 2180F5            LXI  H,(SKEW-NSCTPT)*SCTSIZ  ;MEMORY ADDRESS DECREMENT
007B 39        DADSP:  DAD SP          ;COMPUTE NEXT MEM ADDR, LEAVE IN HL
007C C31500            JMP  R1         ;NOW GO READ. SECTOR IS IN A
                       ;CODE ABOVE HERE MUST FIT BELOW 80H.
                       ;BYTES 80H-EFH ARE READ IT BY THE TIME FIRST
                       ;TRACK READ IS COMPLETE.
               ;NEXT TRACK
007F 39        NXTTRK: DAD  SP         ;INCREMENT MEM ADDR
0080 3A4300            LDA  BTRK+1     ;TRACK
0083 3C                INR  A
0084 324300            STA  BTRK+1
0087 FE02              CPI  LTRK+1     ;HAVE WE DONE LAST TRACK?
0089 FA1300            JM   R0         ;NO, GO READ TRACK
               ;
               ; DONE READING FROM DISC !
               ;
               ;AT THIS POINT STACK CAN BE USED
008[illegible]10001            LXI  SP,STACK
```

```
                        ;
                        ; INITIALIZE BOTH CHANNELS OF IMSAI SERIAL INTERFACE BOARD
                        ;
                        ;IF SIO HAS JUST BEEN RESET, IT EXPECTS A "MODE" THEN A "COMMAND".
                        ;BUT IF IT HASN'T BEEN RESET (WARM START), IT IS NOT EXPECTING A "MODE".
                        ;SO WE SEND IT A DUMMY THAT LEAVES IT EXPECTING A COMMAND REGARDLESS,
                        ;THEN A RESET COMMAND (40H), THEN DESIRED MODE AND COMMAND.
008F 21E800                     LXI  H,SIOSTRING
0092 7E                         MOV  A,M
0093 D303               SIOLUP: OUT  SIOS1
0095 D305                       OUT  SIOS2
0097 23                         INX  H
0098 7E                         MOV  A,M
0099 B7                         ORA  A
009A C29300                     JNZ  SIOLUP
009D AF                         XRA  A          ;TURN OFF INTERUPTS AND
009E D308                       OUT  SIOC       ;...CARRIER DETECT, BOTH CHANNELS
                        ;
                        ; INITIALIZE LINE PRINTER
                        ;
00A0 3E80                       MVI  A,PINIT    ;PRINTER INITIALIZE COMMAND
00A2 D3F6                       OUT  PRINTER
                        ;
                        ; PUT THE VARIOUS JUMPS IN LOWER RAM
                        ;
00A4 3EC3                       MVI  A,0C3H     ;"JMP" OP CODE
                          ;"JMP REBOOT" AT 0
00A6 21033D                     LXI  H,WBOOT
00A9 320000                     STA  WBOOTJMP
00AC 220100                     SHLD WBOOTJMP+1
                          ;"JMP ENTRYPOINT" AT 5 FOR SYSTEM CALLS
00AF 210631                     LXI  H,ENTRYPOINT
00B2 320500                     STA  ENTRYJMP
00B5 220600                     SHLD ENTRYJMP+1
                          ;"JMP NXM" FOR RESTART 7 (DDT WILL CHANGE IF USED).  THIS IS ACCESSED AFTER
                          ;  A JMP INTO NON-EXISTENT MEMORY, ALSO BY WRITE PROTECT VIOLATION ON RAM-4A
                          ;  IF WIRED DIRECT TO "INT" LINE BY USER. AN IMSAI EXTENSION OF BIOS FUNCTIONS
00B8 212D3D                     LXI  H,NXM
00BB 323800                     STA  038H
00BE 223900                     SHLD 038H+1
                        ;
                        ; INITIALIZE IOBYTE FROM SWITCHES
                        ;
00C1 DBFF                       IN   0FFH
00C3 320300                     STA  IOBYTE
```

