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MS-DOS Programmer's Reference Manual

Contents

To our customers:

The *MS™-DOS Programmer's Reference Manual* is a technical reference manual for system programmers. Chapter 1 contains descriptions and examples of the MS-DOS system calls and interrupts. Chapters 2, 3, and 4 contain technical information about MS-DOS. Chapter 5 contains information on how to install your own device drivers on MS-DOS. Chapter 6 describes the BIOS services available to the programmer.

Chapter 1

System Calls

General Information

The MS-DOS system calls provide you with a convenient way to perform certain primitive functions, making it easier to write machine-independent programs. The two types of MS-DOS system calls are interrupts and function calls. This chapter describes the environments from which these routines can be called, how to call them, and the processing performed by each.

Calling and Returning

You can invoke the system calls from Macro Assembler simply by moving any required data into registers and issuing an interrupt. Some of the calls destroy registers, so you may have to save registers before using a system call.

The system calls can also be invoked from any high-level language whose modules can be linked with assembly-language modules.

Control can be returned to MS-DOS in any of four ways:

1. Issue Function Call 4CH:

   ```
   MOV   AH,4CH
   INT   21H
   ```

   This is the preferred method.

2. Issue Interrupt 20H:

   ```
   INT   20H
   ```

   This method simulates system call 00H.

3. Jump to location 0 (the beginning of the Program Segment Prefix):

   ```
   JMP   0
   ```

   Location 0 of the Program Segment Prefix contains an INT 20H instruction, so this technique is simply one step removed from technique 2.

4. Issue Function Call ØØH:

```
MOV   AH,ØØH
INT   21H
```

This transfers control to location Ø in the Program Segment Prefix.

Console, Printer, and Disk Input/Output Calls

The console and printer system calls let you read from and write to the console device and print on the printer without using any machine-specific codes. You can still take advantage of specific capabilities (display attributes such as positioning the cursor or erasing the screen, printer attributes such as double-strike or underline, and so on) by using constants for these codes and reassembling once with the correct constant values for the attributes.

Many of the system calls that perform disk input and output require the placing of values into or the reading of values from two system control blocks: the File Control Block (FCB) and directory entry. For a description of the FCB, see the section "File Control Block" in Chapter 2. For details on the directory entry, see "Disk Directory" in Chapter 4.

XENIX Compatible Calls

MS-DOS supports hierarchical (tree-structured) directories, similar to those found in the XENIX operating system. (For information on tree-structured directories, refer to the *MS-DOS User's Guide.*)

The following system calls are compatible with the XENIX system:

Function 39H	Create Sub-Directory
Function 3AH	Remove a Directory Entry
Function 3BH	Change the Current Directory
Function 3CH	Create a File
Function 3DH	Open a File
Function 3FH	Read From a File or Device
Function 4ØH	Write to a File or Device
Function 41H	Delete a Directory Entry
Function 42H	Move a File Pointer

Function 43H	Change Attributes
Function 44H	I/O Control for Devices
Function 45H	Duplicate a File Handle
Function 46H	Force a Duplicate of a File Handle
Function 4BH	Load and Execute a Program
Function 4CH	Terminate a Process
Function 4DH	Retrieve the Return Code of a Child

There is no restriction in MS-DOS on the depth of a tree (the length of the longest path from root to leaf) except in the number of allocation units available. The root directory will have a fixed number of entries. For non-root directories, the number of files per directory is limited only by the number of allocation units available.

Implementation of the tree structure is simple. Subdirectories of the root have a special attribute set indicating that they are directories. The subdirectories themselves are files, linked through the File Allocation Table (FAT) as usual. Their contents are identical in character to the contents of the root directory.

Attributes apply to the tree-structured directories in the following manner:

Attribute	**Meaning/Function for files**	**Meaning/Function for directories**
volume id	Present at the root. Only one file may have this set.	Meaningless.
directory	Meaningless.	Indicates that the directory entry is a directory. Cannot be changed with Function Call 43H.
read only	Old create, new create, new open (for write or read/write) will fail.	Meaningless.
archive	Set when file is written. Set/reset via Function 43H.	Meaningless.
hidden/ system	Prevents file from being found in search first/search next. Old open will fail.	Prevents directory entry from being found. Function 3BH will still work.

System Call Descriptions

Many system calls require that parameters be loaded into one or more registers before the call is issued; this information is given under Entry Conditions in the individual system call descriptions. Most calls return information in the registers, as given under Exit Conditions and Error Returns.

For some of the system calls, a macro is defined and used in the example for that call. All macro definitions are listed at the end of the chapter, together with an extended example that illustrates the system calls.

The examples are not intended to represent good programming practice. In particular, error checking and user friendliness have been sacrificed to conserve space. Many of the examples are not usable as stand-alone programs, but merely show you how to get started with this command. You may, however, find the macros a convenient way to include system calls in your assembly language programs.

Interrupts

MS-DOS reserves Interrupts 2ØH through 3FH for its own use. Memory locations 8ØH to FCH are reserved for the table of interrupt routine addresses (vectors).

To set an interrupt vector, use Function Call 25H. To retrieve the contents of a vector, use Function Call 35H. Do not write or read vectors directly to or from the vector table.

List of MS-DOS Interrupts

Interrupt		
Hex	Dec	Description
2ØH	32	Program Terminate
21H	33	Function Request
22H	34	Terminate Address
23H	35	CONTROL-C Exit Address
24H	36	Fatal Error Abort Address
25H	37	Absolute Disk Read
26H	38	Absolute Disk Write
27H	39	Terminate But Stay Resident

Program Terminate

Interrupt 2ØH

Causes the current process to terminate and returns control to its parent process. All open file handles are closed and the disk buffer is written to disk. All files that have changed in length should be closed before issuing this interrupt. (See Function Calls 1ØH and 3EH for descriptions of the Close File function calls.)

The following exit addresses are restored from the Program Segment Prefix:

Exit Address	*Offset*
Program Terminate	ØAH
CONTROL-C	ØEH
Critical Error	12H

Interrupt 2ØH is provided for compatibility with earlier versions of MS-DOS. New programs should use Function Call 4CH, Terminate a Process.

Entry Conditions:

CS = *segment address of Program Segment Prefix*

Macro Definition:

```
terminate  macro
           int 2ØH
           endm
```

Example:

```
;CS must be equal to PSP values given at program start
;(ES and DS values)
      INT 2ØH
;There is no return from this interrupt
```

Function Request

Interrupt 21H

See "Function Calls" later in this chapter for a description of the MS-DOS system functions.

Entry Conditions:

AH = *function call number*
Other registers as specified in individual function.

Exit Conditions:

As specified in individual function.

Example:

To call the Get Time function:

```
mov          ah,2CH      ;Get Time is Function 2CH
int          21H         ;THIS INTERRUPT
```

Terminate Address

Interrupt 22H

When a program terminates, control transfers to the address at offset 0AH of the Program Segment Prefix. This address is copied into the Program Segment Prefix from the Interrupt 22H vector when the segment is created. You can set this address using Function Call 25H.

CONTROL-C Exit Address

Interrupt 23H

If the user types CONTROL-C during keyboard input or display output, control transfers to the Interrupt 23H vector in the interrupt table. This address is copied into the Program Segment Prefix from the Interrupt 23H vector when the segment is created. You can set this address using Function Call 25H.

If the CONTROL-C routine saves all registers, it can end with an IRET instruction (return from interrupt) to continue program execution. When the interrupt occurs, all registers are set to the value they had when the original call to MS-DOS was made. There are no restrictions on what a CONTROL-C handler can do (including MS-DOS function calls) as long as the registers are unchanged if IRET is used.

