

# SLIDING INTO BDOS

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### THE SMOOTH AND EASY WAY

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What is this thing everybody is talking about called BDOS? This series will attempt to answer this question in some detail but first we need a little basis to understand WHY in the first place. Digital Research CP/M is an operating system for smaller type micro processor computer systems that is designed to remove much of the normal computer operation drudgery experienced by the computer operator. The operating system software embodies a "system philosophy" that structures and generalizes upon the operating environment of a piece of electronics hardware. The environment presented actually allows that piece of quiet, transistorized machinery to be used at a much higher level. The full impact of what this operating system provides to a computer is most probably felt by the typical micro computer hacker that worked the hard way to get a computer system up and running. While building, debugging, and integrating the pieces, the computer was just a whole bunch of parts interfaced together in an organized manner. However, when the thing is finally a "computer" how does it get used. The low level process of poking data into memory from a front panel or even filling, dumping, or block moving memory data with an EPROM based "monitor program" hardly makes this computer "useful". The process of putting on disks and bringing up CP/M lights the torch for computer usability. In this case the hacker experiences an elated feeling now "NOW I CAN DO SOMETHING!"

Buried inside of the total operating system presentation is the concept of generalization brought up in the previous paragraph. One of the major requirements in order to make a computer useful is that there has to be applications software that performs the jobs intended for the computer. Jobs like accounting, word processing, spread sheet data analysis, or inventory control. Unfortunately the process of producing applications software is very, very expensive. A good package may take anywhere from one to ten man years of development effort to make. If the process of making an applications package had to be custom taylored to a specific hardware environment, then there would not be affordable software available for use upon a given

XYZ computer. Generalization in the operation of a computer environment solves this problem however. With the understanding that at a certain level "all microprocessor computer systems are alike" it is possible, with minimum constraints, to define a set of logical type operations that make a computer useful.

This logical set of operations, for the Digital Research CP/M operating system, is defined within the BDOS portion of the operating system. Here in about 3 1/2 K bytes of tightly written assembly language is the "generalization converter" that takes I/O requests for hardware independant applications programs and turns them into a lower level set of simplistic hardware oriented functions that are then processed through the BIOS. This conversion process is beneficial in the light that CP/M Ver 2.2 can be setup to run on a typical brand XYZ computer for about one half of the effort needed to convert even one of the simplest application packages had that application been written in a hardware dependant manner. Conclusion; software developers can make better, more sophisticated applications available for lower cost and computer users find a competitive software market place where there are many times multiple packages available that perform similar functions.

The thrust of this presentation is to show the prospective applications programmer how to use most of the generalized set of "BDOS System Calls" within Digital Researches CP/M Ver 2.2. The presentation scheme will be to describe all of the functions and use simple examples. The reader is assumed to be modistly familiar with 8080 Assembly Language Programming as all of the examples will be given in machine language. Likewise, in this environment it is assumed by default that the prospective programmer is planning to code in assembly language. If a CP/M compatible high level language is used for programming, such as Digital Research PL/I-80 or Microsoft BASIC-80, then of course the program interface at the "System Call" level becomes transparent to the programmer. Run time subroutines make the high level coded application get converted through yet another step. (One major reason applications code in a high level language runs slower than the equivalent function written in assembly language).

## SUMMARY OF CP/M SYSTEM CALLS

The set of system or "BDOS" I/O entry points available to the CP/M programmer is complete yet simple. The primary beauty of the CP/M system is this small world of completeness. Many programmers familair with other operating systems complain that the CP/M system is weak, unflexible, and incomplete. However, in a microprocessor type computer world, the generalization level defined for the CP/M system allows 85% of all microprocessor type appliciation jobs to be programmed with relative ease. Also, in

my opinion, 8-bit microprocessor hardware is easily capable of performing about 90 percent of the typical tasks targeted for microcomputers. So what is this set of functions? The chart of Figure 1 summarizes, in function number order, all of the system operations specific to CP/M Version 2.2 that will be covered in this presentation. In the subsequent sections that follow the functions will be grouped into categories so that related operations may become familiar with reference to one another.

FIGURE 1. DETAILED SUMMARY OF CP/M 2.2 SYSTEM CALLS

Function Number	DEC	HEX	Function	Entry Value to BDOS Passed in (DE) or (E) regs	Return Value from BDOS Passed in (HL) or (A) register
0	00		System Reset	****	****
1	01		Console Input	****	(A)=character
2	02		Console Output	(E)=character	****
3	03		Reader Input	****	(A)=character
4	04		Punch Output	(E)=character	****
5	05		Printer Output	(E)=character	****
6	06		Direct Console I/O	(E)=0FFH is input (E)=chr is output	(A)=character ****
7	07		Get IOBYTE	****	(A)=IOBYTE
8	08		Set IOBYTE	(E)=IOBYTE	****
9	09		Display Console String	(DE)=string addr	****
10	0A		Input Console String	(DE)=string addr	(A)=# chr input
11	0B		Get Console Status	****	(A)=000H idle (A)=0FFH ready
12	0C		Get CP/M Version Number	****	(HL)=Version #
13	0D		Reset Disk Subsystem	****	****
14	0E		Select Disk Drive	(E)=disk number	****
15	0F		Open a File	(DE)=FCB address	(A)=dir code
16	10		Close a File	(DE)=FCB address	(A)=dir code
17	11		Search for File	(DE)=FCB address	(A)=dir code
18	12		Search for Next	****	(A)=dir code
19	13		Delete File	(DE)=FCB address	(A)=dir code
20	14		Read next Record	(DE)=FCB address	(A)=error code
21	15		Write next Record	(DE)=FCB address	(A)=error code
22	16		Create New File	(DE)=FCB address	(A)=dir code
23	17		Rename File	(DE)=FCB address	(A)=dir code
24	18		Get Login Vector	****	(HL)=login vector
25	19		Get Logged Disk Number	****	(A)=logged disk
26	1A		Set R/W Data Buff Addr	(DE)=buffer addr	****
27	1B		Get Allocation Vector	****	(HL)=alloc vector address
28	1C		Write Protect Disk	(E)=disk number	****
29	1D		Get Read Only Vector	****	(HL)=R/O vector
30	1E		Set File Attributes	(DE)=FCB address	(A)=dir code
31	1F		Get Addr of Disk Parms	****	(HL)=parm addr

32	20	Get/Set User Select	(E)=0FFH get	(A)=current user	
33	21	Read Random Record	(DE)=long FCB adr	(A)=error code	
34	22	Write Random Record	(DE)=long FCB adr	(A)=error code	
35	23	Get Size of File	(DE)=long FCB adr	(r0-2=rec cnt)	
36	24	Set Random Record Num	(DE)=long FCB adr	(r0-2=rec numb)	
37	25	Reset Drive	(DE)=drive vector	****	
38	26	Not used			
39	27	Not used			
40	28	Write Random with	(DE)=long FCB adr	(A)=error code	

-----

The technical means required to "use" or interface to the CP/M system for each function contains a certain common structure that will be discussed here. The base memory page of a CP/M system memory map includes, at a specific memory address, a JUMP instruction to the CP/M BDOS entry point. For most CP/M systems this is address 00005H. To accomplish BDOS I/O the number of the function is placed into the (C) register. If the parameter requires input parameters, then they are passed in the (DE) register pair or the individual (E) register depending upon whether the parameter is a word or byte value. Result information returned by some functions is sent back to the users program in either the (A) register or the (HL) register pair depending upon if the value is a byte or word. The following simple program segment demonstrates the scheme used to output the 26 characters A-Z to the console screen through the use of function number 2.

```
BDOS      EQU      0005H          ;SYSTEM ENTRY
CONOUT    EQU      2              ;OUTPUT FUNCTION

          ORG      0100H          ;TPA BASE
          MVI      B,26           ;PRINT 26 COUNTER
          MVI      C,'A'         ;START WITH 'A'
;
LOOP:     PUSH     B              ;SAVE COUNTER & LETTER
          MOV      E,C           ;LETTER TO (E) FOR OUTPUT
          MVI      C,CONOUT       ;BDOS FUNC TO (C)
          CALL     BDOS           ;GO GO OUTPUT
          POP      B
          INR      C              ;SEQUENCE TO NEXT CHAR
          DCR      B              ;DECREASE CHR COUNTER
          JNZ      LOOP           ;MORE TO DO IF NOT TO ZERO
          RET                    ;IMMEDIATE CCP RETURN
```

## SYSTEM CALLS FOR OPERATOR CONSOLE INPUT AND OUTPUT

Intrinsic to the operation of any computer system, especially of the CP/M gender, is the operator console. The device provides the human interface to the machine and as such

the BDOS includes a generalized set of operator communication functions to perform I/O with the console device. The various options available will each be presented with a brief example.

#### INPUT FROM CONSOLE KEYBOARD: Function 1.

This function waits for and reads in a character from the console device keyboard. The operator typed character is echoed automatically back to the console display if the character is an ASCII printable character (020H to 07EH) or it is a carriage return, line feed, back space, or tab. Note that the BDOS automatically expands tabs to columns of eight characters. Upon outputting the character for the echo, a check is made for console start/stop, CTL-S, and if so the console input routine does not return to the users program until another arbitrary key is depressed.

```
;CONSOLE INPUT EXAMPLE
;
CONIN      EQU      001H          ;FUNC # 1
BDOS       EQU      0005H        ;SYSTEM ENTRY

        ORG      0100H          ;START
        MVI      C,CONIN        ;FUNCTION
        CALL     BDOS           ;GO GET CHARACTER
        STA      INCHAR         ;SAVE FOR WHATEVER REASON
        RET                          ;IMMEDIATE CCP RETURN
;
INCHAR:
        DS       1              ;PLACE TO STORE INPUT CHAR
;
        END
```

#### OUTPUT TO CONSOLE DISPLAY: Function 2.

The ASCII character in the (E) register is sent to the console display device. The output may be any byte value but many times the hardware driver BIOS routines automatically strip off the upper bit of the byte. Upon output the printer echo flag within BDOS is checked (CTL-P) and if set the character is also sent to the printer peripheral device. Note that the BDOS automatically expands output tabs to columns of eight characters. Upon outputting the character a check is made for input of console start/stop, CTL-S, and if so the console output routine does not return to the users program until another arbitrary key is depressed.

```
;CONSOLE OUTPUT EXAMPLE
;
```

```

CONOUT    EQU        002H            ;FUNC # 2
BDOS      EQU        0005H          ;SYSTEM ENTRY

        ORG          0100H          ;START
        LDA          OUTCHAR        ;GET CHARACTER TO OUTPUT
        MOV          E,A
        MVI          C,CONOUT       ;FUNCTION
        CALL         BDOS           ;GO SEND CHARACTER
        RET           ;IMMEDIATE CCP RETURN
;
OUTCHAR:
        DB           'X'            ;PLACE TO GET OUTPUT CHAR
;
        END

```

#### DIRECT USER INTERFACE TO CONSOLE: Function 6.

Some programming applications require that the BDOS not monitor the input/output character stream as is done with functions 1 & 2. To allow for these functions the direct I/O function is supported. The following example shows how it is used to input values and echo them until an input control-Z character is typed.

```

;DIRECT CONSOLE I/O EXAMPLE
;
DIRCIO    EQU        006H            ;FUNCTION NUMBER
BDOS      EQU        0005H          ;SYSTEM ENTRY POINT
CTLZ      EQU        'Z'-040H       ;ASCII CTL-Z CHARACTER
INPUT     EQU        0FFH           ;DIRECT INPUT FLAG

        ORG          0100H          ;CONSOLE INPUT
;
LOOP:
        MVI          E,INPUT        ;SET FOR INPUT
        MVI          C,DIRCIO       ;FUNCTION
        CALL         BDOS           ;GET INPUT OR STATUS
        ORA          A              ;IF (A)=0 NO CHAR WAS READY
        JZ           LOOP           ;CONTINUE TO WAIT FOR INPUT
        CPI          CTLZ           ;IF INPUT WAS CTL Z THEN END
        RZ              ;CCP RETURN ON END
        MOV          E,A            ;CHARACTER TO (E) FOR OUTPUT
        MVI          C,DIRCIO       ;SAME FUNCTION NUMBER AGAIN
        CALL         BDOS           ;GO OUTPUT IT
        JMP          LOOP           ;NEXT CHARACTER INPUT LOOP
;
        END

```

## PRINTING STRINGS OF CHARACTERS TO THE CONSOLE: Function 9.

Message string sequences of characters to be sent to the console are quite common in applications programming. Typical uses may be for user prompt messages, program sign-on messages etc. The BDOS provides a convenient mechanism to allow the programmer to output a whole string of characters rather than having to loop with single character outputs. The string is intended to be stored in consecutive memory locations and end with the ASCII '\$' character. The (DE) registers are used to point to the start of the string. The '\$' signals the end of the string to display and is not sent to the console. The output bytes may be any 8-bit value but many times the hardware driver BIOS routines automatically strip off the upper bit of the byte. Upon output of each character the printer echo flag within BDOS is checked (CTL-P) and if set the character is also sent to the printer peripheral device. Note that the BDOS automatically expands output tabs to columns of eight characters. Upon outputting each character a check is made for input of console start/stop, CTL-S, and if so the console string output routine does not return to the users program until another arbitrary key is depressed.

;CONSOLE STRING PRINT EXAMPLE

```

;
CONSTR    EQU        009H            ;FUNC # 9
BDOS      EQU        0005H          ;SYSTEM ENTRY
CR        EQU        0DH            ;ASCII CARRIAGE RETURN
LF        EQU        0AH            ;ASCII LINE FEED

          ORG        0100H          ;START
          LXI        D,MESSAGE      ;POINT AT STRING TO SEND
          MVI        C,CONSTR       ;FUNCTION
          CALL       BDOS           ;GO SEND STRING
          RET          ;IMMEDIATE CCP RETURN
;
MESSAGE:
          DB         CR,LF,'Hello Operator',CR,LF,'$'
;
          END

```

## READING A STRING OF CHARACTERS IN FROM KEYBOARD: Function 10.

The CP/M console command processor (CCP) assumed to be vary familiar to most CP/M system operators allows buffered command input with editing features. It turns out that this operation is a much needed function for getting in strings of text from the operator console. Use of this function allows standardization of the command input functions so that the operator can easily learn the editing key functions. It also removes the pain of writing the same function over and over again by the applications programmer. The read string command inputs the edited text to a

buffer pointerd to by the (DE) register pair. The caller specifies the maximum length desired and the BDOS returns the actual length of string entered if carriage return is entered prior to exceeding the maximum input length. The input length is returned in both the (A) register and as part of the buffer. Bytes in the string buffer past the end of the entered text are uninitialized. The example shown below gives an assembly language view point of the buffer structure and how to program an input function.

The editing functions supported are the following control and/or special characters:

rub/del	removes and echos the last entered char
ctl-C	initiates system reboot if first char
ctl-E	echos a CR & LF to console without putting them into buffer
ctl-H	(or back space key) back spaces one char removing last entered character
ctl-J	(or line feed key) terminates line input
ctl-M	(or carriage return) terminates input
ctl-R	retypes currently entered characters under current line
ctl-U	deletes all of currently entered data and restarts buffer input on new line
ctl-X	deletes all of currently entered data and restarts buffer input on same line

#### ;CONSOLE INPUT BUFFER EXAMPLE

```
;
CONBUF    EQU        00AH            ;STRING INPUT FUNCTION
BDOS      EQU        0005H          ;SYSTEM ENTRY POINT
LENGTH    EQU        32             ;DESIRED MAXIMUM CHARACTERS

        ORG          0100H          ;START POINT
        LXI          D,STRING        ;POINT AT BUFFER AREA
        MVI          C,CONBUF        ;FUNCTION NUMBER
        CALL         BDOS           ;GO GET STRING
        RET                    ;RETURN TO CCP WITHOUT
                                ;...DOING ANYTHING WITH DATA
;
;
;CONSOLE INPUT BUFFER LAYOUT
;
STRING:
        DB          LENGTH          ;MAXIMUM DESIRED INPUT LENGTH
AMOUNT:
        DS          1               ;BYTE WHERE BDOS RETURNS
                                ;..ACTUAL BYTE COUNT
STRBF:
        DS          LENGTH          ;RESERVED STORAGE FOR UP TO
```



```

;                                ;"LENGTH" NUMBER OF CHARACTERS
;
    END

```

DETERMINING IF THERE IS PENDING KEYBOARD INPUT: Function 11.

Some computer programs are designed to spend large amounts of time processing inside of the computer or manipulating data within disk files without stopping to ask the user if he/she desires to stop the processing sequence. Also it is many times desirable to have a "terminate" capability for application programs without waiting for the operator to answer a character input request. If the normal console input function is used the user computer is not resumed until a character is already input. The console input status check function may be used to poll the user keyboard to determine if a character input is pending. If no input is ready then the user program is immediately resumed with an indication of if there was a pending input. If a character is pending a 0FFH is returned in the (A) register. Otherwise a 000H value is returned. The following example illustrates the use of console status to terminate a normally endless loop that prints the same string over and over.

```

;CONSOLE STATUS USAGE EXAMPLE
;
CONSTAT    EQU        00BH        ;FUNC # 11
CONSTR     EQU        009H        ;PRINT STRING FUNCTION
BDOS       EQU        0005H       ;SYSTEM ENTRY
CR         EQU        0DH         ;ASCII CARRIAGE RETURN
LF         EQU        0AH         ;ASCII LINE FEED

        ORG          0100H        ;START
LOOP:
        LXI          D,MESSAGE    ;POINT AT STRING TO SEND
        MVI          C,CONSTR     ;FUNCTION
        CALL         BDOS         ;GO SEND STRING
        MVI          C,CONSTAT    ;GET ABORT STATUS
        CALL         BDOS
        ORA          A            ;CHECK STATUS
        JZ           LOOP        ;NO KEY SO CONTINUE LOOP
        RET              ;IMMEDIATE CCP RETURN IF ABORT
;
MESSAGE:
        DB           CR,LF,'Depress any Key to STOP','$'
;
        END

```

## AUXILLIARY PERIPHERAL CHARACTER INPUT AND OUTPUT FUNCTIONS

The generalized CP/M BDOS provides the capability for three character by character logical I/O devices to be attached to the computer system. This requirement stems from the fact that most computers are designed to interface to the real world in more ways than just a console device. The three devices are classified as:

a) A lister type device that is generally expected to be a printer of some sort. This classification is an output only device.

b) An input device supporting character input from a source other than the console. The device is specifcally an input type unit. CP/M jargon refers to this device as the "READER" for no particular reason.

c) A generalized character output only device used as a specific data destination other than the console or standard list device. Some computer systems use this device, often times referred to as the "PUNCH" device as a second printer output.