```
                ;
00C6 7A                 MOV  A,D
00C7 B7                 ORA  A
00C8 CAE100             JZ   WBOOT9     ;IF WARM RESTART
                ;
                ; COLD START ONLY:
                ;
                ;    SIGN-ON MESSAGE
00CB 21333D             LXI  H,MESSAGE  ;MESSAGE TEXT IS IN BIOS
00CE 4E         MSLOOP: MOV  C,M
00CF CD0C3D             CALL CONOUT     ;USE CHAR TYPING ROUTINE IN BIOS
00D2 23                 INX  H
00D3 7E                 MOV  A,M
00D4 B7                 ORA  A
00D5 C2CE00             JNZ  MSLOOP
                ;
                ;    INITIALIZE IMSAI PRIORITY INTERRUPT CONTROL BOARD
                ;       THIS CODE SETS IT AS THO A LEVEL 6 INT IS RUNNING,
                ;       TO DISABLE CHANNELS AND MINIMIZE CHANCE OF PROBLEM FROM
                ;       SPURIOUS INTERRUPT.
                ;       BUT CHANNEL 7 IS LEFT ACTIVE FOR USER TO USE FOR MEMORY
                ;       PROTECT VIOLATION, SINCE IMSAI CP/M DOES INTERCEPT RST-7'S
                ;     USERS USING OTHER INTERRUPTS MAY CHANGE THIS.
00D8 3E09               MVI  A,00001001B
00DA D3F7               OUT  PIC8
                ;
                ;    EXIT TO BIOS WITH DISK TO SELECT IN C
00DC 0E00               MVI  C,0        ;SAY SELECT DISK A
00DE C3003D             JMP  BOOTR      ;EXIT TO BIOS
                ;
                ; WARM RESTART ONLY:
                ;       RESTORE I/O BYTE SAVED IN B REGISTER
                ;       SAVED LOGGED DISK NUMBER IN C IS USED BY CCP
                ;
00E1 78         WBOOT9: MOV  A,B
00E2 320300             STA  IOBYTE
00E5 C3303D             JMP  WBOOTR     ;GO TO BIOS WITH DISK # IN C

                ;BYTES TO SEND TO SIO STATUS PORTS
00E8 AE40AE3700SIOSTRING: DB 0AEH,40H,0AEH,37H,0
00ED 2843292031         DB '(C) 1976'

                ;NOTE THAT STACK WRITES OVER EN   F THIS SECTOR
00F5                    END
```

APPENDIX 2

IMSAI BIOS PROGRAM LISTING

```
                ; BIOS.ASM   VERSION 1.31 REV 0    12/13/76
                ;
                ; BASIC I/O SYSTEM FOR IMSAI CP/M
                ;
                ;VERSION 0.0  GE  8/76
                ;        LATER VERSIONS BY JRB

                ; COPYRIGHT (C) 1976,
                ;       IMSAI MANUFACTURING CORP, 14860 WICKS BLVD, SAN LEANDO, CA 94577 USA


                ;NUMBER OF DISK DRIVES IN SYSTEM
0002 =          NDISKS  EQU  2

                ;MEMORY SIZE
4000 =          MEMT    EQU  4000H      ;BEFORE RELOCATION WITH CPM PROGRAM

                ;WHERE TO ENTER CP/M AFTER WARM OR COLD BOOT:
2800 =          CPMB    EQU  MEMT-1800H

3D00 =          BIOS    EQU  MEMT-3*256 ;LOCATION OF BASIC I/O SYSTEM
3D33 =          MESSAGE EQU  BIOS+33H           ;LOCATION OF SIGN-ON MSG TEXT
0004 =          LOGDISK EQU  4          ;WHERE CCP PUTS LOGGED DISK #
0040 =          BIOSTOR EQU  40H                ;WHERE BIOS STORAGE IS IN PAGE 0 RAM
0040 =          FIFSTRING EQU BIOSTOR           ;FLOPPY INTERFACE COMMAND STRING