If Function Ø9H or ØAH (Display String or Buffered Keyboard Input) is interrupted by CONTROL-C, the three-byte sequence Ø3H-ØDH-ØAH (ETX-CR-LF) is sent to the display and the function resumes at the beginning of the next line.

If the program creates a new segment and loads a second program that changes the CONTROL-C address, termination of the second program restores the CONTROL-C address to the value it had before execution of the second program.

Fatal Error Abort Address

Interrupt 24H

If a fatal disk error occurs during execution of one of the disk I/O function calls, control transfers to the Interrupt 24H vector in the vector table. This address is copied into the Program Segment Prefix from the Interrupt 24H vector when the segment is created. You can set this address using Function Call 25H.

BP:SI contains the address of a Device Header Control Block from which additional information can be retrieved.

Interrupt 24H is not issued if the failure occurs during execution of Interrupt 25H (Absolute Disk Read) or Interrupt 26H (Absolute Disk Write). These errors are usually handled by the MS-DOS error routine in COMMAND.COM that retries the disk operation and then gives the user the choice of aborting, retrying the operation, or ignoring the error.

Entry Conditions:

BP:SI = *Device Header Control Block address*

Error Returns:

When an error-handling program gains control from Interrupt 24H, the AX and DI registers can contain codes that describe the error. If Bit 7 of AH is 1, either the error is a bad image of the File Allocation Table or an error occurred on a character device. The device header passed in BP:SI can be examined to determine which case exists. If the attribute byte high-order bit indicates a block device, then the error was a bad FAT. Otherwise, the error is on a character device.

The following are error codes for Interrupt 24H:

Error Code	*Description*
0	Attempt to write on write-protected disk
1	Unknown unit
2	Drive not ready
3	Unknown command
4	Data error
5	Bad request structure length

6	Seek error
7	Unknown media type
8	Sector not found
9	Printer out of paper
A	Write fault
B	Read fault
C	General failure

The user stack will be in effect (the first item described below is at the top of the stack), and will contain the following from top to bottom:

IP	MS-DOS registers from
CS	issuing INT 24H
FLAGS	
AX	User registers at time of original
BX	INT 21H request
CX	
DX	
SI	
DI	
BP	
DS	
ES	
IP	From the original INT 21H
CS	from the user to MS-DOS
FLAGS	

The registers are set such that if an IRET is executed, MS-DOS will respond according to the contents of AL as follows:

AL = Ø	ignore the error
= 1	retry the operation
= 2	terminate the program via INT 23H

Notes:

1. For disk errors, this exit is taken only for errors occurring during an Interrupt 21H. It is not used for errors during Interrupts 25H or 26H.
2. This routine is entered in a disabled state.
3. The SS, SP, DS, ES, BX, CX, and DX registers must be preserved.

4. This interrupt handler should refrain from using MS-DOS funtion calls. If necessary, it may use calls 01H through 0CH. Use of any other call will destroy the MS-DOS stack and will leave MS-DOS in an unpredictable state.

5. The interrupt handler must not change the contents of the device header.

6. If the interrupt handler will handle errors itself rather than returning to MS-DOS, it should restore the application program's registers from the stack, remove all but the last three words on the stack, and then issue an IRET. This will cause a return to the program immediately after the INT 21H that experienced the error. Note that if this is done, MS-DOS will be in an unstable state until a function call higher than 0CH is issued.

Absolute Disk Read

Interrupt 25H

Transfers control to MS-DOS. The number of sectors specified in CX is read from the disk to the Disk Transfer Address.

This call destroys all registers except the segment registers. Be sure to save any registers your program uses before issuing the interrupt.

The system pushes the flags at the time of the call; they are still on the stack upon return. This is necessary because data is passed back in the current flags. Be sure to pop the stack upon return to prevent uncontrolled growth.

Entry Conditions:

AL = *drive number (Ø = A, 1 = B, etc.)*
DS:BX = *Disk Transfer Address*
CX = *number of sectors to read*
DX = *beginning relative sector*

Exit Conditions:

Carry set:
  AL = *error code*
Carry not set:
  Operation was successful.

Error Returns:

Error codes are the same as for Interrupt 24H.

Macro Definition:

```
abs_disk_read macro disk,buffer,num_sectors,first_sector

        mov         al,disk
        mov         bx,offset buffer
        mov         cx,num_sectors
        mov         dx,first_sector
        int         25H
        popf
        endm
```

Example:

The following program copies the contents of a single-sided disk in Drive A to the disk in Drive B. It uses a buffer of 32K bytes.

```
prompt      db   "Source in A, target in B",13,10
            db   "Any key to start. $"
start       dw   0
buffer      db   64 dup (512 dup (?))    ;64 sectors
            .
            .
int_25H:    display prompt              ;see Function 09H
read_kbd                                ;see Function 08H
            mov   cx,5                  ;copy 5 groups of
                                        ;64 sectors
copy:       push   cx                   ;save the loop counter
            abs_disk_read 0,buffer,64,start    ;THIS INTERRUPT
            abs_disk_write 1,buffer,64,start   ;see INT 26H
            add start,64                ;do the next 64 sectors
            pop cx                      ;restore the loop counter
            loop copy
```

Absolute Disk Write

Interrupt 26H

Transfers control to the MS-DOS BIOS. The number of sectors specified in CX is written from the Disk Transfer Address to the disk.

This call destroys all registers except the segment registers. Be sure to save any registers your program uses before issuing the interrupt.

The system pushes the flags at the time of the call; they are still on the stack upon return. This is necessary because data is passed back in the current flags. Be sure to pop the stack upon return to prevent uncontrolled growth.

Entry Conditions:

AL = *drive number (Ø = A, 1 = B, etc.)*
DS:BX = *Disk Transfer Address*
CX = *number of sectors to write*
DX = *beginning relative sector*

Exit Conditions:

Carry set:
  AL = *error code*
Carry not set:
  Operation was successful.

Error Returns:

Error codes are the same as for Interrupt 24H.

Macro Definition:

```
abs_disk_write macro disk,buffer,num_sectors,first_sector
mov        al,disk
mov        bx,offset buffer
mov        cx,num_sectors
mov        dx,first_sector
int        26H
popf
endm
```

Example:

The following program copies the contents of a single-sided disk in Drive A to the disk in Drive B, verifying each write. It uses a buffer of 32K bytes.

```
off        equ   0
on         equ   1
           .
           .
prompt     db    "Source in A, target in B",13,10
           db    "Any key to start. $"
start      dw    0
buffer     db    64 dup (512 dup (?))    ;64 sectors
           .
           .
int_26H:   display prompt            ;see Function 09H
           read_kbd                  ;see Function 08H
           verify on                 ;see Function 2EH
           mov   cx,5                ;copy 5 groups of 64 sectors
copy:      push   cx                 ;save the loop counter
           abs_disk_read 0,buffer,64,start    ;see INT 25H
           abs_disk_write 1,buffer,64,start   ;THIS INTERRUPT
           add start,64              ;do the next 64 sectors
           pop cx                    ;restore the loop counter
           loop copy
           verify off                ;see Function 2EH
```

Terminate But Stay Resident

Interrupt 27H

Used to make a piece of code remain resident in the system after its termination. This call is typically used in .COM files to allow some device-specific interrupt handler to remain resident to process asynchronous interrupts.

When Interrupt 27H is executed, the program terminates but is treated as an extension of MS-DOS. It remains resident and is not overlaid by other programs when it terminates.