The three following examples illustrate the programming techniques used to talk to each of these three devices.

### ;LIST DEVICE OUTPUT EXAMPLE

```
;
LIST      EQU      005H          ;FUNC # 5
BDOS      EQU      0005H        ;SYSTEM ENTRY

        ORG      0100H          ;START
        LDA      LSTCHAR        ;GET CHARACTER TO OUTPUT
        MOV      E,A
        MVI      C,LIST         ;FUNCTION
        CALL     BDOS           ;GO SEND CHARACTER
        RET                ;IMMEDIATE CCP RETURN
;
LSTCHAR:
        DB       'L'           ;PLACE TO GET OUTPUT CHAR
;
        END
```

### ;READER DEVICE INPUT EXAMPLE

```
;
READER    EQU      003H          ;FUNC # 3
BDOS      EQU      0005H        ;SYSTEM ENTRY

        ORG      0100H          ;START
```

```

        MVI        C,READER        ;FUNCTION
        CALL       BDOS             ;GO GET CHARACTER
        STA        RDRCHR           ;SAVE FOR WHATEVER REASON
        RET                             ;IMMEDIATE CCP RETURN
;
RDRCHR:
        DS         1                ;PLACE TO STORE INPUT CHAR
;
        END

;PUNCH DEVICE OUTPUT EXAMPLE
;
PUNCH    EQU        004H            ;FUNC # 4
BDOS     EQU        0005H          ;SYSTEM ENTRY

        ORG        0100H           ;START
        LDA        PNCHCHR         ;GET CHARACTER TO OUTPUT
        MOV        E,A
        MVI        C,PUNCH        ;FUNCTION
        CALL       BDOS            ;GO SEND CHARACTER
        RET                             ;IMMEDIATE CCP RETURN
;
PNCHCHR:
        DB         'P'            ;PLACE TO GET OUTPUT CHAR
;
        END

```

## SYSTEM CONTROL BDOS FUNCTIONS

This family of system calls supported by the CP/M BDOS are designed to allow the programmer a degree of flexibility in manipulating the operation of general CP/M environment. Each function here will generally be discussed individually due to the unique nature of each operation.

### SYSTEM RESET: Function 0.

The system reset function is designed to allow restart of the CP/M system command processor after a user application completes execution or is aborted. The system reset function is equivalent to a JMP to address 0000H or a CTL-C which forces a system WARM Reboot. The reboot operation de-activates all active drives except drive A: which is re-logged. Operation is extremely simple as:

```

RESET    EQU        000H            ;SYSTEM RESET FUNC

```

```

BDOS      EQU      0005H          ;SYSTEM ENTRY POINT

      ORG      0100H
      MVI      C,RESET
      JMP      BDOS              ;CALL ALSO PERMISSABLE
                                   ;EXCEPT THAT FUNCTION
                                   ;DOES NOT RETURN TO USER
                                   ;PROGRAM

```

GET AND SET IOBYTE: Functions 7 & 8.

The generalized CP/M operating system environment communicates via I/O to "logical" type devices. This means that the console, lister, "reader", and "punch" are just treated as a generic device classifications. The CP/M system allows for and supports, to a degree, the capability for the hardware to contain multiple physical devices (peripherals and/or real I/O devices) within each of the generic logical device classifications. The means to support the assignment of multiple physical devices to a given classification is done through the IOBYTE, normally stored at address 00003H of the base page of the CP/M memory. The BIOS hardware I/O software may thusly be written to easily know which one of two printers to talk to when the BDOS requires output to one of two printers. A "default standard" IOBYTE format has been adopted based upon an 8-bit microprocessor system convention developed by Intel Corp as follows:

		(lister)	(punch)	(reader)	(console)
Logical Devices =>		LST:	PUN:	RDR:	CON:
IOBYTE bits =>		7 6	5 4	3 2	1 0
-----					
Bit pattern					
dec	binary				
0	00	TTY:	TTY:	TTY:	TTY:
1	01	CRT:	PTP:	PTR:	CRT:
2	10	LPT:	UP1:	UR1:	BAT:
3	11	UL1:	UP2:	UR2:	UC1:

The designators in the table specify the "standard types of physical devices and are defined as follows:

TTY: A teletype console with keyboard, hard copy display and possibly an integral tape reader/punch  
 CRT: An interactive cathode ray type terminal with keyboard input and display screen  
 BAT: A batch processor workstation with a card reader type input device and a hard copy display/output device  
 UC1: A user defined alternate "console" unit  
 LPT: Line printer  
 UL1: A user defined list device

PTR: Paper Tape Reader  
 UR1: User defined "reader" character input device  
 UR2: User defined "reader" character input device  
 PTP: Paper Tape Punch  
 UP1: User defined "punch" character output device  
 UP2: User defined "punch" character output device

The BDOS support for the I/O device assignment is a standard mechanism to access the IOBYTE's current value and switch it to some other value. Suppose a CP/M computer had two printers connected as LST: and UL1:. If the applications program needs to switch printing output to another printer, the process could be handled as follows:

```

;GET AND SET IOBYTE EXAMPLE
;
SETIOB    EQU        008H            ;SET IOBYTE FUNCTION
GETIOB    EQU        007H            ;GET IOBYTE FUNCTION
BDOS      EQU        00005H          ;SYSTEM ENTRY POINT
LSTMASK   EQU        11$00$00$00B   ;IOBYTE MASK FOR LIST
                                           ;..DEVICE
LPT       EQU        10$00$00$00B   ;BIT VALUE FOR LPT #1
UL1       EQU        11$00$00$00B   ;BIT VALUE FOR LPT #2

          ORG        0100H            ;PROGRAM START
          MVI        C,GETIOB        ;GO GET CURRENT IOBYTE VAL
          CALL       BDOS
          ANI        (NOT LSTMASK) AND 0FFH ;KEEP ALL OTHER BITS
          ORI        UL1 AND LSTMASK ;SET IOBYTE FOR PRINTER #2
          MOV        E,A
          MVI        C,SETIOB        ;FUNCTION TO RESET THE IOBYTE
          CALL       BDOS
          RET                        ;IMMEDIATE CCP RETURN
;
          END
  
```

GET CP/M VERSION NUMBER: Function 12.

Sometimes it is necessary for an applications program to "know" what version of CP/M the program is running under. Version 2.0 and above support a feature to tell the application program what the version number is. One reason is to permit version dependant functions such as random record file I/O to be used if it is supported by the version of CP/M being used. The system call to get the version number returns a two byte value split into two parts as follows:

```

if (H)=0 then this is a CP/M System
(H)=1 then this is an MP/M System
(L)=version number in hex
  
```

```

if (L)=00 then older than CP/M 2.0
(L)=20 then version CP/M 2.0
(L)=21 then version CP/M 2.1
(L)=22 then version CP/M 2.2

```

A program to read the CP/M version number is as follows:

```

;VERSION NUMBER EXAMPLE
;
GETVERS    EQU        00CH                ;FUNCTION 12
BDOS       EQU        00005H             ;SYSTEM ENTRY POINT

          ORG          0100H              ;PROGRAM START
          MVI          C,GETVERS          ;FETCH VERSION NUMBER
          CALL         BDOS
          MOV          A,L                ;SAVE CP/M VERSION NUMBER
          STA          CURVERS
          RET                          ;BACK TO CCP
;
CURVERS:
          DS           1                  ;STORE THE VERSION NUM HERE
          END

```

RESETTING THE CP/M DISK SYSTEM: Function 13.

The CP/M operating system contains features to control access to files upon the disk drives. A directory checksum scheme, beyond the scope of this presentation, permits the operating system to determine when a disk has been changed in a drive thus preventing the a wrong disk from being written upon. This is neat except that in many cases an applications program may require disk changes as functions are changed or new files are required. This system control function permits the application to force read/write status to be set for all drives, drive A: to be logged, and reset of the default disk record buffer address to its default value of 080H within the CP/M base page. The following program sequence shows how to reset the disk system.

```

;RESET DISK SYSTEM EXAMPLE
;
RESET      EQU        0DH                ;FUNCTION 13
BDOS       EQU        0005H             ;SYSTEM ENTRY POINT

          ORG          0100H              ;PROGRAM START
          MVI          C,RESET            ;SET UP FUNCTION
          CALL         BDOS               ;GO RESET THE DRIVES
          RET                          ;BACK TO THE CCP
;
          END

```

## GET AND SET OF CURRENT USER CODE: Function 32.

CP/M Version 2.2 permits the file system on a given drive to be partitioned into up to 15 individual directory areas so that usage areas can be setup. For instance, the system operator could put all assembly language development programs in one user area while having disk utility programs in another. The BDOS allows the application programmer to determine the currently logged user number and to modify it if necessary. The following example sets the current user number up by one. If the highest user number is currently logged then the user 0 area is selected.

```
;GET/SET USER EXAMPLE
;
GSUSR    EQU        020H        ;FUNCTION 20
GET      EQU        0FFH        ;GET FLAG
BDOS     EQU        0005H        ;SYSTEM ENTRY POINT

        ORG         0100H        ;START UP POINT
        MVI         E,SET        ;MAKE THIS A FETCH NUM RQST
        MVI         C,GSUSR
        CALL        BDOS        ;GET THE CURRENT USER #
        INR         A            ;BUMP RETURNED USER UP 1
        ANI         00FH        ;MASK TO MOD(15)
        MOV         E,A          ;MOVE FOR SET TO NEW USER
        MVI         C,GSUSR
        CALL        BDOS
        RET            ;CCP GETS US BACK
;
        END
```

## SYSTEM FUNCTIONS THAT CONTROL THE DISKS

The data storage files for applications programs are stored upon the disk drives attached to the CP/M computer. The BDOS supports a number of functions that allow the state and selection status of the drives to be controlled.

### SELECT DISK: Function 14.

The simplest control function is to select the current disk with which to refer to as the logged or default disk. The function is equivalent to the console CCP command:

```
A>B:<cr>
B>
```

Which changed the currently logged disk to drive B:. A BDOS program to affect the same thing is given in the example program of the next section below. Drive numbers correspond to the

console displayed drive designators as follows:

```
A: = Drive # 0
B: = Drive # 1
```

```
***
```

```
P: = Drive # 15
```

Once a drive has been selected it has its directory "activated" and is maintained in a logged in status until the next warm boot, cold boot, or disk reset BDOS function.

DETERMINE LOGGED DISK: Function 25.

An applications program can determine which disk drive is the currently logged or default drive through use of this function. The BDOS will return in the (A) register the number of the currently selected drive according to the table given above.

The program segment below shows a sequence of BDOS interface code that first determines if drive B: is selected, and if not then does a BDOS call to change it.

;SELECT AND POLL LOGGED DISK DRIVE EXAMPLE

```
;
SELECT    EQU        0EH                ;FUNCTION 14
ASKDRV    EQU        19H                ;FUNCTION 25
BDOS      EQU        0005H              ;SYSTEM ENTRY POINT

        ORG          0100H              ;PROG START
        MVI          C,ASKDRV           ;FIND OUT IF B: IS SELECTED
        CALL         BDOS
        CPI          'B'-'A'
        RZ                          ;DONT SELECT IF ALREADY
                                   ;..LOGGED
        MVI          E,'B'-'A'          ;SET TO LOG AND SELECT B:
        MVI          C,SELECT
        CALL         BDOS
        RET                          ;FINISHED WITH ANOTHER PROG
;
        END
```

DRIVE STATUS SET AND RESET: Functions 28 & 37.

Drive status may be individually controlled by these functions. Operation 28 allows a the currently selected drive to be write protected (set to read/only). The process is simply:



```

WPDSK    EQU        01CH
BDOS      EQU        0005H
          MVI        C,WPDSK          ;WRITE PROTECT DISK
          CALL       BDOS

```

The write protect status of a specific disk may be removed by function 37 which deactivates the directories of each drive specified at call time. Each drive by default then becomes read/write again but requires reactivation through reselection. The reset drive vector is a 16-bit value passed to the BDOS with a "1" bit in each bit position for a drive that equires resetting. The most significant bit of the 16 bit quantity corresponds to drive P: and the LSB to drive A:. The code sequence to reset drive B: would be:

```

RESDSK    EQU        025H
BDOS      EQU        0005H
          MVI        C,RESDSK          ;FUNCTION CODE
          LXI        D,0000$0000$0000$0010B ;DRIVE B: BIT SET
          CALL       BDOS

```

GET DRIVE LOGIN AND READ?ONLY VECTORS: Function 24 & 29.

The BDOS keeps track of all drives that have been selected since the last boot or disk reset functions. These drives are considered in a online status in that the system knows immediately what the space allocation map of the drive is and whether the drive is in read/only status or not. Function 24 allows the application program to determine what subset of the current drive complement are in this online logged status. The vector returned in the (HL) register pair is a bit map like above where a "1" bit means the drive is active. The most significant bit of the 16-bit number corresponds to drive P:. The code below fetches the vector and saves it in a local data area.

```

;LOGIN VECTOR EXAMPLE
;
LOGIN      EQU        018H          ;FUNCTION 24
BDOS       EQU        0005H          ;SYSTEM ENTRY POINT

          ORG        0100H
          MVI        C,LOGIN          ;FUNCTION
          CALL       BDOS
          SHLD       LOCL0G          ;SAVE VECTOR HERE
          RET              ;TO CCP
;
LOCL0G:
          DS         2
          END

```

In a similar manner the BDOS allows determination of which

drives are in the write protected read/only status. A "1" bit in the returned vector indicates read/only status for a specific drive. The code here shows how to fetch it.

```
;READ/ONLY VECTOR EXAMPLE
;
ROVEC    EQU    01DH            ;FUNCTION 29
BDOS     EQU    0005H          ;SYSTEM ENTRY POINT

        ORG     0100H
        MVI     C,ROVEC        ;FUNCTION
        CALL    BDOS
        SHLD    LOCROV         ;SAVE VECTOR HERE
        RET                     ;TO CCP
;
LOCROV:
        DS      2
        END
```

GET ALLOCATION VECTOR AND DISK PARM POINTER: Function 27 & 31.

Two more miscellaneous disk drive interface functions are provided that permit several special types of functions to be performed. The first, function 27 returns an address in the (HL) registers that points to a bit string in memory that corresponds to the data block allocation map of the currently selected drive. The map contains one bits in each position where a block allocated, starting with the MSB of the first byte in the string. The length of the bit string depends upon the total capacity of the drive in allocatable blocks. Function 31 permits an application to determine the characteristics of the currently selected drive. The BDOS returns an address in the (HL) registers that points to a table of 33 bytes that describe the current drive. Data in the table includes such data as number of possible directory entries on the disk, number of allocatable blocks on the disk, and, indirectly, the size of each disk block. The program below is a comprehensive example of how these functions can be used to determine the remaining space left on a the selected drive. The program stores the available space of the drive specified in the first byte of the default FCB into memory location "KPDISK" and then exits to the CCP. The reader can adapt the code as desired.

```
;
;CP/M BDOS INTERFACE EQUATES
;
BASE     EQU     0000H          ;BASE OF CP/M SYSTEM
LOGDRIV  EQU     0004H+BASE     ;LOCATION OF CURRENTLY LOGGED DRIVE
BDOS     EQU     0005H+BASE     ;THE BDOS I/O VECTOR
SLCTDSK  EQU     14             ;SELECT DISK DRIVE
GALVEC   EQU     27             ;GET ADDRESS ALLOCATION VECTOR
```

```

GDSKP   EQU    31           ;GET ADDRESS OF DISK PARAMETER TABLE
;
;
    ORG    0100H
;
;
;PROGRAM TO FETCH REMAINING DISK SPACE IN KBYTES
;
SPCGET:
    LDA    LOGDRIV          ;GET CURRENTLY LOGGED DRIVE AND SAVE
    ANI    0FH              ;STRIP OUT USER NUMBER
    STA    SAVDRIV          ;SAVE CODE
;
    LDA    FCB              ;CHECK IF SAME AS SELECT
    DCR    A                ;ADJUST FCB DRIVE TO MATCH SELECT DRIVE
    MOV    E,A              ;..SELECT IN BDOS
    MVI    C,SLCTDSK        ;SELECT DISK FUNCTION
    CALL   BDOS
;
    MVI    C,GDSKP          ;FIND ADDRESS OF DISK PARAMETER HEADER
    CALL   BDOS
    LXI    B,0002H          ;INDEX TO BLOCK SHIFT FACTOR
    DAD    B
    MOV    B,M              ;(B) = BYTE BLOCK SHIFT FACTOR
    INX    H
    INX    H
    INX    H
    MOV    E,M              ;(DE) = WORD DISK BLOCK COUNT
    INX    H
    MOV    D,M
    INX    D
;
    MOV    A,B              ;ADJUST SHIFT FOR KBYTE SIZE
    SUI    03H
    LXI    H,0001H          ;CALCULATE BLOCK SIZE
SPCCAL:
    ORA    A                ;KNOW KBYTES PER BLOCK?
    JZ     SPCKNW
    DAD    H                ;DOUBLE # SECTORS PER TRACK
    DCR    A                ;DECREMENT BLOCK SHIFT
    JMP    SPCCAL
;
SPCKNW:
    MOV    C,L              ;(BC)=KBYTES PER BLOCK
    MOV    B,H
    LXI    H,0              ;INITIALIZE KPDISK
    SHLD   KPDISK
    PUSH   B                ;SAVE KBYTES/BLOCK
    PUSH   D                ;SAVE NUMBER OF BLOCKS
    MVI    C,GALVEC         ;NOW POINT TO THE ALLOCATION VECTOR
    CALL   BDOS              ;(HL)=ALLOCATION VECTOR ADDRESS