                ;WARM BOOT ENTRY INTO BOOTSTRAP ROUTINE ON TRACK 0, SECTOR 1
0003 =          WBOOTE: EQU  3
                ;
```

```
               ;
               ; I/O ASSIGNMENT BYTE IN LOWER RAM
0003 =         IOBYT   EQU  3
               ;
               ; I/O PORT EQUATES
               ;
00FD =         DISK    EQU  0FDH
0000 =         SPTR    EQU  0          ;FIF STRING POINTER USED BY BIOS
0002 =         TTY     EQU  02H
0003 =         TTYS    EQU  03H
0004 =         CRT     EQU  04H
0005 =         CRTS    EQU  05H
               ;
               ;LINE PRINTER
00F6 =         PRINTER EQU  0F6H       ;OUTPUT PORT
0080 =         PINIT   EQU  80H        ;INITIALIZE COMMAND
0082 =         POFF    EQU  82H        ;TURN OFF MOTOR, FORM FEED
00F6 =         PRINTERS  EQU PRINTER    ;STATUS PORT IS SAME AS OUTPUT PORT
               ;PREADY EQU  XXX        ;MASK FOR PRINTER READY STATUS
               ;NO STATUS CHECK NEEDED AFTER SENDING COMMANDS OR SINGLE CHARS
               ;ANYTHING SENT TO PRINTER WITH B7=0 IS TAKEN AS ASCII CHAR TO PRINT

               ;
               ; EQUATES FOR ASCII CHARACTERS
               ;
0003 =         CTRLC   EQU  3
0009 =         TAB     EQU  9
000A =         LF      EQU  0AH
000C =         FF      EQU  0CH
000D =         CR      EQU  0DH
001A =         CTRLZ   EQU  1AH
005F =         UNDERLINE EQU 5FH
007F =         RUBOUT  EQU  7FH
               ;
               ;
3D00                   ORG  BIOS       ;ORIGIN EQUATED ABOVE
               ;
               ; ENTRY POINT TABLE
               ;
3D00 C30028    ENTAB:  JMP  CPMB       ;COLD START. BOOT HAS DONE ALL INIT, GO DIRECT TO CP/M
3D03 C3A93E            JMP  WBOOT      ;COME HERE TO INITIATE REBOOT (VIA LOCATION 0)
3D06 C3BD3D            JMP  CONSTAT
3D09 C3D53D            JMP  CONIN
3D0C C3E33D            JMP  CONOUT
3D0F C3F13D            JMP  LIST
3D12 C3013E            JMP  PUNCH
3D15 C3123E            JMP  READER
3D18 C3963D            JMP  HOME
3D1B C3AF3D            JMP  SELDSK
3D1E C39C3D            JMP  SETTRK
3D21 C3A13D            JMP  SETSEC
3D24 C3A63D            JMP  SETDMA
3D27 C3573D            JMP  READ
3D2A C3613D            JMP  WRITE
3D2D C38B3E            JMP  NXM        ;FOR RESTART 7: GIVE ERROR MESSAGE
3D30 C30028            JMP  CPMB       ;WARM BOOT RETURNS HERE. GO DIRECT TO CP/M.

               ;
               ; SIGN-ON MESSAGE, TYPED BY BOOT ROUTINE
               ;
3D33 0D0A494D53MESSAGE:  DB CR,LF,'IMSAI 16K CP/M VERS 1.31 ',0

3D4F 2843292031        DB '(C) 1976'
               ;
```

```
                ;
                ; *******************************************
                ;
                ;       DISK ROUTINES
                ;

                ;
                ; READ FROM SELECTED DRIVE/TRACK/SECTOR
                ;
3D57 3A4000     READ:   LDA  CMD
3D5A E60F               ANI  0FH         ; STRIP OLD CMD
3D5C F620               ORI  20H         ; CMD=READ
3D5E C3683D             JMP  W1         ; GO DO IT
                ;
                ; WRITE TO SELECTED DRIVE/TRACK/DISK
                ;
3D61 3A4000     WRITE:  LDA  CMD
3D64 E60F               ANI  0FH        ; STRIP OLD CMD
3D66 F610               ORI  10H        ; CMD=WRITE
3D68 324000     W1:     STA  CMD
                ;
```