This interrupt is provided for compatibility with earlier versions of MS-DOS. New programs should use Function 31H, Keep Process.

Entry Conditions:

CS:DX = *first byte following last byte of code in the program*

Macro Definition:

```
stay_resident macro last_instruc
mov          dx,offset last_instruc
inc          dx
int          27H
endm
```

Example:

```
;CS must be equal to PSP values given at program start
;(ES and DS values)
mov          DX,LastAddress
int          27H
;There is no return from this interrupt
```

Function Calls

Categories of Calls

The MS-DOS function calls are divided into two groups: old and new. The old calls, Functions 00H through 2EH, are included in this version of MS-DOS to provide compatibility with earlier versions. The new calls, Functions 2FH through 57H, should be used in new programs instead of the old calls wherever possible. However, programs that use the new calls cannot be run on earlier versions of MS-DOS.

The function calls can be divided into the following categories:

00H-12H	Old character device I/O
13H-24H	Old file management
25H-26H	Old non-device functions
27H-29H	Old file management
2AH-2EH	Old non-device functions
2FH-38H	New function group
39H-3BH	Directory group
3CH-46H	New file management group
47H	Directory group
48H-4BH	New memory management group
4CH-4FH	New function group
54H-57H	New function group

Error Codes

Many of the function calls in the new group (2FH-57H) return with the carry flag reset if the operation was successful. If the carry flag is set, then an error occurred and register AX contains the binary error return code. These codes are as follows:

Code	**Error**
1	Invalid function number
2	File not found
3	Path not found
4	Too many open files (no handles left)
5	Access denied
6	Invalid handle
7	Memory control blocks destroyed
8	Insufficient memory
9	Invalid memory block address
10	Invalid environment
11	Invalid format
12	Invalid access code

13	Invalid data
15	Invalid drive was specified
16	Attempted to remove the current directory
17	Not same device
18	No more files

File Handles

Some of the new calls use a "file handle" to identify a file or device. A handle is a 16-bit binary value that is returned in register AX when you create or open a file or device using the new calls. This handle should be used in subsequent references to the file.

ASCIIZ Strings

Some calls require an ASCIIZ string in one of the registers as an entry condition. An ASCIIZ string is simply an ASCII string followed by a byte of binary zeroes. The string consists of an optional drive specifier followed by a directory path and (in some cases) a filename. The following string, if followed by a byte of zeroes, is an example:

```
B:\LEVEL1\LEVEL2\FILE
```

Calling MS-DOS Functions

Most of the MS-DOS function calls require input to be passed to them in registers. After setting the proper register values, the function may be invoked in one of the following ways:

1. Place the function number in AH and execute a long call to offset 50H in your Program Segment Prefix. Note that programs using this method will not operate correctly on earlier versions of MS-DOS.

2. Place the function number in AH and issue Interrupt 21H. All of the examples in this chapter use this method.

3. An additional method exists for programs that were written with different calling conventions. This method should be avoided for all new programs. The function number is placed in the CL register and other registers are set according to the function specification. Then an intrasegment call is made to location 5 in the current code segment. That location contains a long call to the MS-DOS function dispatcher. Register AX is always

destroyed if this method is used; otherwise, it is the same as normal function calls. Note that this method is valid only for Function Requests ØØH through Ø24H.

CP/M® -Compatible Calling Sequence

A different sequence can be used for programs that must conform to CP/M calling conventions:

1. Move any required data into the appropriate registers (just as in the standard sequence).
2. Move the function number into the CL register.
3. Execute an intrasegment call to location 5 in the current code segment.

This method can be used only with the functions ØØH through 24H that do not pass a parameter in AL. Register AX is always destroyed when a function is called in this manner.

Treatment Of Registers

When MS-DOS takes control, it switches to an internal stack. All registers are saved except AX and those registers used to return information. The calling program's stack must be large enough to accommodate the interrupt system. It should be at least 8ØH bytes, in addition to the program's needs.

MS-DOS Function Calls in Numeric Order

Function Number	Function Name
00H	Terminate Program
01H	Read Keyboard and Echo
02H	Display Character
03H	Auxiliary Input
04H	Auxiliary Output
05H	Print Character
06H	Direct Console I/O
07H	Direct Console Input
08H	Read Keyboard
09H	Display String
0AH	Buffered Keyboard Input
0BH	Check Keyboard Status
0CH	Flush Buffer, Read Keyboard
0DH	Reset Disk
0EH	Select Disk
0FH	Open File
10H	Close File
11H	Search for First Entry
12H	Search for Next Entry
13H	Delete File
14H	Sequential Read
15H	Sequential Write
16H	Create File
17H	Rename File
19H	Current Disk
1AH	Set Disk Transfer Address
21H	Random Read
22H	Random Write
23H	File Size
24H	Set Relative Record
25H	Set Interrupt Vector
27H	Random Block Read
28H	Random Block Write
29H	Parse File Name
2AH	Get Date
2BH	Set Date
2CH	Get Time
2DH	Set Time
2EH	Set/Reset Verify Flag
2FH	Get Disk Transfer Address
30H	Get Version Number
31H	Keep Process
33H	CONTROL-C Check

35H	Get Interrupt Vector
36H	Get Disk Free Space
38H	Return Country-Dependent Information
39H	Create Sub-Directory
3AH	Remove a Directory Entry
3BH	Change the Current Directory
3CH	Create a File
3DH	Open a File
3EH	Close a File Handle
3FH	Read From a File or Device
40H	Write to a File or Device
41H	Delete a Directory Entry
42H	Move a File Pointer
43H	Change Attributes
44H	I/O Control for Devices
45H	Duplicate a File Handle
46H	Force a Duplicate of a File Handle
47H	Return Text of Current Directory
48H	Allocate Memory
49H	Free Allocated Memory
4AH	Modify Allocated Memory Blocks
4BH	Load and Execute a Program
4CH	Terminate a Process
4DH	Retrieve the Return Code of a Child
4EH	Find Matching File
4FH	Find Next Matching File
54H	Return Current Setting of Verify
56H	Move a Directory Entry
57H	Get or Set a File's Date and Time

MS-DOS Function Calls in Alphabetic Order

Function Name	**Number**
Allocate Memory	48H
Auxiliary Input	Ø3H
Auxiliary Output	Ø4H
Buffered Keyboard Input	ØAH
Change Attributes	43H
Change the Current Directory	3BH
Check Keyboard Status	ØBH
Close a File Handle	3EH
Close File	1ØH
CONTROL-C Check	33H
Create a File	3CH
Create File	16H
Create Sub-Directory	39H
Current Disk	19H
Delete a Directory Entry	41H
Delete File	13H
Direct Console Input	Ø7H
Direct Console I/O	Ø6H
Display Character	Ø2H
Display String	Ø9H
Duplicate a File Handle	45H
File Size	23H
Find Matching File	4EH
Flush Buffer, Read Keyboard	ØCH
Force a Duplicate of a File Handle	46H
Free Allocated Memory	49H
Get Date	2AH
Get Disk Free Space	36H
Get Disk Transfer Address	2FH
Get Version Number	3ØH
Get Interrupt Vector	35H
Get Time	2CH
Get or Set a File's Date or Time	57H
I/O Control for Devices	44H
Keep Process	31H
Load and Execute a Program	4BH
Modify Allocated Memory Blocks	4AH
Move a Directory Entry	56H
Move a File Pointer	42H
Open a File	3DH
Open File	ØFH
Parse File Name	29H
Print Character	Ø5H
Random Block Read	27H

Random Block Write	28H
Random Read	21H
Random Write	22H
Read From a File or Device	3FH
Read Keyboard	Ø8H
Read Keyboard and Echo	Ø1H
Remove a Directory Entry	3AH
Rename File	17H
Reset Disk	ØDH
Retrieve the Return Code of a Child	4DH
Return Current Setting of Verify	54H
Return Country-Dependent Information	38H
Return Text of Current Directory	47H
Search for First Entry	11H
Search for Next Entry	12H
Select Disk	ØEH
Sequential Read	14H
Sequential Write	15H
Set Date	2BH
Set Disk Transfer Address	1AH
Set Relative Record	24H
Set Time	2DH
Set Interrupt Vector	25H
Set/Reset Verify Flag	2EH
Find Next Matching File	4FH
Terminate a Process	4CH
Terminate Program	ØØH
Write to a File or Device	4ØH

Abort

Terminate Program

Function Call ØØH

Terminates a program. This function is called by Interrupt 2ØH, and performs the same processing.