```

```

    POP    D
    POP    B
;
    SHLD    ALLSAVE          ;SAVE ALLOCATION POINTER
    MVI     H,1              ;SET MINIMUM START BIT COUNT
;
UALLOC:
    DCR     H                ;DEC BIT COUNT
    JNZ     STACT            ;STILL ACTIVE BYTE
;
    LHLD    ALLSAVE          ;GET POINTER
    MOV     A,M
    INX     H
    SHLD    ALLSAVE          ;SAVE NEW POINTER
    MVI     H,08H            ;SET BIT COUNTER TO MAX
;
STACT:
    RLC                     ;GET ALLOCATION BIT TO CARRY
    JC      ALLOC            ;DONT COUNT ALLOCATED BLOCKS
    PUSH    H
    LHLD    KPDISK           ;GET KBYTES LEFT COUNT
    DAD     B                ;ADD IN ONE MORE BLOCK COUNT
    SHLD    KPDISK
    POP     H
;
ALLOC:
    DCX     D                ;DEC TOTAL BLOCK COUNT
    MOV     L,A
    MOV     A,D
    ORA     E                ;ALL BLOCKS SCANNED YET
    MOV     A,L              ;RESTORE ALLOC BIT PATTERN
    JNZ     UALLOC          ;MORE TO COUNT
;
    LDA     SAVDRIV          ;RETURN DISK SELECT TO PREVIOUS
    MOV     E,A              ;..SELECT IN BDOS
    MVI     C,SLCTDSK        ;SELECT DISK FUNCTION
    CALL    BDOS
    RET                      ;BACK TO THE CCP
;
;
;PROGRAM DATA STORAGE ALLOCATIONS
;
BLKSIZ:
    DS      2                ;STORAGE FOR ALLOCATION BLOCK SIZE
ALLSAVE:
    DS      2                ;STORAGE FOR ALLOCATION PNT SAVE
SAVDRIV:
    DS      1                ;SAVE CURRENT DISK SELECT DURING RELOG
KPDISK:
    DS      2                ;STORAGE FOR KBYTES PER DRIVE LEFT
;

```

END

The next part in this series will present the the CP/M file system as viewed from the BDOS interface aspect. The FILE CONTROL BLOCK (FCB) will be presented. In addition the procedures to prepare files for I/O and then the actual I/O procedures will be presented. The series will round out to a conclusion with a comprehensive programming example that presents a sequential file I/O set of subroutines that permit character by character I/O with a file to be done.

## SLIDING INTO BDOS (Part II)

### WITH FILES MADE EASY

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Since I know that all devoted Life Lines readers have anxiously been waiting for this "second in a series" tutorial on using files with the CP/M BDOS, I will not go on a long time telling you why this thing about CP/M BDOS file interface is so important. Nor will I try to justify why the tutorial should be valuable. You wouldn't be reading here at this time if you had any inclination to find my work disinteresting. If you are new on the scene and have some questions about what this is all about I would like to direct your attention to the November 1982 issue of Life Lines where the first part of this tutorial series was presented. There the purpose of the BDOS and the general interface concepts were presented. The article went on to include a description of the physical device system calls and other miscellaneous system control type functions.

### THIS TIME IT'S FILES

This month the tutorial continues with a description of the sequential file I/O system supported within the BDOS. The concepts of CP/M file storage are to be described along with appropriate CP/M directory structure definition as it relates to the access of the files stored upon a CP/M disk. The FILE CONTROL BLOCK (FCB) will be described in terms of its functions as related the a file to be accessed upon a disk. I have also included a comprehensive programming example that allows a

sequential file to be accessed character by character.

## HOW FILES ARE STORED UPON THE DISK

The CP/M operating system manages the available space on a disk by dividing the total available space up into a number of relatively small data block storage areas called "GROUPS". A group size is usually described as the minimum allocatable space that a file can occupy. What this means is that the operating system, in its disk space management scheme, lumps sets of the normal 128 byte logical records of a file together into these things called groups. The number of groups that may be contained on a disk depends upon the total file storage space of the disk in logical 128 byte records divided by the number of 128 byte logical records lumped together into a group. (A note to the less casual reader is that the number of groups on a disk is limited by design to 65K groups. Secondly a group is always an integral power of two number of 128 byte logical records with a minimum size of 8 records (1K byte). Group size is necessarily limited to 16K bytes due to the extent system described below).

As a file is stored upon a CP/M disk it consumes disk space in 128 byte logical records. Each time a group becomes filled with records the operating system allocates another group to the file. Hence the term "minimum allocatable size". If, as the file grows in size, the last allocated group assigned to a file is not completely filled the remaining space in the group is "burned" in that it is not usable by other files. The CP/M system keeps track of the group assignments made to the various files on a disk, the files names, and the total number of 128 byte logical records in each file through a stored directory. The first portion of the disk is reserved for the file directory. A fixed number of directory entries, determined by the system's BIOS design, are available, usually a number like 64, 128, or 256, depending upon the size of the disk.

Each file has a unique directory entry "set" that describes the file location upon the disk. A "set" of directory entries is specified because each entry is designed to "point to" or store the group allocation numbers for that file. Each directory entry has a number slots where group numbers can be stored. The system design allows each directory entry to specify the storage for 16K bytes of storage space. For files larger than 16K bytes a separate directory entry is used for each 16k bytes (or remainder portion thereof). Each such piece of a file is referred to as an "EXTENT" of the file. The directory entry "set" for a file contains a byte in each extent directory entry that stores the extent number of the file. Extent numbers start with 0 and may increase to a theoretical limit of 255 or the size of the disk in 16K byte pieces, whichever is smaller.

The chart below describes the functions of all bytes in a typical directory entry. Each entry is 32 bytes long and they are packed four to a logical sector with the number of logical sectors filled up with directory entries limited to the predetermined number of directory entries divided by four.

Figure 1. DISK DIRECTORY ENTRY DEFINITION

byte 00	byte 01	byte 02	byte 03	byte 04	byte 05	byte 06	byte 07
+-----+-----+-----+-----+-----+-----+-----+-----+							
Active							
Entry	Eight Character ASCII File Name Bytes 01 to 08						
& User							
Flag							
+-----+-----+-----+-----+-----+-----+-----+-----+							
byte 08	byte 09	byte 10	byte 11	byte 12	byte 13	byte 14	byte 15
+-----+-----+-----+-----+-----+-----+-----+-----+							
Last							Record
File	Three character ASCII		Extent	Two Bytes		Count	
Name	File Name extension		Number	Reserved		of this	
Char						Extent	
+-----+-----+-----+-----+-----+-----+-----+-----+							
byte 16	byte 17	byte 18	byte 19	byte 20	byte 21	byte 22	byte 23
+-----+-----+-----+-----+-----+-----+-----+-----+							
	Group Number storage for groups attached to this file						
	One byte used per group number if disk contains less						
	255 groups. Two bytes if greater than 256.						
+-----+-----+-----+-----+-----+-----+-----+-----+							
byte 24	byte 25	byte 26	byte 27	byte 28	byte 29	byte 30	byte 31
+-----+-----+-----+-----+-----+-----+-----+-----+							
	Additional Group Number storage.						
	Group Number storage for groups attached to this file						
	One byte used per group number if disk contains less						
	255 groups. Two bytes if greater than 256.						
+-----+-----+-----+-----+-----+-----+-----+-----+							

The bytes of the disk directory entry are each described in the following paragraphs. The first byte stored in an entry is set to indicate if this slot in the predetermined directory area is empty or if it describes an active file extent. A value of 0E5H indicates an empty slot. This value was chosen presumably due to that a freshly formatted diskette contains all 0E5H bytes in the empty sectors, thus making such disk appear to have no files contained thereon. If the byte value is non 0E5H, then the

slot contains a valid file extent descriptor. The CP/M user number area to which an active file is associated is stored in the first directory entry byte. User number values range from 0 to 15.

The next eight bytes contain the primary name of the file in ASCII characters. If the name is shorter than 8 characters then the name is padded to the right with spaces. Following the name field is a three byte file name extension field in ASCII characters. The extension field, if shorter than 3 characters is padded to the right with spaces. For CP/M version 2.2, the upper bits (bit 7) of the extent name bytes are used to describe certain attributes about the file. If the upper bit of the first extent name character is set, then the file is described as a read-only file. The upper bit of the second extent name character, if set, indicates that the file name should not be displayed in directory listings.

Each directory entry, as a file descriptor extent, has the next byte set to a number that specifies which 16K byte chunk of the file that this entry describes. Two bytes after the extent byte are not used within the directory and are normally set to zero by default. The number of records stored in the extent, described by this directory entry, is recorded in the byte 15 position. The maximum value for the record count is 128 (080H) which if equal to  $(128 * 128)$  or 16K bytes, the maximum size of an extent.

Byte positions 16 to 31 contain the group numbers upon the disk that contain the data belonging to the file named in the directory entry. The number of bytes within the total 16 available that are used for group number storage is dependant upon the amount of file data described by this extent and by the group size of the disk. The group numbers are single byte numbers, up to 16 total, if the number of groups upon the disk is less than or equal to 255. If the number of groups upon the disk is more than 255 then byte positions 16 to 31 contain two byte group numbers, stored in low byte/high byte order. The group numbers contained within a directory entry do not have to be in increasing sequential order nor do they have to be consecutive.

The figure below shows two logical records of the directory from a single sided double density disk with 2K byte groups. The total number of groups available is 243 so the group numbers are single byte numbers. Note that only one half of the 16 byte space for group numbers is used due to the fact that 8 entries for 2K byte groups is all that is needed to describe the storage for one full 16K byte extent.

Figure 2. EXAMPLE HEX/ASCII DIRECTORY RECORD DISPLAY



```

00 00414449 52202020 20434F4D 0000000B .ADIR COM....
10 07000000 00000000 00000000 00000000 .....
20 004D4552 47505249 4E4F5652 0000003C .MERGPRINOV...<
30 16171819 00000000 00000000 00000000 .....
40 00434F50 59202020 20434F4D 0000000E .COPY COM....
50 0C000000 00000000 00000000 00000000 .....
60 00435243 4B202020 20434F4D 0000000A .CRCK COM....
70 0D000000 00000000 00000000 00000000 .....

00 E5555345 52202020 204C4F47 00000030 eUSER LOG...0
10 04050600 00000000 00000000 00000000 .....
20 00444454 20202020 20434F4D 00000026 .DDT COM...&
30 0F101100 00000000 00000000 00000000 .....
40 0044552D 56373520 20434F4D 0000002E .DU-V75 COM....
50 12131400 00000000 00000000 00000000 .....
60 00464F52 4D415420 20434F4D 0000000C .FORMAT COM....
70 15000000 00000000 00000000 00000000 .....

```

The above examples all show files that are less than 16K bytes each. Note also the display showing the erased "USER.LOG" file.

## HOW FILES ARE ACCESSED

The files upon a disk are accessed through a user description block called a File Control Block (FCB for short). The file control block, used by virtually all file access BDOS system calls, has the structure as shown in Figure 3. This chart is taken from a Digital Research CP/M manual and is included here for quick educational reference.

Note that the structure of a file control block is much the same as that of a directory entry with a few minor changes. The changes and/or differences are as follows, otherwise the byte descriptions are the same as for the disk directory entry.

The first byte of an FCB allows the programmer to specify which drive should be used for the file access. Drive A: to P: are specified as 1 to 16 respectively while a value of zero indicates that the currently logged default drive should be used for the access.

An FCB contains four additional bytes that are used as pointers for file access position. The "cr", current record number, indicates the sequential record number of this extent that will be accessed upon the next file read or file write system call. The user normally sets the "cr" byte to zero to begin file access at the first logical record of the file. Each time a read or write is performed the current record number is

incremented. When the "cr" byte attains a value of 080H during a sequential file operation the BDOS automatically realizes that the current extent of the file has been fully accessed and performs the necessary disk directory accesses to setup the FCB to allow file access to the next extent. For reading this simply means that the next extent descriptor directory entry from the disk, for this file, is read into memory (ie. the group allocation numbers from the disk are copied into the d0-dn bytes of the FCB, the extent number becomes one greater, the record count from the disk for the new extent is copied into the "rc" byte and the cr byte is zeroed). During a writing operation the "cr" byte attaining a value of 080H indicates that the current extent of the file is full and so the BDOS automatically finds the appropriate directory entry spot on the disk to write in the newly assigned group allocation bytes, record count value and extent number. The BDOS will then create another directory entry on the disk for the new extent of the file. In this case the d0-dn bytes of the FCB are zeroed to indicate that storage has not yet been allocated for this extent.

Figure 3. FILE CONTROL BLOCK DESCRIPTION

```
-----
|dr|f1|f2|/ /|f8|t1|t2|t3|ex|s1|s2|rc|d0|/ /|dn|cr|r0|r1|r2|
-----
00 01 02 ... 08 09 10 11 12 13 14 15 16 ... 31 32 33 34 35
```

where:

dr	drive code (0 - 16) 0 => use default drive for file access 1 => select drive A: for file access 2 => select drive B: for file access ... 16=> select drive P: for file access
f1...f8	contain the files name in ASCII upper case with high bits equal to zero.
t1,t2,t3	contain the file type in ASCII upper case with high bits normally equal zero. tn' denotes the high bit of these bit positions. t1' = 1 => Read/Only file t2' = 1 => SYS file, no DIR list
ex	contains the current extent number, normally set to 00 by the user, but is in the range 0 - 31 during file I/O.
s1	reserved for internal system use
s2	reserved for internal system use, set to

zero on call to OPEN, MAKE, SEARCH system calls.

rc        record count for extent "ex," takes on values 0 to 128.

d0...dn    filled-in by BDOS to indicate file group numbers for this extent.

cr        current record to read or write in a sequential file operation. Normally set to zero by the user upon initial access to a file.

r0,r1,r2   optional random record number in the range of 0 to 65535, with overflow to r2. r0/r1 are a 16 bit value in low/high byte order.

The last three bytes of the FCB, r0,r1, & r2 are used for random record file I/O and will be covered in the third and final part of this tutorial. For simpler sequential I/O the FCB in fact does not even need to be setup for the 36 bytes of storage. 33 bytes suffice for all sequential file I/O FCB operations.

## FILE ACCESS SETUP SYSTEM FUNCTIONS

The procedure for the programmer to use in accessing a file generally starts in one of two ways. The first senario starts with, "Lets see if our file exists on the disk?" There are two BDOS system calls related to the functions of searching the disk directory for a file name match against the FCB specified by the user. These operations allow for the programmer to find out if a specific file name already exists upon the disk. In addition it provides a mechanism to scan a directory to determine all file names that exist in the directory. The second situation comes into being if the programmer is already aware of the file status with respect to "presence" on the disk or as the logical sequence of events following the first senario. These latter functions are used to work with specific files for opening, closing, creating, renaming and deleting.

### SEARCH FIRST AND SEARCH NEXT: Functions 17 and 18.

The search functions scan the directory for match of a file name that compares with the user specified FCB pointed to by the (DE) register pair. The match is made on the basis of comparing the f1-f8, t1-t3, and ex bytes of the FCB to the corresponding bytes of the disk directory entries. Any FCB position that contains an ASCII question mark "?" (03FH) is specified as a "match any character" from the disk directory. The function calls return a value of 0FFH in the (A) register if no more matched

directory entries can be found. The search functions cause the currently valid disk buffer address and the following 128 bytes to be filled with a copy of the directory record containing the matched entry, if one is found. The (A) register is returned with a 0 to 3 value to indicate which one of the four possible 32 byte chunks of the directory record contain the matched entry.

Search first means to find the first occurrence of a matched entry to the FCB. The search next function scans the directory from the current search position instead of from the beginning. Note that it is not normally valid to perform the search next function without first performing the search first function. Also it is not valid to perform other directory or file operations between the search first and search next functions.

The program example below shows a technique for reading all directory entries from the disk drive specified by the first FCB byte into a memory resident list. The list starts at the LIST label with the total matched file count stored in the FILECNT variable. The LISTPOS label stores the next available list load point during the directory scan operation. The search FCB uses the CP/M default FCB location at address 05CH and specifies a total wild card (\*.\*) match. The "ex" byte is zeroed before the search first call so that only the zero extents of the files are returned. The file names are stored in the list in character strings of 16 bytes each with a preceeding drive designator byte and padded to the right with 4 zero bytes. Please note that this program is a segment only and will not directly assemble and run as a CP/M .COM file without a little added lead in and error exit coding.