```
               ;
               ; EXECUTE COMMAND STRING
               ;
3D6B C5                 PUSH B          ;WARM BOOT REQUIRES BC PRESERVED
3D6C 0E0F               MVI  C,15       ;RETRY COUNT: KEEP AT IT!
3D6E 214100    EX0:     LXI  H,STAT     ;POINT AT STATUS
3D71 AF                 XRA  A
3D72 77                 MOV  M,A        ; ZERO STAT BYTE
3D73 D3FD               OUT  DISK       ; EXEC CMD STRING
3D75 86        EX1:     ADD  M          ;GET STATUS
3D76 CA753D             JZ   EX1        ; LOOP UNTIL STAT<>0
3D79 FE01               CPI  1          ;TEST FOR EXACT GOOD RETURN
3D7B CA8E3D             JZ   EX2        ;GO EXIT IF GOOD
               ;DISC ERROR. CONTROLLER HAS ALREADY RETRIED CRC ERRORS 10 TIMES.
3D7E FEA1               CPI  0A1H       ;TEST FOR NOT READY
3D80 CA6E3D             JZ   EX02       ;WAIT FOREVER FOR DOOR TO BE CLOSED
               ;OTHER ERRORS, DISPLAY CODE IN LIGHTS
3D83 2F                 CMA             ;CAUSE LIGHTS DISPLAY COMPLEMENT
3D84 D3FF               OUT  0FFH       ;TO LIGHTS
               ;HOME THE DRIVE - IT SEEMS TO HELP
3D86 3E2F               MVI  A,2FH      ;HOMES ALL DRIVES
3D88 D3FD               OUT  DISK
3D8A 0D                 DCR  C
3D8B C26E3D             JNZ  EX0
               EX2:
3D8E E6F0               ANI  0F0H       ;ISOLATE ERROR CLASS
3D90 1F                 RAR             ; PUT IN LOWER HALF BYTE
3D91 1F                 RAR
3D92 1F                 RAR
3D93 1F                 RAR
3D94 C1                 POP  B
3D95 C9                 RET
               ;
```

```
                     ;
                     ; ALL DRIVES TO TRACK 0
                     ;AND SET TRACK 0 FOR NEXT OP
                     ;
                     ;CLOBBERS C
3D96 3E2F            HOME:   MVI  A,02FH
3D98 D3FD                    OUT  DISK
3D9A 0E00                    MVI  C,0
                             ;JMP SETTRK
                     ;
                     ; SET TRACK. GET IN REG C.
                     ;
3D9C 79              SETTRK: MOV  A,C
3D9D 324300                  STA  TRK+1
3DA0 C9                      RET
                     ;
                     ; SET SECTOR. GET IN REG C.
                     ;
3DA1 79              SETSEC: MOV  A,C
3DA2 324400                  STA  SECT
3DA5 C9                      RET
                     ;
                     ; SET DMA BUFFER ADDRESS.
                     ;   GET IN REG BC.
                     ;
3DA6 79              SETDMA: MOV  A,C
3DA7 324500                  STA  BUFADR
3DAA 78                      MOV  A,B
3DAB 324600                  STA  BUFADR+1
3DAE C9                      RET
                     ;
                     ; SELECT DISK DRIVE. GET IN REG C.
                     ;   C=0 FOR DRIVE 0, C=1 FOR DRIVE 1
                     ;
                     ;CLOBBERS BC.
3DAF 79              SELDSK: MOV  A,C
3DB0 FE02                    CPI  NDISKS
                             ;RP             ;TOO BIG. DO SOMETHING REASONABLE
3DB2 3E80                    MVI  A,80H      ;TRANSLATE TO IMSAI BIT
3DB4 07              SD1:    RLC
3DB5 0D                      DCR  C
3DB6 F2B43D                  JP   SD1
3DB9 324000                  STA  CMD
3DBC C9                      RET
```

```
               ;
               ;**********************************************
               ;
               ;       LOGICAL DEVICE ROUTINES
               ;
               ;THESE ROUTINES USE VARIOUS PHYSICAL DEVICES
               ; DEPENDING ON CONTENTS OF IOBYT