The following exit addresses are restored from the specified offsets in the Program Segment Prefix:

Program terminate	ØAH
CONTROL-C	ØEH
Critical error	12H

All file buffers are written to disk. Be sure to close all files which have been changed in length before calling this function. If a changed file is not closed, its length will not be recorded correctly in the disk directory. See Function Call 1ØH for a description of the Close File call.

Entry Conditions:

AH = ØØH
CS = *segment address of the Program Segment Prefix*

Macro Definition:

```
terminate_program       macro
                        xor         ah,ah
                        int         21H
                        endm
```

Example:

```
;CS must be equal to PSP values given at program start
;(ES and DS values)
   mov   ah,Ø
   int   21H
;There are no returns from this interrupt
```

StdConInput

Keyboard Input

Function Call ∅1H

Waits for a character to be typed at the keyboard, then echoes the character to the display and returns it in AL. If the character is CONTROL-C, Interrupt 23H is executed.

Entry Conditions:

AH = ∅1H

Exit Conditions:

AL = *character typed*

Macro Definition:

```
read_kbd_and_echo   macro
                    mov ah, ∅1H
                    int 21H
                    endm
```

Example:

The following program both displays and prints characters as they are typed. If ENTER is pressed, the program sends a Line Feed-Carriage Return to both the display and the printer.

```
func_∅1H:  read_kbd_and_echo                ;THIS FUNCTION
           print_char          al           ;see Function ∅5H
           cmp                 al,∅DH       ;is it a CR?
           jne                 func_∅1H     ;no, print it
           print_char          1∅           ;see Function ∅5H
           display_char        1∅           ;see Function ∅2H
           jmp                 func_∅1H     ;get another character
```

StdConOutput

Display Character   Function Call Ø2H

Displays a character on the video screen. If a CONTROL-C is typed, Interrupt 23H is executed.

Entry Conditions:

AH = Ø2H
DL = *character to display*

Macro Definition:

```
display_char  macro      character
              mov        dl,character
              mov        ah,Ø2H
              int        21H
              endm
```

Example:

The following program converts lower-case characters to upper case before displaying them.

```
func_Ø2H:     read_kbd                   ;see Function Ø8H
              cmp      al,"a"
              jl       uppercase         ;don't convert
              cmp      al,"z"
              jg       uppercase         ;don't convert
              sub      al,2ØH            ;convert to ASCII code
                                         ;for upper case
uppercase:    display_char al            ;THIS FUNCTION
              jmp      func_Ø2H          ;get another character
```

AuxInput

Auxiliary Input

Function Call Ø3H

Waits for a character from the auxiliary input device, and then returns the character in AL. No status or error code is returned.

If CONTROL-C is typed at console input, Interrupt 23H is executed.

Entry Conditions:

AH = Ø3H

Exit Conditions:

AL = *character returned*

Macro Definition:

```
aux_input macro
          mov ah,Ø3H
          int 21H
          endm
```

Example:

The following program prints characters as they are received from the auxiliary device. It stops printing when an end of file character (ASCII 26, or CONTROL-Z) is received.

```
func_Ø3H:     aux_input              ;THIS FUNCTION
              cmp   al,1AH           ;end of file?
              je    continue         ;yes, all done
              print_char   al        ;see Function Ø5H
              jmp   func_Ø3H         ;get another character
continue:     ret
```

AuxOutput

Auxiliary Output

Function Call 04H

Outputs a character to the auxiliary device. No status or error code is returned.

If CONTROL-C is typed at console input, Interrupt 23H is executed.

Entry Conditions:

AH = 04H
DL = *character to output*

Macro Definition:

```
aux_output   macro      character
             mov        dl,character
             mov        ah,04H
             int        21H
             endm
```

Example:

The following program gets a series of strings of up to 80 bytes from the keyboard, sending each to the auxiliary device. It stops when a null string (CR only) is typed.

```
string       db    81 dup(?)              ;see Function 0AH
             .
             .
func_04H:    get_string 80,string         ;see Function 0AH
             cmp string[1],0              ;null string?
             je    continue               ;yes, all done
             mov   cx, word ptr string[1] ;get string length
             mov   bx,0                   ;set index to 0
send_it:     aux_output string[bx+2]      ;THIS FUNCTION
             inc   bx                     ;bump index
             loop  send_it                ;send another character
             jmp   func_04H               ;get another string
continue:    .
             .
```

Print Character

Function Call Ø5H

Outputs a character to the printer. If CONTROL-C is typed at console input, Interrupt 23H is executed.

Entry Conditions:

AH = Ø5H
DL = *character for printer*

Macro Definition:

```
print_char     macro    character
               mov      dl,character
               mov      ah,Ø5H
               int      21H
               endm
```

Example:

The following program prints a walking test pattern on the printer. It stops if CONTROL-C is pressed.

```
line_num     db       Ø
              .
              .
func_Ø5H:    mov      cx,6Ø           ;print 6Ø lines
start_line:  mov      bl,33           ;first printable ASCII
                                      ;character (!)
             add      bl,line_num     ;to offset one character
             push     cx              ;save number-of-lines counter
             mov      cx,8Ø           ;loop counter for line
print_it:    print_char bl            ;THIS FUNCTION
             inc      bl              ;move to next ASCII character
             cmp      bl,126          ;last printable ASCII
                                      ;character (¾)
             jl       no_reset        ;not there yet
             mov      bl,33           ;start over with (!)
```

```
no__reset:   loop     print__it        ;print another character
             print__char 13            ;carriage return
             print__char 10            ;line feed
             inc      line__num        ;to offset 1st char. of line
             pop      cx               ;restore #-of-lines counter
             loop     start__line      ;print another line
```

Conio

Direct Console I/O

Function Call Ø6H

Returns a keyboard input character if one is ready, or outputs a character to the video display. No check for CONTROL-C is made on the character.