#### Listing 1. A DIRECTORY SCANNING PROGRAM

```

BUFR    EQU    80H+BASE    ;DEFAULT CP/M BUFFER
BDOS    EQU    0005H      ;ENTRY POINT FOR BDOS OPERATIONS
;
SRCHF    EQU    17        ;SEARCH DIR FOR FIRST OCCUR.
SRCHN    EQU    18        ;SEARCH DIR FOR NEXT OCCUR.
STDMA    EQU    26        ;SET DMA ADDRESS
;
FCB EQU    5CH+BASE      ;DEFAULT FILE CONTROL BLOCK
FCBEXT    EQU    FCB+12    ;EXTENT BYTE IN FCB
FCBRNO    EQU    FCB+32    ;RECORD NUMBER IN FCB
;
;
;SETUP SIZE OF ELEMENTS IN THE FILE NAME LIST
;
ITEMSZ    EQU    16        ;EACH LIST ITEM IS 16 BYTES
;
;
;SETUP WILD CARD FILE IMAGE LIKE *.*

```

```

;
    LXI    H,FCB+1      ;PLACE TO PUT WILD CARD IMAGE
    MVI    B,11         ;SIZE TO SET
ALFN:
    MVI    M,'?'        ;PUT IN A JOKER CHAR
    INX    H            ;BUMP FILL POINTER
    DCR    B            ;DCR BYTE COUNTER
    JNZ    ALFN
;
;
;ZERO INITIAL TOTAL FILE COUNT
;
    LXI    H,0000H
    SHLD   FILECNT
;
;
;HERE IF NAME PROPERLY POSITIONED IN THE DEFAULT FCB AREA FOR LIST BUILD
;
NAMEPRES:
    MVI    C,STDMA      ;INITIALIZE DMA ADDRESS TO DEFAULT BUFFER
    LXI    D,BUFR
    CALL   BDOS
;
    XRA    A            ;CLEAR APPROPRIATE FIELDS OF SEARCH FCB
    STA    FCBEXT        ;EXTENT BYTE
    STA    FCBRNO        ;AND RECORD NUMBER
;
    LXI    D,FCB        ;USE DEFAULT FCB FOR SEARCH
    MVI    C,SRCHF       ;SEARCH FOR FIRST OCCURRANCE
    CALL   BDOS
    CPI    0FFH          ;SEE IF FOUND
    JNZ    LOADLIST      ;IF SOME FOUND THEN GO BUILD LIST
;
;
;PUT INSTRUCTIONS HERE TO HANDLE A SITUATION WHERE NO FILES
;MATCHING THE FCB WILD CARD IMAGE ARE FOUND.
;
    JMP     ERROR$EXIT    ;TO USER SUPPLIED ROUTINE
;
;
;BUILD UP LIST WITH ALL FOUND ENTRIES
;
LOADLIST:
    LXI    H,LIST        ;INITIALIZE LIST POINTER PARAMETERS
    SHLD   LISTPOS        ;START = CURRENT POS OF LIST
;
;
;PUT CURRENTLY FOUND NAME TO LIST
;(A) = OFFSET IN DEFAULT BUFFER OF NAME
;
;

```

```

NM2LST:
    ANI    3            ;ZERO BASED TWO BIT INDEX
    ADD    A            ;TIMES 32 TO MAKE POSITION INDEX
    ADD    A
    ADD    A
    ADD    A
    ADD    A
    MOV    C,A          ;PUT IN BC
    XRA    B            ;CLEAR HIGH ORDER
    LXI    H,BUFR       ;TO NAME POSITION IN DEFAULT BUFFER
    DAD    B            ;(HL) = CURRENT FOUND NAME POINTER
    LDA    FCB          ;PUT DISK DRIVE NUMBER INTO NAME PLACE
    MOV    M,A          ;INTO BUFFER
    XCHG
    LHLD   LISTPOS      ;POINTER TO CURRENT LOAD POINT IN LIST
    XCHG
    MVI    B,12         ;MOVE DRIVE DESIGNATOR AND NAME TO LIST
MOVLP:
    MOV    A,M          ;GET NAME BYTE FROM DEFAULT BUFFER
    STAX   D            ;PLACE INTO LIST
    INX    H            ;BUMP POINTERS
    INX    D
    DCR    B            ;CHECK MOVE BYTE COUNT
    JNZ    MOVLP
    XCHG                ;(DE) WAS LEFT WITH NEXT LOAD POINT ADDRESS
;
    MVI    B,ITEMSZ-12  ;REMAINING LIST ITEM SPACES TO ZERO OUT
FILZRO:
    MVI    M,00H        ;PUT IN A ZERO BYTE
    INX    H
    DCR    B            ;ALL REST FILLED YET
    JNZ    FILZRO
;
    SHLD   LISTPOS      ;KEEP NEXT LOAD POINT IN SAFE PLACE
    LHLD   FILECNT      ;INCREASE FILE COUNT FOR EACH FILE
    INX    H
    SHLD   FILECNT
;
;
;SEARCH FOR NEXT OCCURANCE OF SPECIFIED FILE NAME
;
    MVI    C,SRCHN      ;SEARCH NEXT FUNCTION CODE
    LXI    D,FCB        ;FILE NAME SPECIFICATION FIELD
    CALL   BDOS
    CPI    0FFH         ;SEE IF ALL THROUGH DIRECTORY YET
    JNZ    NM2LST       ;IF NOT GO PUT NAME INTO LIST
;
;
;PROGRAM EXECUTION TO HERE IF THE LIST CONTAINS SOME FILE NAMES
;FROM THE DISKETTE
;

```

```

;USER DOES HIS OWN THING FROM HERE
;
;
;DIRECTORY NAME LIST FOR STORAGE OF INPUT NAMES
;
FILECNT:
    DS    2            ;COUNTER FOR NUMBER OF FILES

LISTPOS:
    DS    2            ;STORAGE FOR CURRENT LIST
                    ;LOAD POINTER
;
LIST:
    DS    1            ;START POINT FOR FILE NAME LIST
;
;+++...END OF LISTING 1.

```

OPEN FILE: Function 15.

An existing file on a disk may not be read until the user FCB contains the information about where the file is stored upon the diskette. Function 15 provides a means where the user fills in the file name and then calls the operating system to get the d1-dn bytes of the FCB filled in. Once the file is OPEN then it may be read because subsequent calls to the BDOS to READ will "know where" the file is located. The OPEN function returns a value of 0FFH if the file cannot be found, otherwise the (A) register contains a value of 0 to 3 to indicate that the file was successfully opened. To open a file the programming procedure is simply:

```

;
;OPEN FILE EXAMPLE
;
OPEN      EQU      15      ;OPEN FUNCTION CODE
BDOS      EQU      0005H   ;SYSTEM ENTRY

        ORG      0100H    ;START
        LXI      D,FCB    ;POINT AT FILE CONTROL BLOCK
        MVI      C,OPEN   ;FUNCTION
        CALL     BDOS
        CPI      0FFH     ;CHECK IF NOT FOUND
        JZ       ERROR
        RET                     ;IF OPEN GO TO CCP
;
ERROR:
        MVI      C,9      ;PRINT ERROR MESSAGE
        LXI      D,ERRMS
        CALL     BDOS
        RET
;

```

ERRMS:

```

        DB          'FILE NOT FOUND', '$'
;
;
;FILE ACCESS FILE CONTROL BLOCK
;
FCB:
        DB          00H          ;SET TO USE DEFAULT DRIVE
        DB          'TEST'      DAT',0,0,0,0
        DS          16          ;STORAGE FOR D1 TO DN BYTES
        DB          0           ;CURRENT RECORD BYTE
;
        END

```

CLOSE FILE: Function 16.

Whenever a file is accessed for writing new space is allocated for that file on the disk. This implies that the user FCB contains disk group numbers that are not stored upon the diskette in the directory entry for the file. Function 16 provides a means where the user completes the file writing operation and then calls the operating system to set the directory entry group allocation bytes, the rc byte and the extent byte from the corresponding bytes of the FCB. A file that has been opened for reading only need not be closed because there is no change in the stored disk directory information. The CLOSE function returns a value of 0FFH if the file cannot be found, otherwise the (A) register contains a value of 0 to 3 to indicate that the file was successfully closed. To close a file the programming procedure is simply:

```

;
;CLOSE FILE EXAMPLE
;
CLOSE    EQU        16          ;CLOSE FUNCTION CODE
BDOS     EQU        0005H      ;SYSTEM ENTRY

        ORG         0100H      ;START
        LXI         D,FCB      ;POINT AT FILE CONTROL BLOCK
        MVI         C,CLOSE    ;FUNCTION
        CALL        BDOS
        CPI         0FFH       ;CHECK IF NOT FOUND
        JZ          ERROR
        RET                     ;IF CLOSED GO TO CCP
;
ERROR:
        MVI         C,9        ;PRINT ERROR MESSAGE
        LXI         D,ERRMS
        CALL        BDOS
        RET
;

```



ERRMS:

```

        DB          'FILE NOT FOUND', '$'
;
;
;FILE ACCESS FILE CONTROL BLOCK
;
FCB:
        DB          00H          ;SET TO USE DEFAULT DRIVE
        DB          'TEST'      DAT',0,0,0,0
        DS          16          ;STORAGE FOR D1 TO DN BYTES
        DB          0           ;CURRENT RECORD BYTE
;
        END

```

DELETE FILE: Function 19.

Often time the programmer will create and write files which will subsequently not be needed. The file or files may be deleted through use of function 19. The user sets an FCB to the appropriate file name in the f1-f8, and t1-t3 bytes. The BDOS function then removes the specified file from the directory of the appropriate disk. The user specified file name in the FCB may contain ASCII question marks in which case the delete function may delete multiple files if the file name matches more than one file on the disk with the name. The "?" matches any character at the position of its occurrence in the name. The DELETE function returns a value of 0FFH if the file(s) cannot be found, otherwise the (A) register contains a value of 0 to 3 to indicate that the file was successfully deleted. To delete a file the programming procedure is simply:

```

;
;DELETE FILE EXAMPLE
;
DELETE    EQU        19          ;CLOSE FUNCTION CODE
BDOS      EQU        0005H      ;SYSTEM ENTRY

        ORG          0100H      ;START
        LXI          D,FCB      ;POINT AT FILE CONTROL BLOCK
        MVI          C,DELETE   ;FUNCTION
        CALL         BDOS
        CPI          0FFH       ;CHECK IF NOT FOUND
        JZ           ERROR
        RET              ;IF CLOSED GO TO CCP
;
ERROR:
        MVI          C,9        ;PRINT ERROR MESSAGE
        LXI          D,ERRMS
        CALL         BDOS
        RET

```

```

;
ERRMS:
        DB          'FILE NOT FOUND','$'
;
;
;FILE ACCESS FILE CONTROL BLOCK
;
FCB:
        DB          00H          ;SET TO USE DEFAULT DRIVE
        DB          'TEST'      DAT',0,0,0,0
        DS          16          ;STORAGE FOR D1 TO DN BYTES
        DB          0           ;CURRENT RECORD BYTE
;
        END

```

CREATE FILE: Function 22.

Whenever a new file is desired it must first be created so that there is a spot in the directory to later save the file allocation information (see close function above). The BDOS assumes that the programmer has specified a file name that does not exist upon the disk. If there is a chance that a new file is desired that may duplicate the name of one already upon the disk the previously described delete function should be used to erase the old file before creating the new file. Otherwise the directory may contain two files by the same name. The CREATE function returns a value of 0FFH if there is no room in the directory to store the freshly created directory entry, otherwise the (A) register contains a value of 0 to 3 to indicate that the file was successfully created. A newly created file may be immediately written since the BDOS prepares the user FCB to look like an empty file. To create a file the programming procedure is simply:

```

;
;CREATE FILE EXAMPLE
;
CREATE    EQU        22          ;CREATE FUNCTION CODE
BDOS      EQU        0005H      ;SYSTEM ENTRY

        ORG          0100H      ;START
        LXI          D,FCB      ;POINT AT FILE CONTROL BLOCK
        MVI          C,CREATE    ;FUNCTION
        CALL         BDOS
        CPI          0FFH        ;CHECK IF DIRECTORY FULL
        JZ           ERROR
        RET              ;IF CLOSED GO TO CCP
;
ERROR:

```

```

        MVI        C,9          ;PRINT ERROR MESSAGE
        LXI        D,ERRMS
        CALL       BDOS
        RET

;
ERRMS:
        DB         'DIRECTORY FULL','$'
;
;
;FILE ACCESS FILE CONTROL BLOCK
;
FCB:
        DB         00H          ;SET TO USE DEFAULT DRIVE
        DB         'TEST'      DAT',0,0,0,0
        DS         16          ;STORAGE FOR D1 TO DN BYTES
        DB         0           ;CURRENT RECORD BYTE
;
        END

```

RENAME FILE: Function 23.

Sometimes it is necessary to change the name of a disk file from that already existing in the disk directory. With function 23 the user specifies the name of an existing file on the disk with a standard FCB format except that on calling the BDOS the d1-dn byte area of the FCB are set to the new name desired for the file. All occurrences of the existing file name (ie. all extents) are changed to match the new name. The drive select byte specifies the drive upon which the rename operation should be done. The first byte of the second 16 bytes of the FCB (d0) is expected to be zero. The RENAME function returns a value of 0FFH if the old name file could not be found, otherwise the (A) register contains a value of 0 to 3 to indicate that the file was successfully renamed. To rename a file the programming procedure is simply:

```

;
;RENAME FILE EXAMPLE
;
RENAME   EQU       23          ;RENAME FUNCTION CODE
BDOS     EQU       0005H      ;SYSTEM ENTRY

        ORG        0100H      ;START
        LXI        D,FCB      ;POINT AT FILE CONTROL BLOCK
        MVI        C,RENAME   ;FUNCTION
        CALL       BDOS
        CPI        0FFH       ;CHECK IF DIRECTORY FULL
        JZ         ERROR
        RET              ;IF CLOSED GO TO CCP
;

```

ERROR:

```

MVI      C,9          ;PRINT ERROR MESSAGE
LXI      D,ERRMS
CALL     BDOS
RET

```

;

ERRMS:

```

DB      'FILE NOT FOUND','$'

```

;

;

;FILE ACCESS FILE CONTROL BLOCK

;

FCB:

```

DB      00H          ;SET TO USE DEFAULT DRIVE
DB      'TEST  DAT',0,0,0,0      ;OLD NAME
DB      00H          ;BYTE ASSUMED TO BE ZERO
DB      'NEWNAME DAT',0,0,0,0    ;NEW NAME
DB      0            ;CURRENT RECORD BYTE

```

;

END

## ACCESSING FILE DATA

The previous section showed the reader how to find and setup files for subsequent I/O. Other file/directory handling functions were also presented. This has all led up to the big moment when the users program is finally ready to read or write data from/to a disk file. So here it is at last...

CP/M disk file data is moved between the disk and memory in blocks of 128 bytes called logical records or "sectors" in older fashioned CP/M lingo. Two functions to be presented here are included in the CP/M BDOS function code to allow sequential access to blocks of data in a file. The READ function starts at the beginning of a file and reads data blocks till the end of the file. The opposing WRITE operation moves data blocks to a new disk file and writes till the end of the users data when the file is closed (or the disk is full if the programmer has too much data). The BDOS includes one other function that allows the user to specify the area in his program where the 128 byte disk record buffer is to be located. These three functions will each be individually described below.

### SET DISK BUFFER ADDRESS: Function 26.

The 128 byte data buffer that is to be used by the BDOS for file I/O is based at an address commonly referred to as the "DMA ADDRESS". This address or "buffer pointer" is passed to the BDOS in the (DE) registers when performing function 26. The program below simply sets the buffer address to "DATBF", a storage area

after the end of the short program.

```

;
;SET BUFFER ADDRESS EXAMPLE
;
STDMA    EQU        26        ;SET BUFFER ADDRESS FUNCTION CODE
BDOS     EQU        0005H     ;SYSTEM ENTRY

        ORG        0100H     ;START
        LXI        D,DATBF   ;POINT AT DATA BUFFER
        MVI        C,STDMA   ;FUNCTION
        CALL       BDOS
        RET                    ;BACK TO CCP
;
DATBF:
        DS         128       ;SETUP 128 BYTE BUFFER
;
        END

```

READ AND WRITE DISK RECORDS: Functions 20 and 21.

The disk read and write functions are very similar in operation in that both move 128 bytes of data to/from the users program. The READ assumes entry with (DE) pointing to an active FCB setup by the open file function. The read sequential function reads the 128 byte record specified by the "cr" field of the FCB into the buffer pointer to by the current disk buffer address. After each READ operation the "cr" field is incremented to the next record number. If the "cr" field overflows past the end of the extent without encountering the end of the file then the BDOS automatically opens the next extent in preparation for the next read operation. The READ function returns a 00H code in the (A) register if the READ was performed successfully. If the end of file is encountered a non zero value is returned in (A).

The WRITE function assumes, on entry to the BDOS, that the (DE) registers point at a validly opened or created FCB. The WRITE will move 128 bytes of data from the buffer specified by the current disk buffer address to the disk. The written record is placed at the "cr" record position of the extent. As each record is written the "cr" field is incremented in preparation for the next write operation. Similar to the READ, if the "cr" field overflows past the end of the current extent, the BDOS automatically closes the current extent and creates a new extent in preparation for the next write operation. The WRITE command may be performed on an existing file. If the file currently contains data at the "cr" record then the WRITE will overlay the current data with the new 128 byte record. The WRITE function returns a 00H value in the (A) register if the operation is successful. A non-zero value is returned if the write function

was unsuccessful due to a full disk or directory.