               ;
               ; CONSOLE STATUS
               ;
3DBD CDC53D    CONSTAT: CALL CONS      ;GETS STATUS OF SPECIFIC DEVICE
3DC0 B7                ORA  A
3DC1 C8                RZ              ;IF NOT READY RETURN 0 IN A
3DC2 3EFF              MVI  A,0FFH     ;ELSE RETURN FF
3DC4 C9                RET
               ;
3DC5 3A0300    CONS:   LDA  IOBYT      ;USE BITS 1-0 TO DETERMINE CONSOLE DEVICE
3DC8 CD213E            CALL RLCDISPATCH
3DCB 3C3E               DW  TTYSTAT
3DCD 613E               DW  CRTSTAT
3DCF D33D               DW  READERSTAT  ;2: BATCH MODE, USE READER DEVICE
3DD1 883E               DW  NULLSTAT    ;3: UNASSIGNED CHANNEL
               ;
               ;READER STATUS FOR BATCH MODE: NEVER A CHARACTER READY.
               ;THIS IS CAUSE PRESENCE OF A CHARACTER FREQUENTLY MEANS
               ;"ABORT WHAT YOU'RE DOING".
3DD3 AF        READERSTAT: XRA A
3DD4 C9                    RET
               ;
               ; CONSOLE IN
               ;
3DD5 3A0300    CONIN:  LDA  IOBYT
3DD8 CD213E            CALL RLCDISPATCH
3DDB 313E               DW  TTYIN       ;0: TTY
3DDD 663E               DW  LSCRTIN     ;1: CRT
                                        ;CHANGE ABOVE TO 'CRTIN' TO GET RID OF SPECIAL FEATURE
3DDF 123E               DW  READER      ;2: BATCH MODE: READER INPUT
3DE1 883E               DW  NULLI       ;3: UNASSIGNED CHANNEL
               ;
```

```
                    ;
                    ; CONSOLE OUT
                    ;
                    ;MUST PRESERVE HL FOR NXM AND BOOTSTRAP
3DE3 3A0300         CONOUT: LDA   IOBYT
3DE6 CD213E                 CALL RLCDISPATCH       ;GO TO ONE OF FOLLOWING ADDRESSES
3DE9 413E                    DW   TTYOUT      ;BITS=0: USE TTY AS CONSOLE
3DEB 723E                    DW   CRTOUT      ;1: CRT
3DED F13D                    DW   LIST        ;2: BATCH MODE: OUTPUT TO LIST  DEVICE
3DEF 723E                    DW   NULLO       ;3: UNASSIGNED
                    ;
                    ; LIST OUT
                    ;
3DF1 3A0300         LIST:   LDA   IOBYT
3DF4 07                     RLC               ;BITS 7-6 TO 2-1
3DF5 07                     RLC
3DF6 CD213E                 CALL RLCDISPATCH
3DF9 413E                    DW   TTYOUT      ;0: TTY
3DFB 723E                    DW   CRTOUT      ;1: CRT
3DFD 843E                    DW   LPTOUT      ;2: LINE PRINTER
3DFF 723E                    DW   NULLO       ;3: UNASSINGNED
                    ;
                    ; PUNCH OUT
                    ;
3E01 3A0300         PUNCH:  LDA   IOBYT       ;BITS 4-5 TO 1-2
3E04 0F                     RRC
3E05 0F                     RRC
3E06 0F                     RRC
3E07 CD223E                 CALL DISPATCH
3E0A 413E                    DW   TTYOUT      ;0: TTY
3E0C 723E                    DW   PUNO        ;1: HIGH SPEED PUNCH
3E0E 723E                    DW   NULLO       ;2: UNASSIGNED
3E10 723E                    DW   NULLO       ;3: UNASSIGNED
                    ;
                    ; READER IN
                    ;
3E12 3A0300         READER: LDA   IOBYT       ;BITS 3-2 TO 2-1
3E15 0F                     RRC
3E16 CD223E                 CALL DISPATCH
3E19 313E                    DW   TTYIN       ;0: TTY
3E1B 883E                    DW   RDRIN       ;1: HIGH SPEED
3E1D 883E                    DW   NULLI       ;2: UNASSIGNED
3E1F 883E                    DW   NULLI       ;3: UNASSIGNED
                    ;
```

```
               ;
               ;
               ;SUBROUTINE TO DISPATCH TO ONE OF 4 FOLLOWING ADDRESSES
               ;DEPENDING ON IOBYT BITS CALLER HAS POSITIONED IN
               ;BITS 2 AND 1 OF A.
               ;RETURNS TO SUBROUTINE CALL PRIOR TO CALL TO DISPATCH.
               ;
3E21 07        RLCDISPATCH: RLC
3E22 E606      DISPATCH: ANI 06H       ;MASK BITS
3E24 E3                XTHL            ;SAVE CALLER'S H, GET TABLE ADDRESS
3E25 D5                PUSH D          ;**
3E26 5F                MOV  E,A
3E27 1600              MVI  D,0        ;SET UP FOR DAD
3E29 19                DAD  D          ;INDEX INTO TABLE
3E2A 7E                MOV  A,M
3E2B 23                INX  H
3E2C 66                MOV  H,M        ;TABLE WORD TO HL
3E2D 6F                MOV  L,A        ;..
3E2E D1                POP  D          ;**
3E2F E3                XTHL            ;PUT ADDRESS OF ROUTINE, GET CALLER'S H
3E30 C9                RET             ;GO TO ROUTINE !
               ;
               ;
               ;****************************************************
               ;
               ;       PHYSICAL DEVICE ROUTINES
               ;
               ;  ADDRESSED BY LOGICAL DEVICE ROUTINES ABOVE,
               ;ALSO TTY AND CRT MAY HAVE EXTERNAL ENTRY POINTS