Entry Conditions:

AH = Ø6H
DL = *function code*
ØØH = return character typed at the keyboard, if available
FFH = display character in DL

Exit Conditions:

If DL = FFH on entry, then:
Zero flag set and AL = *keyboard input character,* if available
or
Zero flag not set and AL = ØØH, if no character available

Macro Definition:

```
dir_console_io  macro  switch
                mov    dl,switch
                mov    ah,Ø6H
                int    21H
                endm
```

Example:

The following program sets the system clock to 0 and continuously displays the time. When any character is typed, the display stops changing; when any character is typed again, the clock is reset to 0 and the display starts again.

```
time         db "00:00:00.00",13,10,"$"          ;see Function 09H
                                                 ;for explanation of $
ten          db 10
             .
             .
func__06H:   set__time 0,0,0,0                   ;see Function 2DH
read__clock: get__time                           ;see Function 2CH
             convert    ch,ten,time              ;see end of chapter
             convert    cl,ten,time[3]           ;see end of chapter
             convert    dh,ten,time[6]           ;see end of chapter
             convert    dl,ten,time[9]           ;see end of chapter
             display    time                     ;see Function 09H
             dir__console__io 0FFH               ;THIS FUNCTION
             jne        stop                     ;yes, stop timer
             jmp        read__clock              ;no, keep timer
                                                 ;running
stop:        read__kbd                           ;see Function 08H
             jmp        func__06H                ;start over
```

ConInput

Direct Console Input

Function Call 07H

Waits for a character to be typed at the keyboard, and then returns the character. This call does not echo the character or check for CONTROL-C. (For a keyboard input function that echoes or checks for CONTROL-C, see Function Call 01H or 08H.)

Entry Conditions:

AH = 07H

Exit Conditions:

AL = *character from keyboard*

Macro Definition:

```
Dir_console_input macro
                  mov     ah,07H
                  int     21H
                  endm
```

Example:

The following program prompts for a password (8 characters maximum) and places the characters into a string without echoing them.

```
password     db 8 dup(?)
prompt       db "Password: $"               ;see Function 09H for
                                            ;explanation of $
             .
             .
func_07H:    display prompt                 ;see Function 09H
             mov cx,8                       ;maximum length of
                                            ;password
             xor  bx,bx                     ;so BL can be used as
                                            ;index
```

```
get__pass:    dir__console__input       ;THIS FUNCTION
              cmp al,ØDH                ;was it a CR?
              je   continue             ;yes, all done
              mov password[bx],al       ;no, put character in
                                        ;string
              inc  bx                   ;bump index
              loop get__pass            ;get another character
continue:     .                         ;BX has length of
              .                         ;password + 1
```

ConInputNoEcho

Read Keyboard

Function Call 08H

Waits for a character to be typed at the keyboard, and then returns it in AL. If CONTROL-C is pressed, Interrupt 23H is executed. This call does not echo the character. (For a keyboard input function that echoes the character and checks for CONTROL-C, see Function Call 01H.)

Entry Conditions:

AH = 08H

Exit Conditions:

AL = *character from keyboard*

Macro Definition:

```
read_kbd  macro
          mov   ah,08H
          int   21H
          endm
```

Example:

The following program prompts for a password (8 characters maximum) and places the characters into a string without echoing them.

```
password      db  8 dup(?)
prompt        db  "Password: $"       ;see Function 09H
                                      ;for explanation of $
                   .
                   .
func_08H:     display prompt          ;see Function 09H
              mov  cx,8               ;maximum length of
                                      ;password
              xor   bx,bx             ;BL can be an index
```

```
get_pass:        read_kbd                    ;THIS FUNCTION
                 cmp    al,ØDH               ;was it a CR?
                 je     continue             ;yes, all done
                 mov    password[bx],al      ;no, put char. in string
                 inc    bx                   ;bump index
                 loop   get_pass             ;get another character
continue:        .                           ;BX has length of
                 .                           ;password + 1
```

ConStringOutput

Display String

Function Call 09H

Displays a string of characters. Each character is checked for CONTROL-C. If a CONTROL-C is detected, an interrupt 23H is executed.

Entry Conditions:

AH = 09H
DS:DX = *pointer to a string to be displayed terminated by a $ (24H)*

Macro Definition:

```
display  macro  string
         mov    dx,offset string
         mov    ah,09H
         int    21H
         endm
```

Example:

The following program displays the hexadecimal code of the key that is typed.

```
table       db     "0123456789ABCDEF"
sixteen     db     16
result      db     " - 00H"                       ;see text for
crlf        db     13,10, "$"                     ;explanation of $
             .
             .
func_09H:read_kbd_and_echo                        ;see Function 01H
            convert al,sixteen,result[3]          ;see end of chapter
            display result                        ;THIS FUNCTION
            jmp     func_09H                      ;do it again
```

ConStringInput

Buffered Keyboard Input

Function Call ØAH

Waits for characters to be typed, reads characters from the keyboard, and places them in an input buffer until (ENTER) is pressed. Characters are placed in the buffer beginning at the third byte. If the buffer fills to one less than the maximum specified, then additional keyboard input is ignored and ASCII 7 (BEL) is sent to the display until (ENTER) is pressed.

The string can be edited as it is being entered. If CONTROL-C is typed, Interrupt 23H is executed.

The input buffer pointed to by DS:DX must be in this form:

byte 1	-	Maximum number of characters in buffer, including the carriage return (1-255; you set this value).
byte 2	-	Actual number of characters typed, not including the carriage return (the function sets this value).
bytes 3-n	-	Buffer; must be at least as long as the number in byte 1.

Entry Conditions:

AH = ØAH
DS:DX = *pointer to an input buffer (see above)*

Exit Conditions:

DS:[DX + 1] = *number of characters received, excluding the carriage return*

Macro Definition:

```
get_string   macro  limit,string
             mov    dx,offset string
             mov    string,limit
             mov    ah,ØAH
             int    21H
             endm
```

Example:

The following program gets a 16-byte (maximum) string from the keyboard and fills a 24-line by 80-character screen with it.

```
buffer            label  byte
max_length        db     ?                    ;maximum length
chars_entered     db     ?                    ;number of chars
string            db     17 dup (?)           ;16 chars + CR
strings_per_line  dw     0                    ;how many strings
                                              ;fit on line
crlf              db     13,10,"$"
                  .
                  .
func_0AH:         get_string 16,buffer        ;THIS FUNCTION
                  xor    bx,bx                ;so byte can be
                                              ;used as index
                  mov    bl,chars_entered     ;get string length
                  mov    buffer[bx + 2],"$"   ;see Function 09H
                  mov    al,50H               ;columns per line
                  cbw
                  div    chars_entered        ;times string fits
                                              ;on line
                  xor    ah,ah                ;clear remainder
                  mov    strings_per_line,ax  ;save col. counter
                  mov    cx,24                ;row counter
display_screen:   push   cx                   ;save it
                  mov    cx,strings_per_line  ;get col. counter
display_line:     display  string             ;see Function 09H
                  loop   display_line
                  display crlf                ;see Function 09H
                  pop    cx                   ;get line counter
                  loop   display_screen       ;display 1 more line
```

ConInputStatus

Check Keyboard Status

Function Call 0BH

Checks to see if a character is available in the type-ahead buffer. If CONTROL-C is in the buffer, Interrupt 23H is executed.

Entry Conditions:

AH = 0BH

Exit Conditions:

If AL = FFH, there are characters in the type-ahead buffer.
If AL = 00H, there are no characters in the type-ahead buffer.

Macro Definition:

```
check_kbd_status  macro
                  mov   ah,0BH
                  int   21H
                  endm
```

Example:

The following program continuously displays the time until any key is pressed.

```
time       db  "00:00:00.00",13,10,"$"
ten        db  10
               .
               .
func_0BH:  get_time                      ;see Function 2CH
           convert  ch,ten,time          ;see end of chapter
           convert  cl,ten,time[3]       ;see end of chapter
           convert  dh,ten,time[6]       ;see end of chapter
           convert  dl,ten,time[9]       ;see end of chapter
           display  time                 ;see Function 09H
           check_kbd_status              ;THIS FUNCTION
           cmp      al,0FFH              ;has a key been typed?
           je       all_done             ;yes, go home
           jmp      func_0BH             ;no, keep displaying
all_done:  ret                           ;time
```

ConInputFlush

Flush Buffer, Read Keyboard   Function Call ØCH

Empties the keyboard type-ahead buffer. Further processing depends on the value in AL when the function is called:

1, 6, 7, 8, or ØAH - The corresponding input system call is executed.
Any other value - No further processing is done.