The small program below is designed to read the first record of a file 'TEST.DAT', and write it into the small file 'ONEREC.DAT'. The program should be reasonably self documenting.

```

;
;READ AND WRITE FUNCTION EXAMPLES
;
READ      EQU      20      ;READ FUNCTION CODE
WRITE     EQU      21      ;WRITE FUNCTION CODE
OPEN      EQU      15      ;OPEN FUNCTION CODE
CLOSE     EQU      16      ;CLOSE FUNCTION CODE
DELETE    EQU      19      ;DELETE FUNCTION CODE
CREATE    EQU      22      ;CREATE NEW FILE
STDMA     EQU      26      ;SET DISK BUFFER ADDRESS
BDOS      EQU      0005H   ;SYSTEM ENTRY

      ORG      0100H      ;START
      LXI      D,DATBF    ;POINT AT DATA BUFFER
      MVI      C,STDMA    ;FUNCTION
      CALL     BDOS

;

      LXI      D,FCBIN    ;POINT AT AND OPEN INPUT FILE
      MVI      C,OPEN
      CALL     BDOS
      CPI      0FFH      ;CHECK FOR OPEN ERROR
      JZ       ERROR

;

      LXI      D,FCBOUT   ;DEFAULT DELETE OF NEW FILE
      MVI      C,DELETE   ;..IN CASE IT EXISTS ALREADY
      CALL     BDOS
      LXI      D,FCBOUT   ;POINT AT FILE CONTROL BLOCK
      MVI      C,CREATE   ;FUNCTION TO MAKE NEW FILE
      CALL     BDOS
      CPI      0FFH      ;CHECK IF DIRECTORY FULL
      JZ       ERROR
      XRA      A          ;CLEAR THE INPUT CR FIELD TO READ
      STA      INCR       ;..FIRST RECORD
      LXI      D,FCBIN    ;READ FIRST FILE
      MVI      C,READ
      CALL     BDOS
      ORA      A          ;CHECK IF READ WAS O.K.
      JNZ      ERROR
      LXI      D,FCBOUT   ;WRITE TO OUTPUT FILE
      MVI      C,WRITE
      CALL     BDOS
      ORA      A          ;CHECK THAT DISK WASNT FULL
      JNZ      ERROR
;

```

```

        LXI        D,FCBOUT    ;CLOSE THE OUTPUT FILE
        MVI        C,CLOSE
        CALL       BDOS
        CPI        0FFH        ;CHECK CLOSE STATUS
        RNZ                ;BACK TO CCP IF NO ERROR
;
ERROR:   MVI        C,9        ;PRINT ERROR MESSAGE
        LXI        D,ERRMS
        CALL       BDOS
        RET
;
ERRMS:   DB          'PROGRAM FILE ERROR','$'
;
;
;FILE ACCESS FILE CONTROL BLOCKS
;
FCBIN:   DB          00H        ;SET TO USE DEFAULT DRIVE
        DB          'TEST  DAT',0,0,0,0
        DS          16        ;STORAGE FOR D1 TO DN BYTES
INCR:    DB          0        ;CURRENT RECORD BYTE
;
FCBOUT:  DB          00H        ;SET TO USE DEFAULT DRIVE
        DB          'ONEREC DAT',0,0,0,0
        DS          16        ;STORAGE FOR D1 TO DN BYTES
        DB          0        ;CURRENT RECORD BYTE
;
DATBF:   DS          128        ;SETUP 128 BYTE BUFFER
;
        END

```

## SEQUENTIAL FILE I/O PROGRAMMING EXAMPLE

The assembly language code of Listing 2 presents a comprehensive set of I/O routines that allow either an input or output sequential file to be processed on a byte by byte basis. The routines perform all necessary sector buffering. The reader is encouraged to fully study the code and gain an understanding of how it all works. The program uses most of the BDOS functions presented in this tutorial.

Listing 2. CHARACTER BY CHARACTER DISK I/O ROUTINES

```
;*****  
;  
; DEMONSTRATION SEQUENTIAL CP/M FILE CHARACTER BY  
; CHARACTER I/O ROUTINES. NOTE THAT THE MAIN BODY  
; OF THIS PROGRAM IS NOT DESIGNED TO RUN AS IS IN  
; ANY NORMAL MANNER.  
;  
; MANY THANKS ARE DUE TO WARD CHRISTENSEN WHO PREPARED THE  
; ORIGINAL SET OF SIMILAR I/O ROUTINES BURIED INSIDE OF  
; THE CP/M USERS GROUP MODEM PROGRAM THAT HAS BECOME SO  
; VERY POPULAR. THANKS AGAIN WARD.  
;  
;*****  
;  
;  
;CP/M BDOS EQUATES  
;  
RDCON EQU 1  
WRCON EQU 2  
PRINT EQU 9  
OPEN EQU 15 ;OPEN FILE  
CLOSE EQU 16 ;CLOSE FILE  
SRCHF EQU 17 ;SEARCH FOR FIRST  
ERASE EQU 19 ;DELETE FILE  
READ EQU 20 ;READ FILE RECORD  
WRITE EQU 21 ;WRITE FILE RECORD  
MAKE EQU 22 ;CREATE NEW FILE  
STDMA EQU 26 ;SET DATA BUFFER POINTER  
BDOS EQU 0005H ;SYSTEM I/O ENTRY POINT  
FCB EQU 5CH ;SYSTEM FCB  
FCBEXT EQU FCB+12 ;FILE EXTENT  
FCBSNO EQU FCB+32 ;SECTOR #  
FCB2 EQU 6CH ;SECOND FCB  
DSKBUF EQU 080H ;DEFAULT DISK BUFFER ADDRESS  
SECSIZ EQU 080H ;CP/M SECTOR SIZE  
;  
WBOOT EQU 00 ;CP/M WARM BOOT ENTRY ADDRESS  
;  
;  
;DEFINE ASCII CHARACTERS USED  
;  
LF EQU 10 ;LINEFEED  
CR EQU 13 ;CARRIAGE RETURN  
EOFCHR EQU 01AH ;CP/M END OF FILE CHAR  
;  
;  
;START OF EXECUTABLE CODE  
;  
ORG 100H  
LXI SP,STACK ;SETUP A STACK TO USE  
;
```



```

;
;SEQUENTIAL I/O WRITE OF CP/M FILE ENABLED BY USING THIS SEQUENCE
;OF SUBROUTINE CALLS. THE FILE CONTROL BLOCK IS ASSUMED TO BE
;STORED AT THE DEFAULT LOCATION AT 05CH IN THE BASE PAGE OF
;CP/M MEMORY MAP.
;
SIOWR:
    CALL    ERASFIL        ;ERASE RECIEVED FILE
    CALL    MAKEFIL        ;ESTABLISH NEW FILE
    CALL    INITWR         ;INITIALIZE FILE WRITE PARAMETERS
;
;
;MAKE FOLLOWING CALL TO PLACE A CHARACTER FROM THE (A) REGISTER
;INTO THE CP/M FILE. LOOP DOING THIS TILL YOU HAVE ALL IN FILE THAT
;IS NEEDED.
;
    CALL    WRCHAR         ;PUT CHAR IN FILE
;
    CALL    WREOF          ;FLUSH LAST SECTOR TO CP/M FILE
    CALL    CLOSFIL        ;CLOSE IT UP
;
;
;SEQUENCE OF COMMAND CALLS TO OPEN AND USE A SEQUENTIAL CHARACTER
;FILE FOR READING. THE FILE CONTROL BLOCK IS ASSUMED TO BE LOCATED
;AT THE DEFAUT LOCATION OF 05CH IN THE BASE CP/M PAGE.
;ONCE THE FILE IS INITIALIZED THE CHARACTERS CAN BE READ ONE BY
;ONE UNTIL THE RDCHAR SUBROUTINE RETURNS A SET CARRY FLAG
;INDICATING A END OF PHYSICAL FILE CONDITION. EOF IS SENSED AS
;PHYSICAL END OR 01AH CHARACTER WHICHEVER COMES FIRST
;
SIORD:
    CALL    OPENFIL        ;OPEN THE CP/M FILE
    CALL    INITRD         ;GO INIT FOR FILE READ
    CALL    RDCHAR         ;GET CHAR FROM CP/M FILE
    JC      EOF            ;CHECK FOR EOF
;
EOF:
;    PLACE CODE HERE FOR END OF FILE HANDLING
;
;I/O HANDLING SUBROUTINES
;
;
;
;>--> ERASFIL: ERASE THE INCOMING FILE.
;
;IF IT EXISTS, ASK IF IT MAY BE ERASED.
;
ERASFIL:
    LXI     D,FCB          ;POINT TO CTL BLOCK
    MVI     C,SRCHF        ;SEE IF IT..
    CALL    BDOS           ;..EXISTS

```

```
    INR    A          ;FOUND?
    RZ          ;..NO, RETURN
    CALL    ILPRT      ;PRINT:
    DB      '++CP/M FILE EXISTS, TYPE Y TO ERASE: ',0
    CALL    KEYIN      ;GET A CHARACTER FROM CONSOLE
    ANI     5FH        ;MAKE UPPER CASE
    CPI     'Y'        ;WANT ERASED?
    JNZ     EXIT       ;QUIT IF NOT ERASE
    CALL    CRLF       ;BACK TO START OF LINE
;
;
;ERASE OLD FILE
;
    LXI     D,FCB      ;POINT TO FCB
    MVI     C,ERASE    ;GET BDOS FNC
    CALL    BDOS       ;DO THE ERASE
    RET          ;FROM "ERASFIL"
;
;
;>--> MAKEFIL: MAKES THE FILE TO BE RECEIVED
;
MAKEFIL:
    LXI     D,FCB      ;POINT TO FCB
    MVI     C,MAKE     ;GET BDOS FNC
    CALL    BDOS       ;TO THE MAKE
    INR     A          ;FF=BAD?
    RNZ          ;OPEN OK
;
;
;DIRECTORY FULL - CAN'T MAKE FILE
;
    CALL    ERXIT
    DB      '++ERROR - CANNOT MAKE FILE',CR,LF
    DB      '++DIRECTORY MUST BE FULL',CR,LF,'$'
;
;
;>--> OPENFIL: OPENS THE FILE TO BE SENT
;
OPENFIL:
    LXI     D,FCB      ;POINT TO FILE
    MVI     C,OPEN     ;GET FUNCTION
    CALL    BDOS       ;OPEN IT
    INR     A          ;OPEN OK?
    RNZ          ;FILE OPENED OK
    CALL    ERXIT      ;..NO, ABORT
    DB      '++CANNOT OPEN CP/M FILE','$'
;
;
;>--> CLOSFIL: CLOSES THE RECEIVED FILE
;
CLOSFIL:
```

```

    LXI    D,FCB          ;POINT TO FILE
    MVI    C,CLOSE        ;GET FUNCTION
    CALL   BDOS           ;CLOSE IT
    INR    A              ;CLOSE OK?
    RNZ                    ;..YES, RETURN
    CALL   ERXIT          ;..NO, ABORT
    DB     '++CANNOT CLOSE CP/M FILE','$'
;
;
;>-->  INITRD:  INITIALIZES FILE READ PARAMETERS
;
INITRD:
    MVI    A,00H          ;SET THE BUF CNT TO EMPTY
    STA    CHRINBF
    LXI    D,DSKBUF       ;SET THE DMA BUFFER POINTER
    PUSH   D
    MVI    C,STDMA
    CALL   BDOS
    POP    D
    XCHG                    ;SET SECTOR POINTER
    SHLD   SECPTR
    RET
;
;
;>-->  RDCHAR:  READS A CHARACTER FROM FILE
;
;RETURN IS WITH DESIRED CHARACTER IN
;THE A REGISTER. IF EOF, THEN
;RETURN IS WITH THE CARRY FLAG SET.
;
RDCHAR:
    LDA    CHRINBF        ;GET NUMBER OF CHAR IN BUF
    ORA    A              ;CHECK IF BUFFER EMPTY
    JZ     RDBLOCK        ;GO GET A SECTOR IF EMPTY
    DCR    A              ;DECREMENT
    STA    CHRINBF
    LHLD   SECPTR         ;GET BUFFER POINTER
    MOV    A,M            ;GET CHARACTER FOR CALLER
    INX    H              ;INCREMENT POINTER
    SHLD   SECPTR
    CPI    EOFCHR         ;CHECK FOR LOGICAL CP/M EOF
    STC
    RZ                    ;RETURN EXIT FOR LOGICAL EOF
    CMC                    ;CLEAR CARRY SO EOF NOT INDICATED
                    ;ON NORMAL RETURN
    RET                    ;FROM "RDCHAR"
;
;
;BUFFER IS EMPTY - READ IN ANOTHER SECTOR
;
RDBLOCK:

```

```
LXI    D,FCB
MVI    C,READ
CALL   BDOS
ORA    A          ;READ OK?
JZ     RDBFULL    ;YES
DCR    A          ;EOF?
JZ     REOF       ;GOT EOF
;
;
;READ ERROR
;
CALL   ERXIT
DB     '++CP/M FILE READ ERROR','$'
;
REOF:
STC                    ;SET CARRY FLAG FOR EOF EXIT
RET
;
;
;BUFFER IS FULL
;
RDBFULL:
MVI    A,SECSIZ      ;INIT BUF CHAR COUNT
STA    CHRINBF
LXI    H,DSKBUF       ;INIT BUFFER..
SHLD   SECPTR         ;...POINTER
JMP    RDCHAR         ;PASS CHAR TO CALLER
;
;
;>--> INITWR: INITIALIZES FILE WRITE PARAMETERS
;
INITWR:
MVI    A,00H          ;SET THE BUF CNT TO EMPTY
STA    CHRINBF
LXI    D,DSKBUF       ;SET THE DMA BUFFER POINTER
PUSH   D
MVI    C,STDMA
CALL   BDOS
POP    D
XCHG                   ;SET SECTOR POINTER
SHLD   SECPTR
RET
;
;
;>--> WRCHAR: WRITE A CHARACTER TO FILE
;
;ENTRY IS WITH CHARACTER IN A
;ENTRY AT WREOF FILLS REMAINING BYTES
;OF SECTOR WITH 01AH PER CP/M CONVENTION.
;
WRCHAR:
```

```

    LHL D,SECPTR      ;PUT CHAR IN BUFFER
    MOV  M,A
    INX  H             ;BUMP POINTER
    SHLD SECPTR
    LDA  CHRINBF       ;INCR CHAR COUNT
    INR  A
    STA  CHRINBF
    CPI  SECSIZ        ;CHECK IF SECTOR FULL
    RNZ          ;GO BACK IF OK
;
WRBLOCK:
    LXI  D,FCB         ;IF FULL THEN WRITE
    MVI  C,WRITE       ;..THE..
    CALL BDOS          ;..BLOCK
    ORA  A
    JNZ  WRERR         ;OOPS, ERROR
    MVI  A,00H         ;RESET THE CHAR CNT
    STA  CHRINBF
    LXI  H,DSKBUF      ;RESET BUFFER..
    SHLD SECPTR        ;..POINTER
    RET
;
WRERR:
    CALL ERXIT         ;EXIT W/MSG:
    DB   '++ERROR WRITING CP/M FILE',CR,LF,'$'
;
WREOF:
    LDA  CHRINBF       ;FILL REST OF SECTOR WITH 01AH
    LHL D,SECPTR
    MVI  B,E0FCHR
WREND:
    MOV  M,B           ;PUT IN THE CP/M EOF CODE
    INX  H
    INR  A             ;INC THE CHAR CNT
    CPI  SECSIZ        ;BUFFER FULL YET
    JNZ  WREND
    JMP  WRBLOCK       ;GO PUT FILLED BLOCK ON DISK
;
;
;--> KEYIN: GETS A KEY CODE IN FROM CONSOLE
;
KEYIN:
    PUSH B             ;SAVE..
    PUSH D             ;..ALL..
    PUSH H             ;..REGS
    MVI  C,RDCON       ;GET CON CHAR FUNCTION CODE
    CALL BDOS          ;GET CHARACTER
    MOV  A,E
    POP  H             ;RESTORE..
    POP  D             ;..ALL..
    POP  B             ;..REGS

```

```

    RET
;
;
; >--> CTYPE: TYPES VIA CP/M SO TABS ARE EXPANDED
;
CTYPE:
    PUSH    B            ;SAVE..
    PUSH    D            ;..ALL..
    PUSH    H            ;..REGS
    MOV     E,A          ;CHAR TO E
    MVI     C,WRCON      ;GET BDOS FNC
    CALL    BDOS         ;PRIN THE CHR
    POP     H            ;RESTORE..
    POP     D            ;..ALL..
    POP     B            ;..REGS
    RET             ;FROM "CTYPE"
;
;
; >--> CRLF: TYPE A CARRAGE RETURN LINE FEED PAIR AT CONSOLE
;
CRLF:
    MVI     A,CR
    CALL    CTYPE
    MVI     A,LF
    CALL    CTYPE
    RET
;
;
; >--> ILPRT: INLINE PRINT OF MSG
;
;THE CALL TO ILPRT IS FOLLOWED BY A MESSAGE,
;BINARY 0 AS THE END.  BINARY 1 MAY BE USED TO
;PAUSE (MESSAGE 'PRESS RETURN TO CONTINUE')
;
ILPRT:
    XTHL            ;SAVE HL, GET HL=MSG
ILPLP:
    MOV     A,M        ;GET CHAR
    ORA     A          ;END OF MSG?
    JZ      ILPRET     ;..YES, RETURN
    CPI     1          ;PAUSE?
    JZ      ILPAUSE     ;..YES
    CALL    CTYPE      ;TYPE THE CHARACTER OF MESSAGE
ILPNEXT:
    INX     H          ;TO NEXT CHAR
    JMP     ILPLP      ;LOOP
;
;
;PAUSE WHILE TYPING HELP SO INFO DOESN'T
;  SCROLL OFF OF VIDEO SCREENS
;

```

```

ILPAUSE:
    CALL    ILPRT            ;PRINT:
    DB      CR,LF,'PRESS RETURN TO CONTINUE OR ^C TO EXIT'
    DB      CR,LF,0
    CALL     KEYIN           ;GET ANY CHAR
    CPI     'C' -40H         ;REBOOT?
    JZ      EXIT             ;YES.
    JMP     ILPNEXT          ;LOOP
;
ILPRET:
    XTHL                    ;RESTORE HL
    RET                     ; & RETURN ADDR PAST MESSAGE
;
;
;>--> PRTMSG: PRINTS MSG POINTED TO BY (DE)
;
;A '$' IS THE ENDING DELIMITER FOR THE PRINT.
;NO REGISTERS SAVED.
;
PRTMSG:
    MVI     C,PRINT          ;GET BDOS FNC
    JMP     BDOS             ;PRINT MESSAGE, RETURN
;
;
;>--> ERXIT: EXIT PRINTING MSG FOLLOWING CALL
;
ERXIT:
    POP     D                ;GET MESSAGE
    CALL    PRTMSG           ;PRINT IT
;
EXIT:
    LXI     D,080H           ;RESET DEFAULT DMA ADDRESS FOR EXIT
    MVI     C,STDMA
    CALL    BDOS
    LHLD    STACK            ;GET ORIGINAL STACK
    SPHL                    ;RESTORE IT
    JMP     WBOOT            ;GO DO A WARM BOOT OF CP/M TO BRING
                            ;BACK IN CCP
;
;
;FOLLOWING 2 USED BY THE CP/M DISK BUFFERING ROUTINES
;
SECPTR DW    DSKBUF          ;POINTER TO DISK BUFFER POS
CHRINBF DB    0              ;# OF CHARACTERS IN BUFFER
;
;
;SETUP A STACK AREA
;
    DS      38               ;STACK AREA
STACK DS      2              ;STACK POINTER
;

```

```
; -----  
;  
    END  
;  
;+++...END OF LISTING 2
```

The reader is invited to be with us again next month when the tutorial continues into its third and final part. The functions of random record file I/O will be presented with complete programming examples to show how random I/O works. Several special file I/O tricks will be shown that permit unique problems to be solved under the CP/M operating system. One of these will be a program that does "update" on an existing file without the use of the random record I/O capabilities. So long till January and I hope that all Life Lines readers have a joyous holiday season.