               ;
               ; TELETYPE INPUT
               ;
3E31 CD3C3E    TTYIN:  CALL TTYSTAT
3E34 CA313E            JZ   TTYIN      ;WAIT FOR A CHAR TO BE AVAILABLE
3E37 DB02              IN   TTY        ;INPUT IT
3E39 E67F              ANI  7FH        ;REMOVE PARITY
3E3B C9                RET
               ;
               TTYSTAT:        ;USED HERE AND IN CONSTAT ABOVE
3E3C DB03              IN   TTYS       ;GET STATUS
3E3E E602              ANI  02H        ;MASK BIT
3E40 C9                RET             ;A IS NON-0 IF CHAR AVAILABLE
               ;
               ; TELETYPE OUTPUT
               ;
               ;CLOBBERS DE. BOOT DEPENDS ON PRESERVING HL
               ;MUST PRESERVE HL FOR NXM, BOOTSTRAP
3E41 DB03      TTYOUT: IN   TTYS       ;STATUS
3E43 0F                RRC             ;TEST BIT 0
3E44 D2413E            JNC  TTYOUT     ;WAIT TILL READY TO ACCEPT CHARACTER
3E47 79                MOV  A,C
3E48 D302              OUT  TTY        ;OUTPUT THE CHARACTER
3E4A FE0D              CPI  CR
3E4C C0                RNZ             ;DONE EXCEPT CR
               ;DELAY 100 MSEC FOR CR, FOR SLOW-RETURNING TERMINALS
3E4D 110429            LXI  D,10500D
3E50 1B        TTYWT1: DCX  D
3E51 B2                ORA  D          ;DEPENDS ON A7=0 AT ENTRY TO ROUTINE
3E52 F2503E            JP   TTYWT1     ;LOOP TAKES 9.5 USEC PER COUNT
3E55 C9                RET
               ;
               ;
               ; CRT INPUT
               ;
3E56 CD613E    CRTIN:  CALL CRTSTAT
3E59 CA563E            JZ   CRTIN
3E5C DB04              IN   CRT
3E5E E67F              ANI  7FH
3E60 C9                RET
               ;
3E61 DB05      CRTSTAT: IN  CRTS
3E63 E602              ANI  02H
3E65 C9                RET
               ;
               ;MORE CONVENIENT CRT INPUT FOR LEAR-SIEGLER ADM-3
               LSCRTIN:
3E66 CD563E            CALL CRTIN      ;GET CHAR FROM REGULAR ROUTINE
               ;IGNORE BREAK KEY - ITS EASY TO FUMBLE AND HIT IT
3E69 CA663E            JZ   LSCRTIN
               ;CONVERT UNDERLINE (ARROW ON OLDER KEYBOARDS) TO RUBOUT
               ;SO IT ISN'T NECESSARY TO USE SHIFT KEY TO CORRECT ERRORS
               ;NOT DESIRABLE IF YOUR KEYBOARD HAS BACK ARROW.
3E6C FE5F              CPI  UNDERLINE
3E6E C0                RNZ
3E6F 3E7F              MVI  A,RUBOUT
3E71 C9                RET
               ;
               ; NOTE: IF TYPEING ^Z TO THE EDITOR ERASES THE SCREEN ON YOUR ADM-3,
               ; OPEN IT UP AND SET THE 'CLEAR SCREEN' SWITCH TO 'DISABLE'.