Entry Conditions:

AH = ØCH
AL = *function code*
1, 6, 7, 8, or ØAH = call corresponding function
Any other value = perform no further processing

Exit Conditions:

If AL = ØØH, type-ahead buffer was flushed; no other processing was performed.

Macro Definition:

```
flush_and_read_kbd   macro  switch
                     mov    al,switch
                     mov    ah,ØCH
                     int    21H
                     endm
```

Example:

The following program both displays and prints characters as they are typed. If ENTER is pressed, the program sends a Carriage Return-Line Feed to both the display and the printer. (The example assumes that a CONTROL-C processing routine has been set up before the loop is entered.)

```
func_ØCH: flush_and_read_kbd 1          ;THIS FUNCTION
          print_char     al             ;see Function Ø5H
          cmp            al,ØDH         ;is it a CR?
          jne            func_ØCH       ;no, print it
          print_char     1Ø             ;see Function Ø5H
          display_char   1Ø             ;see Function Ø2H
          jmp            func_ØCH       ;get another character
```

ResetDisk

Reset Disk

Function Call ØDH

Ensures that the internal buffer cache matches the disks in the drives. This call flushes all file buffers. All buffers that have been modified are written to disk and all buffers in the internal cache are marked as free. Directory entries are not updated; you must close files that have changed in order to update their directory entries (see Function Call 1ØH, Close File).

This function need not be called before a disk change if all files which were written to have been closed. It is generally used to force a known state of the system; CONTROL-C interrupt handlers should call this function.

Entry Conditions:

AH = ØDH

Macro Definition:

```
reset_disk  macro  disk
            mov    ah,ØDH
            int    21H
            endm
```

Example:

```
mov        ah,ØDH
int        21H
;There are no errors returned by this call.
```

Select Disk

Function Call ØEH

Selects the specified drive as the default drive.

Entry Conditions:

AH = ØEH
DL = *new default drive number (Ø = A, 1 = B, etc.)*

Exit Conditions:

AL = *number of logical drives*

Macro Definition:

```
select_disk macro  disk
            mov    dl,disk[-64]
            mov    ah,ØEH
            int    21H
            endm
```

Example:

The following program selects the drive not currently selected in a 2-drive system.

```
func_ØEH:  current_disk              ;see Function 19H
           cmp    al,ØØH             ;drive A selected?
           je     select_b           ;yes, select B
           select_disk "A"           ;THIS FUNCTION
           jmp    continue
select_b:  select_disk "B"           ;THIS FUNCTION
continue:  .
           .
```

OpenFile

Open File Function Call ØFH

Opens a File Control Block (FCB) for the named file, if the file is found in the disk directory. The FCB is filled in as follows:

If the drive code in the file specification is Ø (default drive), it is changed to the number of the actual disk used (1 = A, 2 = B, etc.). This lets you change the default drive without interfering with subsequent operations on this file.

The current block field (offset ØCH) is set to zero.

The record size (offset ØEH) is set to the system default of 128.

The file size (offset 1ØH), date of last write (offset 14H), and time of last write (offset 16H) are set from the directory entry.

Before performing a sequential disk operation on the file, you must set the current record field (offset 2ØH). Before performing a random disk operation on the file, you must set the relative record field (offset 21H). If the default record size (128 bytes) is not correct, set it to the correct length.

Entry Conditions:

AH = ØFH
DS:DX = *pointer to an unopened FCB for the file*

Exit Conditions:

If AL = ØØH, the directory entry was found
If AL = FFH, the directory entry was not found.

Macro Definition:

```
open    macro   fcb
        mov     dx,offset fcb
        mov     ah,ØFH
        int     21H
        endm
```

Example:

The following program prints the file named TEXTFILE.ASC that is on the disk in Drive B. If a partial record is in the buffer at end of file, the routine that prints the partial record prints characters until it encounters an end of file mark (ASCII 26, or CONTROL-Z).

```
fcb             db      2,"TEXTFILEASC"
                db      25 dup (?)
buffer          db      128 dup (?)
                .
                .
func_0FH:       set_dta   buffer          ;see Function 1AH
                open   fcb                ;THIS FUNCTION
read_line:      read_seq   fcb            ;see Function 14H
                cmp     al,02H            ;end of file?
                je      all_done          ;yes, go home
                cmp     al,00H            ;more to come?
                jg      check_more        ;no, check for partial
                                          ;record
                mov     cx,128            ;yes, print the buffer
                xor     si,si             ;set index to 0
print_it:       print_char buffer[si]     ;see Function 05H
                inc     si                ;bump index
                loop    print_it          ;print next character
                jmp     read_line         ;read another record
check_more:     cmp     al,03H            ;part. record to print?
                jne     all_done          ;no
                mov     cx,128            ;yes, print it
                xor     si,si             ;set index to 0
find_eof:       cmp     buffer[si],26     ;end of file mark?
all_done:       close   fcb               ;see Function 10H
```

CloseFile

Close File

Function Call 10H

Closes an open file and updates the directory information on that file. This function must be called after a file is changed to update the directory entry.

If a directory entry for the file is found, the location of the file is compared with the corresponding entries in the File Control Block (FCB). The directory is updated, if necessary, to match the FCB.

Entry Conditions:

AH = 10H
DS:DX = *pointer to the open FCB of the file to close*

Exit Conditions:

If AL = 00H, the directory entry was found.
If AL = FFH, no directory entry was found.

Macro Definition:

```
close   macro   fcb
        mov     dx,offset fcb
        mov     ah,10H
        int     21H
        endm
```

Example:

The following program checks the first byte of the file named MOD1.BAS in Drive B to see if it is FFH, and prints a message if it is.

```
message     db      "Not saved in ASCII format",13,10,"$"
fcb         db      2,"MOD1     BAS"
            db      25 dup (?)
buffer      db      128 dup (?)
            .
            .
```

```
func_10H:     set_dta   buffer          ;see Function 1AH
              open      fcb             ;see Function 0FH
              read_seq  fcb             ;see Function 14H
              cmp       buffer,0FFH     ;is first byte FFH?
              jne       all_done        ;no
              display   message         ;see Function 09H
all_done:     close     fcb             ;THIS FUNCTION
```

DirSearchFirst

Search for First Entry Function Call 11H

Searches the disk directory for the first name that matches the filename in the FCB. The name can have the ? wild card character to match any character. To search for hidden or system files, DS:DX must point to the first byte of the extended FCB prefix.

If a directory entry for the filename in the FCB is found, an unopened FCB of the same type (normal or extended) is created at the Disk Transfer Address.

If an extended FCB is pointed to by DS:DX, the following search pattern is used:

1. If the attribute byte (offset FCB-1) is zero, only normal file entries are found. Entries for the volume label, sub-directories, hidden files, and system files will not be returned.

2. If the attribute field is set for hidden or system files, or directory entries, it is considered an inclusive search. All normal file entries plus all entries matching the specified attributes are returned. To look at all directory entries except the volume label, the attribute byte may be set to hidden + system + directory (all 3 bits set).

3. If the attribute field is set for the volume label, it is considered an exclusive search, and only the volume label entry is returned.