## SLIDING INTO BDOS (Part III)

### UNDERSTANDING RANDOM FILES

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The time has arrived to complete the third and final part of this series on the operation of the CP/M BDOS as viewed from the assembly language programmers perspective. Presently we will build upon the extensive treatment of sequential files presented in Part II of the series to provide a basis for understanding the CP/M 2.2 random file I/O capability. Please note that functions of the BDOS presented here are specific to CP/M Versions 2.2 and 3.0. Older CP/M systems using Version 1.4 do not directly support random access file I/O and as such are not compatible with the programming examples presented below.



## WHY RANDOM FILE I/O ANYWAY

In the beginning of the CP/M era, sometime around the release of Version 1.3 by Digital Research, small inexpensive single-user micro processor systems were typically used for simple-minded data processing applications. Most computing operations were linear with respect to the data handling by the CPU. Data entered from paper tape, cassette, card readers, or human entry from a keyboard tended to be limited to a sequential processing from start to finish. The usage of such data by the computer in data analysis, program compilation, or logging applications was also largely sequential. Finally the data output operations based upon the needs of hard copy, backup, and transmission from micro to micro were relegated to sequential processing applications.

Anticipated applications of micro type computer hardware by operating system designers, at that time, seemed to dictate that the disk file structures of the operating systems should be sequential in nature. This was true for the earliest releases of CP/M and Intel's ISIS II operating system. Other simple floppy disk operating systems like PERTEC's FDOS and MITS' Disk Extended Basic operating systems were also strictly sequential in the treatment of the disk file allocation and storage. However, these two systems permitted random record I/O within the bounds of an already existing file provided the space to store the records was previously pre-allocated as contiguous disk space in the file structure. The process of random I/O was then easy as a relative offset between the beginning record number for the file and the offset desired within the file.

As the micro processor applications market opened up in the late 1970's it seemed that new uses for computers were being found weekly. It has gotten to the point that micro processor computer users have a large array of very sophisticated software packages to choose from and utilize in their business and hobby activities. The main thing that can be pointed out about many of these packages is that the processes they perform are hardly linear with respect to the handling of data. Interactive programs like word processors, data base managers, spelling checkers, and spread sheet analysis programs may very well need to be able to store or access data to/from a disk file in a manner that cannot be handled in the old sequential manner. The sequential philosophy generally limited file update to appending to the end of the file and read access to a particular record had to read N-1 records from the beginning of the file prior to being able to read record N.

Random access file I/O within an operating system anticipates the requirements of non-sequential I/O by permitting access to various records directly. Any record that was

previously written may be read upon demand. Likewise the user/programmer may write any record desired. The Digital Research CP/M operating system supports this type of I/O in a powerful yet elegantly simple manner through a set of four BDOS system functions. These calls allow random access disk files to be implemented within the standard CP/M compatible file structure.

## RANDOM FILE STRUCTURE UNDER CP/M 2.2

The structure of random files under the CP/M operating system is much the same as that for sequential files. Part II of this series (Lifelines, January 1982) described and illustrated the sequential structure in detail. The reader will recall that CP/M treats disk data in fixed records of 128 bytes. These records are collected together into "groups" that are stored on the disk as an allocated group. The disk space reserved for a given file, in its directory entry, is always marked, identified, and allocated in the even multiples of the "allocation group size".

I previously mentioned two older operating systems that supported random file I/O within the confines of a pre-allocated file. This system requires that all of the space for an "N" record file be reserved as contiguous disk space even if the file only contains two records (#0 and #N). Making a random access file bigger than the pre allocated size was virtually impossible. The CP/M Ver 2.2 random file access system has overcome the problems described above. A random file under CP/M contains only the number of allocated groups required to hold the stored records. The holes between the defined records do not consume unused disk space.

If a file under CP/M is created with only random record 0 of the file written then that file contains 128 bytes of real data and consumes one allocation group of disk space. The allocation group consumed also may contain other adjacent random records to fill out the size of the group. For instance, on single density 8" disks with a 1024 byte allocation group size, a one record (#0) file would be able to be written with additional record numbers 1 to 7 within the same allocation group. Likewise if a single record file was created with only record number 9 written, that file would consume only one allocation group of disk space. Additional record numbers 8, and 10 to 15 could then be written without requiring additional disk space.

## RANDOM FILE I/O SYSTEM CALLS

Let us next investigate the five BDOS system calls that CP/M

supports for random I/O within files. The chart of Figure 1 on the following page details the look of a random access file control block. Note that the file control block contains three bytes at the end that are used to store the random record number that will currently be accessed. The random access system calls all utilize this field to determine the portion of the file to access at read/write time.

A CP/M random file may contain up to 64K records of 128 bytes numbered from 0 to 65535. Two bytes of the file control block hold this record number, r0 as the low byte and r1 as the high byte. This provides accessibility to records up to a maximum file size of 8 megabytes. The r2 byte of the file control block is not used except as the overflow or carry out of the r1 byte. If byte r2 ever contains a value that is non-zero the record number is beyond the end of the 8 megabyte limit for the file.

To access a random file, it must first be opened in the normal manner with the "open" BDOS function call. In the case of creating a new random file the make file BDOS call is sufficient in that the the results of the make operation are equivalent to the open function on a zero length file.

#### READ RANDOM RECORD: Function 33.

This system call is made with the (DE) register pair pointing to a 36 byte file control block. Bytes r0-r2 are set up with the random record to read. The BDOS then fetches the addressed record from the file and places it in the callers record buffer pointed to by the last set buffer address function

Figure 1. FILE CONTROL BLOCK DESCRIPTION

```

-----
|dr|f1|f2|/ /|f8|t1|t2|t3|ex|s1|s2|rc|d0|/ /|dn|cr|r0|r1|r2|
-----
00 01 02 ... 08 09 10 11 12 13 14 15 16 ... 31 32 33 34 35

```

where:

dr            drive code (0 - 16)  
              0 => use default drive for file access  
              1 => select drive A: for file access  
              2 => select drive B: for file access  
              ...  
              16=> select drive P: for file access

f1...f8       contain the files name in ASCII upper case  
              with high bits equal to zero.

t1,t2,t3 contain the file type in ASCII upper case with high bits normally equal zero. tn' denotes the high bit of these bit positions.  
t1' = 1 => Read/Only file  
t2' = 1 => SYS file, no DIR list

ex contains the current extent number, normally set to 00 by the user, but is in the range 0 - 31 during file I/O.

s1 reserved for internal system use

s2 reserved for internal system use, set to zero on call to OPEN, MAKE, SEARCH system calls.

rc record count for extent "ex," takes on values 0 to 128.

d0...dn filled in by BDOS to indicate file group numbers for this extent.

cr current record to read or write in a sequential file operation. Normally set to zero by the user upon initial access to a file.

r0,r1,r2 optional random record number in the range of 0 to 65535, with overflow to r2. r0/r1 are a 16 bit value in low/high byte order.

call. The r0-r2 fields of the file control block are not changed as a result of the random read function such that a subsequent random read operation would read the same record. The random read function may return a number of error codes as described below:

Error Code 00 - The random read function worked without error and the user buffer contains the desired data.

Error Code 01 - The random read operation addresses a record that is contained in a disk allocation group not allocated to the file. This means that the group field number slot of the appropriate extent of the file that should contain the record is equal to 0.

Error Code 03 - The random read operation just requested required that a different extent descriptor directory entry had to be open for the impending operation, however prior to opening the new extent the current extent could not be closed due to disk read/only status or a disk change.

Error Code 04 - The random read operation just requested

required access to an extent of the file that does not exist on the disk.

Error Code 06 - The random read operation just requested required access to a record number beyond the bounds of the disk drive, ie the disk drive is less than 8 megabytes and the record requested is within an allocation group beyond the end of the disk.

#### WRITE RANDOM RECORD: Function 34.

This system call is made with the (DE) register pair pointing to a 36 byte file control block. Bytes r0-r2 are set up with the random record to write. The BDOS then moves the data in the callers record buffer pointed to by the last set buffer address function call to the addressed record in the file. The r0-r2 fields of the file control block are not changed as a result of the random write function such that a subsequent random write operation would write the same record. The random write function may return a number of error codes as described below:

Error Code 00 - The random write function worked without error and the user buffer contains the desired data.

Error Code 03 - The random write operation just requested required that a different extent descriptor directory entry had to be open for the impending operation, however prior to opening the new extent the current extent could not be closed due to disk read/only status or a disk change.

Error Code 05 - The random write operation just requested required access to an extent of the file that does not exist on the disk. In the process of creating the new extent the disk directory was found to be full.

Error Code 06 - The random write operation just requested required access to a record number beyond the bounds of the disk drive, ie the disk drive is less than 8 megabytes and the record requested is within an allocation group beyond the end of the disk.

#### WRITE RANDOM RECORD WITH ZERO FILL: Function 40.

This system call is made with the (DE) register pair

pointing to a 36 byte file control block. Bytes r0-r2 are set up with the random record to write. The BDOS then moves the data in the callers record buffer, pointed to by the last set buffer address function call, to the addressed record in the file. The r0-r2 fields of the file control block are not changed as a result of the random write function such that a subsequent random file operation would access the same record. If the random write operation caused a new allocation group to be allocated to the file the other records of the same block are filled with zeros. The random write with zero fill function may return a number of error codes identical to those described for function number 34 above.

#### COMPUTE FILE SIZE: Function 35.

This system call determines the number of 128 byte records in a file and sets the number of records into the r0 and r1 bytes of the 36 byte file control block addressed by the (DE) register pair. The returned size is a virtual size in that if the file was created by random write operations and the file contains "holes" the file size function does not take the holes into account. Another way of looking at this is to think of this function as returning a record number that is one greater than the maximum record number currently in the file. If the file had no "holes" or it had been written in the conventional sequential fashion, then the file size reported by this function is the real file size. This function provides a convenient function of positioning a file at its end so that subsequent sequential or random update could be performed.

#### SET RANDOM RECORD: Function 36:

The (DE) register pair is set to point to a 36 byte file control block that has previously been used to reference a file in the sequential mode. Upon reference with this system call the r0 to r2 fields are filled in with the random record number that corresponds to the current file position, ie the BDOS simply computes the real current record number as follows:

The current extent number is multiplied by 128, the number of records per extent, and to this product is added the numerical value of the CR field, current record in this extent. The final result is placed into the r0-r2 fields of the FCB.

#### LOOKING AT SOME EXAMPLES

The following simple assembly language program is designed to write record numbers 0 and 143 into a file on the disk. The write random function is used to write the first record with all A's and the second record, # 143, with all B's.

```
;
;
;RANDOM RECORD I/O DEMONSTRATION FOR CP/M 2.2
;
; THIS FIRST LEVEL DEMONSTRATION IS DESIGNED TO
; SHOW HOW TO INITIALLY SET UP A FILE TO BE A RANDOM FILE
; AND TO WRITE TWO RECORDS INTO THE FILE SUCH THAT THE
; FIRST RECORD (RECORD NUMBER 0) AND THE SEVENTEENTH
; RECORD OF THE SECOND EXTENT (RECORD NUMBER 143) BOTH
; CONTAIN DATA. THE PURPOSE IS TO DEMONSTRATE THE
; RESULTING DISK DIRECTORY ENTRIES THAT RESULT FROM
; AN INCOMPLETE FILE. THIS DEMO PROGRAM DOES NO RANDOM
; WRITE ERROR CHECKING.
;
;
;SYSTEM LEVEL INTERFACE EQUATES
;
BDOS      EQU      0005H          ;SYSTEM INTERFACE VECTOR
MAKE      EQU      22            ;MAKE NEW FILE FUNCTION
SBADDR    EQU      26            ;SET DISK BUFFER ADDR
OPEN      EQU      15            ;OPEN FILE FUNCTION
CLOSE     EQU      16            ;FILE CLOSE FUNCTION
DELETE    EQU      19            ;DELETE FILE FUNCTION
RRAND     EQU      33            ;READ RANDOM FUNCTION
WRAND     EQU      34            ;WRITE RANDOM FUNCTION
WRANDF    EQU      40            ;WRITE RANDOM WITH 00 FILL
;
;
      ORG      0100H          ;START OF A PROGRAM
;
      XRA      A              ;ZERO BYTES OF THE FCB
      STA      EXT            ;EXTENT FIELD
      STA      CR              ;CURRENT RECORD COUNT
      STA      RR+2           ;AND THE R2 FIELD
      LXI      H,0000H        ;ALSO ZERO RANDOM RECORD FIELED
      SHLD     RR
;
      LXI      D,BUFFER       ;SET DISK BUFFER ADDRESS
      MVI      C,SBADDR
      CALL     BDOS
;
      LXI      D,RANDFCB      ;POINT AT OUR FCB
      MVI      C,DELETE       ;ERASE TEST FILE IF IT ALREADY EXISTS
      CALL     BDOS
;
```

```
LXI    D,RANDFCB    ;MAKE A NEW FILE FOR TEST
MVI    C,MAKE
CALL   BDOS
;
MVI    A,'A'        ;FILL FIRST RECORD WITH A'S
CALL   FILL         ;GO FILL
LXI    H,0000H      ;SET RECORD NUMBER TO WRITE A'S INTO
SHLD   RR
LXI    D,RANDFCB    ;WRITE RECORD OF A'S
MVI    C,WRAND      ;NORMAL WRITE RANDOM FUNCTION
CALL   BDOS
;
MVI    A,'B'        ;FILL NEXT RECORD WITH B'S
CALL   FILL         ;GO FILL
LXI    H,143        ;SET RECORD NUMBER TO WRITE B'S INTO
SHLD   RR
LXI    D,RANDFCB    ;WRITE RECORD OF B'S
MVI    C,WRAND      ;NORMAL WRITE RANDOM FUNCTION
CALL   BDOS
;
LXI    D,RANDFCB    ;CLOSE JUST WRITTEN FILE
MVI    C,CLOSE
CALL   BDOS
;
;
RET          ;BACK TO CCP BY IMMEDIATE RETURN
;
;
;SUBROUTINE TO FILL BUFFER WITH A PATTERN
;
; ENTRY WITH (A) CONTAINING BYTE TO FILL BUFFER WITH
;
FILL:
LXI    H,BUFFER     ;POINT AT BUFFER FOR FILL
MVI    B,128        ;FILL BYTE COUNTER
FILLP:
MOV     M,A          ;PUT A BYTE INTO BUFFER
INX     H            ;BUMP POINTER
DCR     B            ;DECREMRNT BYTE COUNT
JNZ     FILLP        ;CONTINUE TILL BUFFER FULL
RET
;
;
;RANDOM FILE TEST DATA AREA
;
RANDFCB:
DB      00           ;USE CURRENT LOGGED DRIVE FOR TEST
DB      'RANDFILE'   ;NAME OF FILE TO PLAY WITH
DB      'TST'        ;..AND THE EXTENSION NAME
EXT:
DB      00,00,00,00  ;EXTENT, S1, S2, AND FCBSZ BYTES
```



```

    DS    16          ;STORAGE FOR THE ALLOCATION NUMBERS
CR:
    DS    1          ;CURRENT RECORD BYTE
RR:
    DS    2          ;RANDOM RECORD NUMBER (R0,R1)
    DS    1          ;RANDOM RECORD OVERFLOW BYTE (R2)
;
;
;RANDOM DISK I/O DATA BUFFER
;
BUFFER:
    DS    128        ;ONE RECORD BUFFER
;
    END

```

The above program was assembled and caused to run on an empty single density disk in the default disk drive. The following display shows how the directory upon the disk looked after running the program. Notice that the file only consumes two allocated groups. Due to the fact that this was a single density disk with 1024 byte allocation groups of 8 records each, then if record number 8 was subsequently written the directory entries would change to include an allocation block number in the second group number slot of the first extent of the file.