               ;
               ; CRT OUTPUT
               ;
               ;MUST PRESERVE HL FOR BOOT, NXM
               ;CLOBBERS DE
3E72 DB05      CRTOUT: IN   CRTS
3E74 0F                RRC
3E75 D2723E            JNC  CRTOUT
3E78 79                MOV  A,C
3E79 D304              OUT  CRT
3E7B FE0D              CPI  CR
3E7D C0                RNZ
               ;HOOK FOR USER TO PATCH IN CR WAIT IF DESIRED ON THIS CHANNEL
3E7E  10100            LXI  D,1        ;PUT CODE HERE A LA TTYOUT ABOVE
3E81 C3503E            JMP  TTYWT1
```

```
               ;
               ; LINE PRINTER OUT
               ;
               LPTOUT:
               ; INSERT A STATUS CHECK HERE TO BE SAFE ?
3E84 79                MOV  A,C       ;THE CHARACTER
3E85 D3F6              OUT  PRINTER
3E87 C9                RET
               ;
               ; NULL DEVICE, FOR UNDEFINED DEVICES.
               ;
               ;FOR UNASSIGNED AND AND UNIMPLEMENTED INPUT DEVICES,
               ;HERE IS AN INFINITE SOURCE OF EOF'S:
3E88 3E1A      NULLI:  MVI  A,CTRLZ
3E8A C9                RET
3E88 =         NULLSTAT EQU NULLI      ;CHARACTER ALWAYS READY

               ;DON'T USE CRT FOR UNASS INPUT DEVICES CAUSE IF THERE
               ; IS NO CRT ON SYSTEM BUT INTERFACE BOARD IS PRESENT,
               ; SYSTEM WILL HANG.
               ;
               ;FOR UNUASS AND UNIMP OUTPUT DEVICES, USE CRT.
               ;  IF NO CRT IS PRESENT, THIS IS AN INFINITE DATA SINK.
3E72 =         NULLO   EQU  CRTOUT
               ;
               ; HERE IS WHERE TO PUT HIGH SPEED READER DRIVER
               ;
3E88 =         RDRIN   EQU  NULLI      ;MEANWHILE, USE NULL DEVICE
3E88 =         RDRSTAT EQU  NULLSTAT
               ;
               ; HERE IS WHERE TO PUT HICH SPEED PUNCH DRIVER
               ;
3E72 =         PUNO    EQU  NULLO      ;MEANWHILE, USE NULL DEVICE
               ;
               ;
               ; ***************************************************
               ;
               ;       STARTUP & RESTART STUFF
               ;