Entry Conditions:

AH = 11H
DS:DX = *pointer to the unopened FCB of the file to search for*

Exit Conditions:

If AL = 00H, a directory entry was found.
If AL = FFH, no directory entry was found.

Macro Definition:

```
search_first        macro  fcb
                    mov    dx,offset fcb
                    mov    ah,11H
                    int    21H
                    endm
```

Example:

The following program verifies the existence of a file named REPORT.ASM on the disk in Drive B.

```
yes         db       "FILE EXISTS.$"
no          db       "FILE DOES NOT EXIST.$"
fcb         db       2,"REPORT ASM"
            db       25 dup (?)
buffer      db       128 dup (?)
crlf        db       13,10, "$"
            .
            .
func_11H:   set_dta buffer               ;see Function 1AH
            search_first fcb             ;THIS FUNCTION
            cmp      al,0FFH             ;directory entry found?
            je       not_there           ;no
            display  yes                 ;see Function 09H
            jmp      continue
not_there:  display  no                  ;see Function 09H
continue:   display  crlf                ;see Function 09H
            .
            .
```

SearchNext

Search for Next Entry

Function Call 12H

Used after Function Call 11H (Search for First Entry) to find additional directory entries that match a filename that contains wild card characters. The ? wild card character in the filename matches any character. This call searches the disk directory for the next matching name. To search for hidden or system files, DS:DX must point to the first byte of the extended FCB prefix.

If a directory entry for the filename in the FCB is found, an unopened FCB of the same type (normal or extended) is created at the Disk Transfer Address.

Entry Conditions:

AH	=	12H
DS:DX	=	*pointer to the unopened FCB of the file to search for*

Exit Conditions:

If AL = 00H, a directory entry was found.
If AL = FFH, no directory entry was found.

Macro Definition:

```
search_next macro fcb
            mov   dx,offset fcb
            mov   ah,12H
            int   21H
            endm
```

Example:

The following program displays the number of files on the disk in Drive B.

```
message      db        "No files",10,13,"$"
files        db        0
ten          db        10
ten          db        10
fcb          db        2,"???????????"
             db        25 dup (?)
buffer       db        128 dup (?)
             .
             .
func_12H:    set_dta buffer             ;see Function 1AH
             search_first fcb           ;see Function 11H
             cmp       al,0FFH          ;directory entry found?
             je        all_done         ;no, no files on disk
             inc       files            ;yes, increment file
                                        ;counter
search_dir:  search_next   fcb          ;THIS FUNCTION
             cmp       al,0FFH          ;directory entry found?
             je        done             ;no
             inc       files            ;yes, increment file
                                        ;counter
             jmp       search_dir       ;check again
done:        convert files,ten,message  ;see end of chapter
all_done:    display   message          ;see Function 09H
```

DeleteFile

Delete File

Function Call 13H

Deletes all directory entries that match the filename given in the specified unopened FCB. The filename can contain the ? wild card character to match any character.

Entry Conditions:

AH = 13H
DS:DX = *pointer to an unopened FCB*

Exit Conditions:

If AL = 00H, a directory entry was found.
If AL = FFH, no directory entry was found.

Macro Definition:

```
delete   macro  fcb
         mov    dx,offset fcb
         mov    ah,13H
         int    21H
         endm
```

Example:

The following program deletes each file on the disk in Drive B that was last written before December 31, 1982.

```
year       dw     1982
month      db     12
day        db     31
files      db     0
ten        db     10
message    db     "NO FILES DELETED.",13,10,"$"
                           ;see Function 09H for
                           ;explanation of $
fcb        db     2,"???????????"
           db     25 dup (?)
buffer     db     128 dup (?)
                  .
                  .
```

```
func_13H:     set_dta    buffer             ;see Function 1AH
              search_first  fcb             ;see Function 11H
              cmp      al,FFH               ;directory entry found?
              je       all_done             ;no, no files on disk
compare:      convert_date buffer           ;see end of chapter
              cmp      cx,year              ;next several lines
              jg       next                 ;check date in directory
              cmp      dl,month             ;entry against date
              jg       next                 ;above & check next file
              cmp      dh,day               ;if date in directory
              jge      next                 ;entry isn't earlier.
              delete   buffer               ;THIS FUNCTION
              inc      files                ;bump deleted-files
                                            ;counter
next:         search_next fcb               ;see Function 12H
              cmp      al,00H               ;directory entry found?
              je       compare              ;yes, check date
              cmp      files,0              ;any files deleted?
              je       all_done             ;no, display NO FILES
                                            ;message.
              convert files,ten,message     ;see end of chapter
all_done:     display message               ;see Function 09H
```

SeqRead

Sequential Read

Function Call 14H

Reads a record sequentially. The record pointed to by the current block (offset 0CH) and the current record (offset 20H) fields of the FCB is loaded at the Disk Transfer Address. The current block and current record fields are then incremented.

The record size is set to the value at offset 0EH in the FCB.

Entry Conditions:

AH = 14H
DS:DX = *pointer to the opened FCB of the file to read*

Exit Conditions:

If AL = 00H, the read was completed successfully.
If AL = 01H, end of file was encountered; there was no data in the record.
If AL = 02H, there was not enough room at the Disk Transfer Address to read one record; the read was canceled.
If AL = 03H, end of file was encountered; a partial record was read and padded to the record length with zeroes.

Macro Definition:

```
read_seq    macro  fcb
            mov    dx,offset fcb
            mov    ah,14H
            int    21H
            endm
```

Example:

The following program displays the file named TEXTFILE.ASC that is on the disk in Drive B; its function is similar to the MS-DOS TYPE command. If a partial record is in the buffer at end of file, the routine that displays the partial record displays characters until it encounters an end of file mark (ASCII 26, or CONTROL-Z).

```
fcb          db        2,"TEXTFILEASC"
             db        25 dup (?)
buffer       db        128 dup (?), "$"
             .
             .
func_14H:    set_dta  buffer            ;see Function 1AH
             open     fcb               ;see Function 0FH
read_line:   read_seq   fcb             ;THIS FUNCTION
             cmp      al,02H            ;end of file?
             je       all_done          ;yes
             cmp      al,02H            ;end of file with partial
                                        ;record?
             jg       check_more        ;yes
             display  buffer            ;see Function 09H
             jmp      read_line         ;get another record
check_more:  cmp      al,03H            ;partial record in buffer?
             jne      all_done          ;no, go home
             xor      si,si             ;set index to 0
find_eof:    cmp      buffer[si],26     ;is character EOF?
             je  all_done               ;yes, no more to display
             display_char  buffer[si]   ;see Function 02H
             inc      si                ;bump index to next
                                        ;character
             jmp      find_eof          ;check next character
all_done:    close    fcb               ;see Function 10H
```

SeqWrite

Sequential Write

Function Call 15H

Writes a record sequentially. The record pointed to by the current block (offset 0CH) and the current record (offset 20H) fields of the FCB is written from the Disk Transfer Address. The current block and current record fields are then incremented.

The record size is set to the value at offset 0EH in the FCB. If the record size is less than a sector, the data at the Disk Transfer Address is written to a buffer. The buffer is written to disk when it contains a full sector of data, when the file is closed, or when Function Call 0DH (Reset Disk) is issued.

Entry Conditions:

AH = 15H
DS:DX = *pointer to the opened FCB of the file to write*

Exit Conditions:

If AL = 00H, the write was completed successfully.
If AL = 01H, the disk was full; the write was canceled.
If AL = 02H, there was not enough room in the disk transfer segment to write one record; the write was canceled.