G=00:00, T=2, S=1, PS=1

```

00  0052414E 4446494C 45545354 00000001 *.RANDFILETST....*
10  02000000 00000000 00000000 00000000 *.*****
20  0052414E 4446494C 45545354 01000010 *.RANDFILETST....*
30  00030000 00000000 00000000 00000000 *.*****
40  E5E5E5E5 E5E5E5E5 E5E5E5E5 E5E5E5E5 *eeeeeeeeeeeeeeee*
50  E5E5E5E5 E5E5E5E5 E5E5E5E5 E5E5E5E5 *eeeeeeeeeeeeeeee*
60  E5E5E5E5 E5E5E5E5 E5E5E5E5 E5E5E5E5 *eeeeeeeeeeeeeeee*
70  E5E5E5E5 E5E5E5E5 E5E5E5E5 E5E5E5E5 *eeeeeeeeeeeeeeee*

```

The following two sector displays off the single density disk show the A's and B's written by the program above. All other sectors in the group numbers 02 and 03 were empty, ie contained whatever data that used to be there. This brings up the subject of the write random with zero fill function. A small segment of

G=02:00, T=2, S=17, PS=20

```

00  41414141 41414141 41414141 41414141 *AAAAAAAAAAAAAAAA*
10  41414141 41414141 41414141 41414141 *AAAAAAAAAAAAAAAA*
20  41414141 41414141 41414141 41414141 *AAAAAAAAAAAAAAAA*
30  41414141 41414141 41414141 41414141 *AAAAAAAAAAAAAAAA*

```

```

40  41414141 41414141 41414141 41414141 *AAAAAAAAAAAAAAAAAAAA*
50  41414141 41414141 41414141 41414141 *AAAAAAAAAAAAAAAAAAAA*
60  41414141 41414141 41414141 41414141 *AAAAAAAAAAAAAAAAAAAA*
70  41414141 41414141 41414141 41414141 *AAAAAAAAAAAAAAAAAAAA*

```

G=03:07, T=3, S=6, PS=5

```

00  42424242 42424242 42424242 42424242 *BBBBBBBBBBBBBBBBBB*
10  42424242 42424242 42424242 42424242 *BBBBBBBBBBBBBBBBBB*
20  42424242 42424242 42424242 42424242 *BBBBBBBBBBBBBBBBBB*
30  42424242 42424242 42424242 42424242 *BBBBBBBBBBBBBBBBBB*
40  42424242 42424242 42424242 42424242 *BBBBBBBBBBBBBBBBBB*
50  42424242 42424242 42424242 42424242 *BBBBBBBBBBBBBBBBBB*
60  42424242 42424242 42424242 42424242 *BBBBBBBBBBBBBBBBBB*
70  42424242 42424242 42424242 42424242 *BBBBBBBBBBBBBBBBBB*

```

the first demonstration program was changed to cause the second write operation to be done with zero fill. The changed portion of the program is shown below:

```

    LXI    D,RANDFCB      ;WRITE RECORD OF A'S
    MVI    C,WRAND        ;NORMAL WRITE RANDOM FUNCTION
    CALL   BDOS
;
    MVI    A,'B'          ;FILL NEXT RECORD WITH B'S
    CALL   FILL           ;GO FILL
    LXI    H,143          ;SET RECORD NUMBER TO WRITE B'S INTO
    SHLD   RR
    LXI    D,RANDFCB      ;WRITE RECORD OF B'S
    MVI    C,WRANDF       ;WRITE RANDOM ZERO FILL FUNCTION
    CALL   BDOS
;
    LXI    D,RANDFCB      ;CLOSE JUST WRITTEN FILE

```

Note from the directory display below that there is no change in the appearance of the entries from the first example. This time the only thing that changed was the data in allocation group 3. Due to the second write this allocation group contains a sector of B's at GROUP=03:07 with the other seven sectors of the group now containing zeroes from the zero fill operation. The function of zero fill is to leave a clean slate on records numbers subsequently read from the same allocation block. The BDOS is capable of reporting unwritten record information for records that correspond to group number slots in the directory entries that contain a '00' byte indicating unallocated. However once a group is allocated for one record the BDOS cannot determine if other sectors of that group have been written or

not. Thus `ero` function may be issued when creating a random access file for the first time. The programmer may then use a record of 128 zeroes to indicate that the record is not used as opposed to accidentally mistaking the garbage data from uninitialized sectors written without zero fill as real data.

G=00:00, T=2, S=1, PS=1

```

00  0052414E 4446494C 45545354 00000001 *.RANDFILETST....*
10  02000000 00000000 00000000 00000000 *.....*
20  0052414E 4446494C 45545354 01000010 *.RANDFILETST....*
30  00030000 00000000 00000000 00000000 *.....*
40  E5E5E5E5 E5E5E5E5 E5E5E5E5 E5E5E5E5 *eeeeeeeeeeeeeeee*
50  E5E5E5E5 E5E5E5E5 E5E5E5E5 E5E5E5E5 *eeeeeeeeeeeeeeee*
60  E5E5E5E5 E5E5E5E5 E5E5E5E5 E5E5E5E5 *eeeeeeeeeeeeeeee*
70  E5E5E5E5 E5E5E5E5 E5E5E5E5 E5E5E5E5 *eeeeeeeeeeeeeeee*

```

The next example program is included here to show a clever means of implementing arbitrary record selection I/O within a file without resorting to random file I/O. The intent is not to indicate that the following scheme is the preferred method. The program below was developed with the CP/M Ver 1.4 operating system in mind. However the algorithm works fine with CP/M 2.2 as well. The technique used to play with random records by using sequential read and write operations is to manipulate the "cr" field of a standard 33 byte file control block. The "cr" byte is the only meant that the BDOS uses to indicate the next record to access. The programmer may change this byte value to force the BDOS to go to any record within the current extent.

If the first extent of a file is opened, the group allocation values for that extent lie in the file control block. If the technique of performing "your own" random I/O is done, the code must access record numbers not to exceed 07fh without first closing the current extent and opening the next. This can be done with either the conventional open and close operations or the programmer, when done working with the current extent may open next automatically by performing a dummy read of record 080H of the current extent. The programming example below uses the "roll your own" technique but does not anticipate a file size greater than 16K (one extent size).

The program below is a skeleton structure of a .COM file serialization procedure. The idea is to insert a six byte serial number string into the target file PROG.COM on drive B:. The serial number is inserted into the file at the places specified by the labels in the table at the start of the listing. These values are stripped out of the symbol table that is generated at the assembly of the PROG.ASM file. If the assembler does not

generate a symbol table then the label values may be pulled off the .PRN listing output. The insert points are places within the "to be serialized" program where the programmer has determined that he would like to place the serial number string. Within the file itself, the labels point to the place where the string is to be inserted with respect to run time load address. The real file offset is 0100H bytes less. In addition, the scheme does not insert all six bytes of the program serial number at each location. The byte at each label address minus one contains a value between 1 and 6 of the number of serial number bytes that should actually be inserted at serialization time.

The list of label values in the program below is used to build, at assembly time, a table of record numbers where the specific serial number strings are to be inserted. This table is then used to fill in the "cr" byte of the file control block as each serial number is to be inserted. The table also contains the byte offset within the record where the insert point is to start. As each serial number is to be inserted the appropriate record is read, the number is inserted (with length specified by the value from the file record just accessed), and the record is written back to the disk. Sequential read and write operations are used for both operations. Logic within the code listing below also provides for the occurrence that the serial number string may cross the end of the first record and flow into the next record. In this case the first is rewritten followed by reading of the next with the remainder of the insert proceeding from the beginning of the second record.

Please note that the program example is given as a skeleton only and the serial number entry process, increment process, and the disk I/O error exit points are left for the reader/programmer to fill in with code of his own choosing.

```
;
;
;PROGRAM SERIAL NUMBER INSERTION EQUATES
;  EACH ADDRESS IS A VALUE INSIDE OF THE "PROG.COM"
;  FILE THAT IS THE PLACE TO PUT THE SERIAL NUMBER.
;
SERA    EQU    0132H
SERB    EQU    01E9H
SERC    EQU    0278H
SERD    EQU    039AH
SERE    EQU    06FFH
SERF    EQU    0732H
SERG    EQU    0BBCH
SERH    EQU    0C08H
;
;
```

```

;CP/M BDOS SYSTEM CALLS FUNCTION NUMBERS
;
BOOT    EQU    0000H        ;REBOOT LOCATION ENTRY POINT
BDOS    EQU    0005H        ;BDOS FUNCTION ENTRY POINT
RESET   EQU    13          ;RESET DISK SYSTEM
OPEN    EQU    15          ;OPEN FILE FUNCTION
CLOSE   EQU    16          ;CLOSE FILE FUNCTION
DMAADR  EQU    26          ;SET DATA BUFFER ADDRESS
READ    EQU    20          ;READ SEQUENTIAL
WRITE   EQU    21          ;WRITE SEQUENTIAL
;
;
;DEFINE BASE EXECUTION AREA FOR THIS PROGRAM
;
START   EQU    0100H
;
;
    ORG     START          ;BASE OF EXECUTION AREA
;
;
;START UP HERE WITH PROGRAM INITIALIZATION AND
;DEFINE PROCEDURE TO FETCH IN SERIAL NUMBER TO INSERT INTO
;THE FILE
;
SERASK:

;
;ENTER APPROPRIATE CODE HERE TO PUT A SIX BYTE SERIAL NUMBER
;INTO VARIABLE "SERSTR"
;

;
;
;SERIAL NUMBER INSERT POINT PROCESSING
;
;
SERCOPY:
    MVI     C,RESET        ;RESET DISK SYSTEM UPON INSERT
    CALL    BDOS
    LXI     D,PROGFCB      ;SET TO OPEN THE PROG.COM FILE
    MVI     C,OPEN
    CALL    BDOS
    INR     A              ;CHECK IF OPEN ERROR
    JNZ     SERCP1         ;OPEN SO GO START WRITE

;
;PRINT ERROR MESSAGE HERE AS TO INDICATE THAT THE FILE
;"PROG.COM" IS NOT PRESENT ON DRIVE B:.
;
    JMP     SERASK         ;IF ERROR BACK TO GET A NEW SERIAL

```

; ..NUMBER OR TO EXIT

SERCP1:

MVI B,00H ;INDEX COUNTER FOR TABLE VALUES

SERIST:

MOV L,B

MVI H,00H

DAD H ;DOUBLE TO WORDS

LXI D,INSTAB ;INTO TABLE

DAD D

MOV A,M ;GET RECORD NUMBER FOR PLACE

STA PROGFCB+32 ;SET TO READ THIS RECORD

INX H

MOV C,M ;GET BYTE LOCATION OF COUNTER

PUSH B

LXI D,PROGFCB ;USE PROG FCB TO READ

MVI C,READ

CALL BDOS ;GO READ SECTOR

POP B ;INDEX TO LENGTH

MOV L,C

MVI H,0

LXI D,080H ;BASE OF DEFAULT BUFFER

DAD D

MOV C,M ;GET LENGTH

INX H ;POINT TO NEXT BUFFER BYTE

LXI D,SERSTR ;POINT (DE) TO SERIAL LOCATION

;

MOVL:

MOV A,H ;SEE IF PAST THE END OF BUFFER

CPI 01H

JNZ SAMSEC ;STILL IN THE SAME SECTOR

;

MVI H,0 ;RESET TO NEXT SECTOR BASE

PUSH B

PUSH H

PUSH D

LXI H,PROGFCB+32 ;DECREASE RECORD FOR WRITE

DCR M

LXI D,PROGFCB

MVI C,WRITE ;WRITE LAST SECTOR

CALL BDOS

LXI D,PROGFCB

MVI C,READ ;READ NEXT SECTOR

CALL BDOS

POP D

POP H

POP B

;

SAMSEC:

PUSH B

LDAX D ;GET A SERIAL NUMBER BYTE

```

MOV     M,A           ;AND SLAM INTO BUFFER
POP     B
INX     H
INX     D
DCR     C             ;DONE ALL BYTES HERE YET
JNZ     MOVLP
;
PUSH    B
LXI     H,PROGFCB+32   ;SET BACK CURRENT RECORD FOR WRITE
DCR     M
LXI     D,PROGFCB
MVI     C,WRITE        ;REWRITE THIS SECTOR
CALL    BDOS
POP     B
INR     B             ;BUMP TABLE SCAN INDEX
LDA     TABLEN        ;CHECK FOR DONE
CMP     B
JNC     SERIST         ;GO FOR NEXT TABLE ENTRY

;
;PUT IN LOGIC HERE TO SPECIFY THE NEXT OF SEQUENTIAL SERIAL NUMBERS
;OR TO GO BACK TO THE TOP OF THE PROGRAM TO GET A NEW SERIAL NUMBER.
;

;
;
;PARAMETER DATA AREA FOR SERAL NUMBER PROGRAM
;
;
;"PROG.COM" FILE ACCESS CONTROL BLOCK
;
PROGFCB:
DB      'B'-040H       ;DISK DRIVE B: ALL THE TIME
DB      'PROG COM',0,0,0,0
DS      17             ;ALLOCATION SPACE
;
;
;
;SERIAL NUMBER INSERTION POINT REFERENCE TABLE
;
INSTAB:
DB      ((SERA-0100H-1)/128) ;RECORD NUMBER
DB      ((SERA-0100H-1) AND 07FH) ;BYTE OFFSET
DB      ((SERB-0100H-1)/128) ;RECORD NUMBER
DB      ((SERB-0100H-1) AND 07FH) ;BYTE OFFSET
DB      ((SERC-0100H-1)/128) ;RECORD NUMBER
DB      ((SERC-0100H-1) AND 07FH) ;BYTE OFFSET
DB      ((SERD-0100H-1)/128) ;RECORD NUMBER
DB      ((SERD-0100H-1) AND 07FH) ;BYTE OFFSET
DB      ((SERE-0100H-1)/128) ;RECORD NUMBER
DB      ((SERE-0100H-1) AND 07FH) ;BYTE OFFSET

```

```
DB      ((SERF-0100H-1)/128)      ;RECORD NUMBER
DB      ((SERF-0100H-1) AND 07FH) ;BYTE OFFSET
DB      ((SERG-0100H-1)/128)      ;RECORD NUMBER
DB      ((SERG-0100H-1) AND 07FH) ;BYTE OFFSET
DB      ((SERH-0100H-1)/128)      ;RECORD NUMBER
DB      ((SERH-0100H-1) AND 07FH) ;BYTE OFFSET
;
TABLEN:
DB      (($-INSTAB)/2)-1          ;NUMBER OF TABLE ENTRIES
;                                     ;..MINUS 1 FOR LOOP EASE
SERSTR:
DS      10H                      ;PLACE TO KEEP BINARY SERIAL NUMBER
;
;
END
;
;
;...END OF SERIAL NUMBER INSERT PROGRAM
```

The next and final example is a fully functional program that uses random record I/O under CP/M 2.2 to perform a "useful" function. The program mixes up the records of a file in an ordered yet bizarre way in order that the file contents may be encoded to prevent its use until such time that it is unscrambled. The unmixing process is also performed by the program below. The records or "sectors" of the file are mixed and unmixed in place on the disk in that the disk file is not copied. Random access file I/O is used to swap records directly. The comment block at the beginning of the program listing contains an explanation of the program "intent" and the record mixing algorithm chosen. Operation of the program, should the reader wish to utilize the encoding and decoding functions provided, is also described in the listing.

This example program is presented as a working example of random file I/O in use. Detailed description of the internal workings of the program are beyond the scope of this tutorial but may be inferred by studying the listing and reading the rather prolific comment statements. For readers that would like to avoid the aggravation of typing in the source code for the program below or for the other programs presented in this BDOS tutorial series, Part I in Lifelines, November 1982 and Part II in Lifelines, January 1983, a machine readable copy of the source code files on an eight inch single density diskette may be obtained from Michael J. Karas, 2468 Hansen Court, Simi Valley, California 93065. Please send diskettes preformatted, labeled and in a returnable mailer of some sort. Also include either stamps or money for return postage (no postage meter tapes, those are accepted on date of printing only) for your return package.