               ;
               ; RESTART 7 ROUTINE. PRESUMABLY MEANS JMP TO NON-EXISTENT MEMORY
               ;       TYPES "CRASH" AND TOP OF STACK (PRESUMED TO BE PC)
               ;       AND BYTE TOP OF STACK POINTS TO
               ;
3E8B C1        NXM:    POP  B          ;GET PC OF CRASH (OR MAYBE GARBAGE)
3E8C 310001            LXI  SP,100H    ;SET UP STACK BELOW 100H
3E8F C5                PUSH B          ;SAVE THAT PC
               ;TYPE "CRASH"
3E90 21D33E            LXI  H,NXMMSG
3E93 CDC83E            CALL CONOMSG
               ;TYPE WHAT IS PROBABLY THE PC OF THE PROBLEM
3E96 E1                POP  H          ;GET WHAT WAS ON STACK AT ENTRY TO NXM
3E97 7C                MOV  A,H        ;HI ORDER BYTE
3E98 CDDA3E            CALL HOUT       ;HEX OUTPUT A
3E9B 7D                MOV  A,L        ;LO ORDER BYTE
3E9C CDDA3E            CALL HOUT
               ;TYPE BYTE TOP OF STACK-1 POINTS TO: THIS MIGHT BE THE INSTRUCTION
               ; THAT CAUSED CRASH (RST-7, ETC)
3E9F 0E20              MVI C,' '
3EA1 CDE33D            CALL CONOUT     ;TYPE A SPACE
3EA4 2B                DCX H           ;POINT ONE LESS
3EA5 7E                MOV A,M         ;GET BYTE
3EA6 CDDA3E            CALL HOUT       ;OUTPUT IT
               ;REBOOT THE SYSTEM, SAME AS ANY WARM RESTART
                       ;JMP WBOOT
               ;
               ;
               ; ROUTINE TO INITIATE WARM RESTART
               ;
               ;SET UP TO
               ;READ UNIT A, TRACK 0, SECTOR 1 TO LOCATION 0
3EA9 3E01      WBOOT:  MVI  A,1
3EAB 324000            STA  CMD        ;UNIT 0
3EAE 324400            STA  SECT       ;SECTOR 1
3EB1 210000            LXI  H,0
3EB4 224200            SHLD TRK        ;TRACK 0
3EB7 224500            SHLD BUFADR     ;RAM LOCATION 0
               ;
               ;PRESERVE IOBYTE IN B, SELECTED DISK IN C
               ;(BOOT DOES NOT ALTER THESE REGISTERS)
3EBA 3A0400            LDA  LOGDISK    ;CCP SETS THIS.
3EBD 4F                MOV  C,A
3EBE 3A0300            LDA IOBYT
3EC1 47                MOV B,A
               ;
               ;NOW DO READ - CLOBBERS IOBYTE, DISKN
3EC2 CD573D            CALL READ       ;PRESERVES BC
               ;
               ;GO TO ROUTINE READ FROM SECTOR 1
3EC5 C30300            JMP  WBOOTE
               ;
               ;ROUTINE READ FROM SECTOR 1 RETURNS TO WBOOTR ENTRY TO THIS PACKAGE.
               ;ENTRY CURRENTLY JMPS DIRECTLY TO CONSOLE COMMAND PROCESSOR.
               ;
               ;
               ;OUT OF LINE STUFF FOR NXM
               ;
               ;TYPE MESSAGE HL POINTS TO ON CONSOLE.  TERMINATED BY 0 BYTE
               CONOMSG:
3EC8 7E                MOV  A,M        ;GET A CHAR OF MESSAGE
3EC9 B7                ORA  A          ;SET FLAGS
3ECA C8                RZ              ;DONE IF 0 BYTE
3ECB 4F                MOV  C,A        ;TO C-REG FOR CONOUT
3ECC CDE33D            CALL CONOUT     ;OUTPUT IT ON CONSOLE
3ECF 23                INX  H          ;POINT NEXT CHARACTER
3ED0 C3C83E            JMP  CONOMSG    ;KEEP OUTPUTTING TO END

3ED3 4352415348NXMMSG: DB 'CRASH ',0   ;TEXT USED BY "NXM" ROUTINE
               ;
               ;HEX OUTPUT (A) TO CONSOLE
3EDA F5        HOUT:   PUSH PSW
3EDB 0F                RRC
3EDC 0F                RRC
3EDD 0F                RRC
3EDE 0F                RRC
3EDF CDE33E            CALL HOUTNIBL
3EE2 F1                POP  PSW
               HOUTNIBL:
3EE3 E60F              ANI  0FH        ;MASK 4 BITS
3EE5 FE0A              CPI  10         ;IS IT A OR BIGGER
3EE7 FAEC3E            JM   HNBL1      ;IF NO
3EEA C607              ADI  'A'-'0'-10 ;YES, ADD DIFFERENCE BETWEEN ASCII A AND 9+1
3EEC C630      HNBL1:  ADI  '0'        ;CONVERT IT TO ASCII CHARACTER
3EEE 4F                MOV  C,A        ;TO C REGISTER FOR CONOUT
3EEF C3E33D            JMP  CONOUT     ;PRINT IT AND RETRURN
               ;
```

```
                ENDBIOS:
                ;
                ; I/O VARIABLES
                ;
                ;IN PAGE 0 RAM

0040                    ORG  BIOSTOR
                ;
                ; DISC INTERFACE COMMAND STRING
                FIFSTRING:
0040            CMD:    DS   1
0041            STAT:   DS   1
0042            TRK:    DS   2
0044            SECT:   DS   1
0045            BUFADR: DS   2


                ;
                ; OLD ENTRY POINT FOR SYS
                ;       OFFICIAL ENTRY IS NOW VIA 5, BUT SOME PROGRAMS MAY STILL USE THIS
                ;
3FFD                    ORG  MEMT-3
3FFD C38B3E             JMP  NXM        ;GO TO NXM ROUTINE WHICH WILL PRINT LOC OF "CALL 3FFD"
                ;
3EF2                    ORG  ENDBIOS    ;MAKES ASSEMBLER TYPE OUT END OF VARIABLE CODE

3EF2                    END
```