## LISTING FOR SECRET.ASM A RANDOM I/O PROGRAM EXAMPLE

```
;
;
;RANDOM RECORD I/O DEMONSTRATION FOR CP/M 2.2
;
; THIS THIRD LEVEL DEMONSTRATION PROGRAM IS DESIGNED TO
; DEMONSTRATE RANDOM FILES BY DEVELOPING A 'NOT NECESSARILY
; PRACTICAL' ALGORITHM FOR ENCODING A PROGRAM FILE ON A DISK.
; THE INTENT IS TO MAKE THE TRANSMISSION OF AN OBJECT FILE
; ARBITRARILY SCRAMBLED ON A 128 BYTE BY 128 BYTE RECORD BASIS
; SUCH THAT IF THE TRANSMITTED FILE, EITHER ON FLOPPY DISKETTE
; OR ON THE PHONE LINE WERE INTERCEPTED BY AN ILLICIT THIRD
; PARTY, THEN THE THIRD PARTY WOULD RECEIVE GARBAGE UNLESS
; HE HAD POSSESSION OF THE DECODING ALGORITHM.
;
; THIS PROGRAM WILL IMPLEMENT SUCH AN ALGORITHM IN BOTH AN
; ENCODING AND DECODING FORMAT. HERE IS THE ALGORITHM USED.
; (OBTAINING DUE TO THE FACT THAT THIS APPEARS IN THE
; PUBLIC IMAGE AS A MAGAZINE ARTICLE WILL PREVENT THE FOLLOWING
; ALGORITHM TO BE OF 'SECRET' USE).
;
; THE OPERATOR ENTERS THE COMMAND TO RUN THE PROGRAM AS:
;
;     A>SECRET filename.typ E<cr>
;
;         where filename.typ is the
;         file to encode. And "E"
;         indicates to encode the file
;
; or:
;
;     A>SECRET filename.typ D<cr>
;
;         where filename.typ is the
;         file to decode. And "D"
;         indicates to decode the file
;
; THE ENCODING PROCESS WRITES THE ENCODED FILE RIGHT IN PLACE
; WITHIN THE USER SPECIFIED FILE. NO MEANS IS USED TO SPECIFY
; IN THE ENCODED FILE THAT IT IS ENCODED.
;
; THE DECODE PROCESS READS AND DECODES THE FILE RIGHT IN PLACE
; WITHIN THE USER SPECIFIED FILE NAME.
;
; THE ALGORITHM LEAVES THE FIRST RECORD OF THE FILE INTACT AND
; DOES NOT ENCODE THE PART OF A FILE BEYOND 128 RECORDS IN SIZE.
; FOR FILES LARGER THAN 128 RECORDS THE FINAL RECORDS BEYOND THE
; 128'TH ARE LEFT UNTOUCHED. THE BDOS IS CALLED TO DETERMINE THE
; SIZE OF THE FILE SO THE NUMBER OF RECORDS IN THE FILE ARE
; KNOWN. THIS NUMBER OF RECORDS WILL BE REFERRED TO HERE AS "NR".
```

```
; IF "NR" IS GREATER THAN 128 THEN "NR" IS SET TO 128. THEN THE
; FIRST "NR-1" BYTES OF THE FIRST RECORD ARE READ SEQUENTIALLY
; TO MAKE A LIST OF ONE BYTE BINARY NUMBERS WITH A NUMBER OF
; ENTRIES EQUAL TO THE NUMBER OF RECORDS IN THE FILE MINUS ONE,
; UP TO A MAXIMUM OF 127 NUMBERS.
;
; THIS LIST IS THEN PROCESSED TO CONVERT ALL OF THE NUMBERS IN THE
; LIST TO BE WITHIN THE RANGE OF 1 TO "NR-1". THIS CONVERSION IS
; DONE BY FIRST "ANDING" EACH OF THE BYTES IN THE LIST WITH A MASK.
; THE MASK HAS A NUMERICAL VALUE EQUAL TO "NR-1" ROUNDED UP TO
; THE NEXT BIGGEST  $[(2^N) - 1]$  VALUE, IE IF THE FILE HAS 5
; RECORDS THE MASK IS 07H. IF THE FILE HAS 59 RECORDS THE MASK
; HAS A VALUE OF 3FH. THE LIST IS THEN SCANNED FOR VALUES THAT
; ARE GREATER THAN "NR-2". EACH VALUE THAT IS GREATER THAN
; "NR-2" IS DIVIDED BY TWO IGNORING THE REMAINDER. FINALLY EACH
; LIST VALUE IS INCREMENTED BY ONE TO MAKE A REAL FILE READABLE
; RECORD NUMBER.
;
; THE LIST IS THEN USED AS A RECORD SCRAMBLE/UNSCRAMBLE LIST.
; FOR SCRAMBLING IT IS SCANNED FROM THE BEGINNING WHILE
; UNSCRAMBLING SCANS THE LIST FROM THE END. SCRAMBLING PROCEEDS
; AS FOLLOWS (THE UNSCRAMBLE PROCESS IS THE REVERSE):
;
;     THE SECOND FILE RECORD IS NOW INTERCHANGED IN
;     POSITION WITH THE RECORD POINTED BY THE FIRST
;     NUMBER IN THE LIST. THE THIRD FILE RECORD IS
;     INTERCHANGED WITH THE RECORD POINTED TO BY THE
;     SECOND LIST VALUE. THIS PROCESS CONTINUES UNTIL
;     THE END OF THE LIST. DURING THE PROCESS OF
;     INTERCHANGING THE FILE SECTORS IN THIS RATHER
;     BIZARRE MANNER, EACH TIME A LIST VALUE IS FOUND
;     TO HAVE A LEAST SIGNIFICANT BIT THAT IS EQUAL
;     TO "1" THEN THAT RECORD HAS EACH BYTE XOR'ED
;     WITH THE RECORD NUMBER.
;
;
;                               WRITTEN BY:
;                               MICHAEL J. KARAS
;                               2468 HANSEN COURT
;                               SIMI VALLEY, CA 93065
;                               (805) 527-7922
;
;
;
;SYSTEM LEVEL INTERFACE EQUATES
;
BDOS      EQU      0005H      ;SYSTEM INTERFACE VECTOR
MAKE      EQU      22        ;MAKE NEW FILE FUNCTION
SBADDR    EQU      26        ;SET DISK BUFFER ADDR
OPEN      EQU      15        ;OPEN FILE FUNCTION
CLOSE     EQU      16        ;FILE CLOSE FUNCTION
DELETE    EQU      19        ;DELETE FILE FUNCTION
```

```

RRAND EQU 33 ;READ RANDOM FUNCTION
WRAND EQU 34 ;WRITE RANDOM FUNCTION
WRANDF EQU 40 ;WRITE RANDOM WITH 00 FILL
PRINT EQU 9 ;PRINT STRING TILL $
FSIZE EQU 35 ;COMPUTE FILE SIZE FUNCTION
DEFCB EQU 05CH ;DEFAULT FILE CONTROL BLOCK
DEFBUF EQU 080H ;DEFAULT BUFFER LOCATION
;
EXEC EQU 08000H ;EXECUTE SPOT FOR SMALL PROGRAM
BOOT EQU 00000H ;SYSTEM REBOOT ENTRY POINT
;
;
;ASCII CHARACTER DEFINITIONS
;
CR EQU 0DH ;CARRIAGE RETURN
LF EQU 0AH ;LINE FEED
;
;
ORG 0100H ;START OF A PROGRAM
LXI SP,STACK ;SETUP A STACK FOR EXECUTION
LXI D,SNGMSG ;PRINT SIGNON MESSAGE
MVI C,PRINT
CALL BDOS
;
;
;CHECK IF THERE WAS A COMMAND LINE FILE NAME
;
LDA DEFCB+1 ;IF FIRST BYTE 20 THEN NO NAME
CPI ' '
JZ CMDERR ;IF NO FILE NAME PRINT ERROR
LDA DEFCB+17 ;GET OPTION CHARACTER
CPI 'E' ;CHECK FOR ENCODE
JZ PROCESS ;GO TO PROCESS IF ENCODE
CPI 'D' ;CHECK IF DECODE
JZ PROCESS ;GO PROCESS OF DECODE
;
CMDERR:
LXI D,ERRM1 ;PRINT ERROR MESSAGE
MVI C,PRINT
CALL BDOS
JMP BOOT ;EXIT IF NO FILE NAME OR OPTION
;
;
;HERE IF AN ENTRY FILE NAME AND A VALID OPTION
;
PROCESS:
STA OPTION ;SAVE OPTION CHAR FOR LATER
;...REFERENCE
XRA A ;SETUP FCB FOR OPEN
STA DEFCB+12 ;ZERO EXTENT BYTE
STA DEFCB+32 ;ZERO CURRENT RECORD BYTE

```

```
    STA    DEFCB+35      ;ZERO R2 BYTE
    LXI    H,0000H
    SHLD   DEFCB+33      ;ZERO RANDOM RECORD NUMBER
;
    MVI    C,OPEN        ;OPEN FILE USER SPECIFIED
    LXI    D,DEFCB       ;USE DEFAULT FCB BUILT BY CCP
    CALL   BDOS          ;GO ATTEMPT OPEN
    INR    A             ;CHECK IF FOUND
    JNZ    FOUND
;
    MVI    C,PRINT       ;PRINT NOT FOUND ERROR
    LXI    D,ERRM2
    CALL   BDOS
    JMP    BOOT          ;EXIT
;
;
;FOUND FILE SO LETS NEXT COMPUTE ITS FILE SIZE
;
FOUND:
    LXI    D,DEFCB       ;THAT SAME FCB AGAIN
    MVI    C,FSIZE
    CALL   BDOS          ;GET THE FILES SIZE IN RECORDS
    LHLD   DEFCB+33      ;GET SIZE OF THE FILE
    MOV    A,H           ;CHECK IF GREATER THAN 128 RECORDS
    ORA    A
    JNZ    TOBIG
    MOV    A,L
    ORA    A             ;CHECJ IF FILE EMPTY OR ONLY ONE RECORD
    JZ     TOSMALL
    CPI    1
    JZ     TOSMALL
    CPI    129
    JC     SIZINA        ;WE HAVE SIZE IN (A)
TOBIG:
    MVI    A,128         ;SET SIZE TO 128 DEFAULT
SIZINA:
    STA    NR            ;SAVE NUMBER OF RECORDS
    JMP    READFST
;
TOSMALL:
    MVI    C,PRINT       ;PRINT FILE SIZE ERROR MESSAGE
    LXI    D,ERRM3
    CALL   BDOS
    JMP    BOOT
;
;
;READ FIRST RECORD INTO LIST BUFFER
;
READFST:
    LXI    D,LIST        ;SET DMA ADDRESS TO LIST BUFFER
    MVI    C,SBADDR
```

```

CALL    BDOS
LXI     H,0000H      ;SET FIRST RECORD
SHLD    DEFCB+33
XRA     A
STA     DEFCB+35      ;CLEAR R2 BYTE
MVI     C,RRAND       ;READ RANDOM FIRST RECORD
LXI     D,DEFCB
CALL    BDOS          ;NO NEED TO CHECK READ ERROR BECAUSE
                      ;..WE KNOW THAT THESE RECORDS EXIST
;
;
;HERE TO PROCESS LIST INTO A SET OF NUMBERS THAT FIT OUT FILE
;RECORD COUNT RANGE.
;
LDA     NR            ;FETCH NUMBER OF RECORDS
DCR     A              ;SET NR-1
;
MVI     B,0FFH        ;INITIAL MASK VALUE
MVI     C,07H          ;NUMBER OF TIMES TO ROTATE FOR MASK
;
MKLP:
RAL                      ;CHECK FOR ZERO BIT IN NR-1
JC      HMSK           ;EXIT WE HAVE OUR MASK ONE BIT FROM (A)
PUSH    PSW
MOV     A,B            ;PUT A ZERO BIT INTO MASK
ORA     A              ;CLEAR CARRY
RAR                      ;PUT ZERO IN
MOV     B,A
POP     PSW
DCR     C              ;DEBUMP SHIFT COUNT
JNZ     MKLP
;
HMSK:
;HERE IF (B) HAS LIST MASK VALUE
LDA     NR            ;GET NUMBER OF VALUES IN LIST
DCR     A
MOV     C,A            ;PUT LOOP COUNTER INTO (C)
MOV     D,A            ;SAVE NR-1 IN (D)
LXI     H,LIST         ;POINT AT LIST
LSTPROC:
MOV     A,M            ;GET A LIST BYTE
ANA     B              ;MASK IT
CMP     D              ;IS RESULT GREATER THAN NR-2
JC      VALOK          ;VALUE IS OK
ORA     A              ;DIVIDE BY TWO IF TOO BIG
RAR
VALOK:
INR     A              ;SET VALUES TP FOR REAL RECORD NUMBERS
MOV     M,A            ;PUT CONVERTED NUMBER INTO LIST AGAIN
INX     H              ;BUMP LIST POINTER
DCR     C              ;DEC LOOP COUNTER
JNZ     LSTPROC        ;DO ALL BYTES OF LIST

```

```
;
;
;ENCODE/DECODE THE FILE HERE
;
ENCODE:
    LXI    H,LIST           ;KEEP A POINTER TO THE LIST
    LDA    OPTION           ;IF OPTION IS 'E' WE GO FORWARD
    CPI    'E'
    MVI    A,1              ;DEFAULT FORWARD CURRENT RECORD
    JZ     FORWA            ;GO FORWARD
    LDA    NR               ;INDEX TO END OF LIST FOR DECODE
    DCR    A                ;SET START RECORD FOR DECODE
    MOV    E,A
    DCR    E                ;ZERO BASE INDEX
    MVI    D,0
    DAD    D
;
FORWA:
    SHLD   LISTP            ;SAVE LIST POINTER
    STA    CURR             ;SET CURRENT RECORD NUMBER TO START
    LDA    NR
    DCR    A
    STA    CNTR             ;SET NUMBER OF SWAPS
;
ENCLP:
    LXI    D,BUF1           ;SET BUFFER ONE AS DMA ADDRESS
    MVI    C,SBADDR
    CALL   BDOS
    LDA    CURR              ;READ CURRENT RECORD
    MOV    L,A
    MVI    H,00
    SHLD   DEFCB+33         ;SET RECORD NUMBER
    LXI    D,DEFCB
    MVI    C,RRAND          ;READ THAT RECORD
    CALL   BDOS
    ORA    A                ;CHECK ERROR
    JNZ    DSKERR
;
    LXI    D,BUF2           ;SET BUFFER 2 AS DMA ADDRESS
    MVI    C,SBADDR
    CALL   BDOS
    LHLD   LISTP            ;GET SWAP POSITION
    MOV    L,M
    MVI    H,00
    SHLD   DEFCB+33         ;SET SWAP RECORD NUMBER
    LXI    D,DEFCB
    MVI    C,RRAND          ;READ SWAP RECORD
    CALL   BDOS
    ORA    A                ;CHECK ERROR
    JNZ    DSKERR
;
```

```

    LHLD    LISTP          ;IS SWAP RECORD AN ODD NUMB
    MOV     B,M            ;SABE XOR PATTERN IN (B)
    MOV     A,M
    RAR
    JNC     SWRT           ;GO DO SWAP WRITE DIRECTLY IF EVEN
    LDA     OPTION         ;WHICH BUFFER TO XOR
    LXI     H,BUF2         ;DEFAULT FOR 'E'
    CPI     'E'
    JZ      INB2           ;USE BUFFER 2
    LXI     H,BUF1         ;IF DECODE USE BUFFER 1
INB2:
    MVI     C,128          ;BUTE COUNT OF XOR
XORLP:
    MOV     A,M            ;GET A BYTE TO XOR
    XRA     B
    MOV     M,A           ;PUT BYTE BACK
    INX     H             ;BUMP BUFFER POINTER FOR XORING
    DCR     C             ;DEC BYTE COUNT
    JNZ     XORLP
;
SWRT:
    LXI     D,BUF1         ;SET BUFFER ONE AS DMA ADDRESS
    MVI     C,SBADDR
    CALL    BDOS
    LHLD    LISTP         ;GET SWAP POSITION
    MOV     L,M
    MVI     H,00
    SHLD    DEFCB+33      ;SET SWAP RECORD NUMBER
    LXI     D,DEFCB
    MVI     C,WRAND        ;WRITE SWAP RECORD
    CALL    BDOS
    ORA     A             ;CHECK ERROR
    JNZ     DSKERR
;
    LXI     D,BUF2         ;SET BUFFER 2 AS DMA ADDRESS
    MVI     C,SBADDR
    CALL    BDOS
    LDA     CURR           ;WRITE CURRENT RECORD
    MOV     L,A
    MVI     H,00
    SHLD    DEFCB+33      ;SET RECORD NUMBER
    LXI     D,DEFCB
    MVI     C,WRAND        ;WRITE THAT RECORD
    CALL    BDOS
    ORA     A             ;CHECK ERROR
    JNZ     DSKERR
;
    LDA     CURR           ;FETCH LOOP PARMS
    MOV     B,A
    LHLD    LISTP
;

```

```
LDA    OPTION          ;CHECK OPTION
CPI    'E'
JZ     INCF            ;IF ENCODE INCR FORWARD
;
DECB:
DCX    H              ;DECREMENT DOWN THROUGH LOOP
DCR    B
JMP    PSVE           ;SAVE PARMS
INCF:
INX    H
INR    B
PSVE:
SHLD   LISTP          ;SAVE NEW LIST POSITION
MOV    A,B
STA    CURR
;
LDA    CNTR           ;FETCH LOOP COUNTER
DCR    A
STA    CNTR
JNZ    ENCLP          ;GO TO LOOP TO PROCESS MORE IF
                        ;NOT DONE YET
;
;
;HERE WE ARE DONE WRITING SO LETS CLOSE UP AND GO HOME
;
LXI    D,DEFCB
MVI    C,CLOSE
CALL   BDOS
INR    A              ;CHECK ERROR CODE
JZ     DSKERR
;
MVI    C,PRINT        ;PRINT DONE MESSAGE
LXI    D,DONMSG
CALL   BDOS
JMP    BOOT           ;EXIT
;
;
;EXIT POINT WITH ERROR MESSAGE IF THE DISK WRITE OPERATION
;RESULTED IN AN ERROR
;
DSKERR:
LXI    D,ERRM4        ;PRINT GARBAGE FILE ERROR
MVI    C,PRINT
CALL   BDOS
JMP    BOOT           ;EXIT FOR THE POOR GUY
;
;
;PROGRAM OPERATIONAL MESSAGES
;
SNGMSG:
DB     CR,LF,'MICRO RESOURCES Disk File Scramble and'
```



```
    DB    CR,LF,'Unscramble Utility Designed to Demonstrate'
    DB    CR,LF,'CP/M Ver 2.2 Random Record I/O. (1/24/82)','$'
;
DONMSG:
    DB    CR,LF,'File Processing Complete','$'
;
ERRM1:
    DB    CR,LF,'No File Name Specified or Improper Option','$'
;
ERRM2:
    DB    CR,LF,'Specified File Not Found','$'
;
ERRM3:
    DB    CR,LF,'Cannot Process Files with 0 or 1 Record(s)','$'
;
ERRM4:
    DB    CR,LF,'File I/O Error, This Error Should NOT Normally'
    DB    CR,LF,'Happen, But the File is now Garbaged...','$'
;
;
;PROGRAM DATA STORAGE SECTION
;
OPTION:
    DS     1           ;PLACE TO STORE COMMAND LINE OPTION CHAR
;
NR:
    DS     1           ;NUMBER OF RECORDS TO SWAP
;
CNTR:
    DS     1           ;ENCODE/DECODE LOOP COUNTER
;
CURR:
    DS     1           ;CURRENT SWAP SECTOR
;
LISTP:
    DS     2           ;LIST SCAN POINTER
;
LIST:
    DS     128         ;LIST BUFFER
;
BUF1:
    DS     128         ;DATA BUFFER 1
;
BUF2:
    DS     128         ;DATA BUFFER 2
;
    DS     36
STACK    EQU    $      ;USER STACK AREA
;
;
    END
```

```
;
;
;+++...END OF FILE
```

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