Macro Definition:

```
write_seq  macro  fcb
           mov    dx,offset fcb
           mov    ah,15H
           int    21H
           endm
```

Example:

The following program creates a file named DIR.TMP on the disk in Drive B that contains the disk number (Ø = A, 1 = B, etc.) and filename from each directory entry on the disk.

```
record_size   equ        14                      ;offset of Record Size
                                                 ;field in FCB
              .
              .
fcb1          db         2,"DIR     TMP"
              db         25 dup (?)
fcb2          db         2,"???????????"
              db         25 dup (?)
buffer        db         128 dup (?)
              .
              .
func_15H:   set_dta        buffer              ;see Function 1AH
            search_first   fcb2                ;see Function 11H
            cmp            al,ØFFH             ;directory entry found?
            je             all_done            ;no, no files on disk
            create         fcb1                ;see Function 16H
            mov            fcb1[record_size],12
                                               ;set record size to 12
write_it:   write_seq      fcb1                ;THIS FUNCTION
            search_next    fcb2                ;see Function 12H
            cmp            al,ØFFH             ;directory entry found?
            je             all_done            ;no, go home
            jmp            write_it            ;yes, write the record
all_done:   close          fcb1                ;see Function 1ØH
```

Create File

Function Call 16H

Searches the directory for an empty entry or an existing entry for the filename in the specified FCB.

If an empty directory entry is found, it is initialized to a zero-length file and the Open File function call (ØFH) is called. You can create a hidden file by using an extended FCB with the attribute byte (offset FCB-1) set to 2.

If an entry is found for the specified filename, all data in the file is released, making a zero-length file, and the Open File function call (ØFH) is issued for the filename. In other words, if you try to create a file that already exists, the existing file is erased and a new, empty file is created.

Entry Conditions:

AH = 16H
DS:DX = *pointer to an unopened FCB for the file*

Exit Conditions:

If AL = ØØH, an empty directory entry was found.
If AL = FFH, no empty directory entry was available.

Macro Definition:

```
create      macro  fcb
            mov    dx,offset fcb
            mov    ah,16H
            int    21H
            endm
```

Example:

The following program creates a file named DIR.TMP on the disk in Drive B that contains the disk number (0 = A, 1 = B, etc.) and filename from each directory entry on the disk.

```
record__size  equu      14                 ;offset of Record Size
                                           ;field of FCB
                .
                .
fcb1          db        2,"DIR     TMP"
              db        25 dup (?)
fcb2          db        2,"???????????"
              db        25 dup (?)
buffer        db        128 dup (?)
                .
                .
func__16H:  set__dta       buffer          ;see Function 1AH
            search__first  fcb2            ;see Function 11H
            cmp            al,0FFH         ;directory entry found?
            je             all__done       ;no, no files on disk
            create         fcb1            ;THIS FUNCTION
            mov            fcb1[record__size],12
                                           ;set record size to 12
write__it:  write__seq     fcb1            ;see Function 15H
            search__next   fcb2            ;see Function 12H
            cmp            al,0FFH         ;directory entry found?
            je             all__done       ;no, go home
            jmp            write__it       ;yes, write the record
all__done:  close          fcb1            ;see Function 10H
```

Rename

Rename File

Function Call 17H

Changes the name of a file. The current drive code and filename occupy the usual position in the file's FCB, and are followed by a second filename at offset 11H. (The two filenames cannot be the same name.) The disk directory is searched for an entry that matches the first filename, which can contain the ? wild card character.

If a matching directory entry is found, the filename in the directory entry is changed to match the second filename in the modified FCB. If the ? wild card character is used in the second filename, the corresponding characters in the filename of the directory entry are not changed.

Entry Conditions:

AH = 17H
DS:DX = *pointer to the FCB containing the current and new filenames*

Exit Conditions:

If AL = 00H, a directory entry was found.
If AL = FFH, no directory entry was found or no match exists.

Macro Definition:

```
rename    macro  fcb,newname
          mov    dx,offset fcb
          mov    ah,17H
          int    21H
          endm
```

Example:

The following program prompts for the name of a file and a new name, then renames the file.

```
fcb         db      37 dup (?)
prompt1     db      "Filename: $"
prompt2     db      "New name: $"
reply       db      17 dup(?)
crlf        db      13,10,"$"
                .
                .
func_17H:   display  prompt1              ;see Function 09H
            get_string  15,reply          ;see Function 0AH
            display  crlf                 ;see Function 09H
            parse    reply[2],fcb         ;see Function 29H
            display  prompt2              ;see Function 09H
            get_string  15,reply          ;see Function 0AH
            display  crlf                 ;see Function 09H
            parse    reply[2],fcb[16]     ;see Function 29H
            rename   fcb                  ;THIS FUNCTION
```

Curdsk

Current Disk

Function Call 19H

Returns the code of the currently selected drive.

Entry Conditions:

AH = 19H

Exit Conditions:

AL = *currently selected drive (Ø = A, 1 = B, etc.)*

Macro Definition:

```
current_disk        macro
                    mov     ah,19H
                    int     21H
                    endm
```

Example:

The following program displays the currently selected (default) drive in a 2-drive system.

```
message     db        "Current disk is $"  ;see Function Ø9H
                                           ;for explanation of $
crlf        db        13,1Ø,"$"
                      .
                      .
func_19H:   display   message              ;see Function Ø9H
            current_disk                   ;THIS FUNCTION
            cmp       al,ØØH               ;is it disk A?
            jne       disk_b               ;no, it's disk B
            display_char "A"               ;see Function Ø2H
            jmp       all_done
disk_b:     display_char "B"               ;see Function Ø2H
all_done:   display   crlf                 ;see Function Ø9H
```

SetDTA

Set Disk Transfer Address   Function Call 1AH

Sets the Disk Transfer Address to the specified address. Disk transfers cannot wrap around from the end of the segment to the beginning, nor can they overflow into the next segment.

If you do not set the Disk Transfer Address, it defaults to offset 8ØH in the Program Segment Prefix.

Entry Conditions:

AH = 1AH
DS:DX = *address to set as Disk Transfer Address*

Macro Definition:

```
set_dta     macro  buffer
            mov    dx,offset buffer
            mov    ah,1AH
            int    21H
            endm
```

Example:

The following program prompts for a letter, converts the letter to its alphabetic sequence (A = 1, B = 2, etc.), and then reads and displays the corresponding record from a file named ALPHABET.DAT on the disk in Drive B. The file contains 26 records; each record is 28 bytes long.

```
record_size         equ     14            ;offset of Record Size
                                          ;field of FCB
relative_record     equ     33            ;offset of Relative Record
                                          ;field of FCB
                .
                .
fcb             db          2,"ALPHABETDAT"
                db          25 dup (?)
buffer          db          34 dup(?),"$"
prompt          db          "Enter letter:   $"
```

```
crlf          db          13,10,"$"
                .
                .
func_1AH:     set_dta     buffer            ;THIS FUNCTION
              open        fcb               ;see Function 0FH
              mov         fcb[record_size],28  ;set record size
get_char:     display     prompt            ;see Function 09H
              read_kbd_and_echo             ;see Function 01H
              cmp         al,0DH            ;just a CR?
              je          all_done          ;yes, go home
              sub         al,41H            ;convert ASCII
                                            ;code to record #
              mov         fcb[relative_record],al  ;set relative record
              display     crlf              ;see Function 09H
              read_ran    fcb               ;see Function 21H
              display     buffer            ;see Function 09H
              display     crlf              ;see Function 09H
              jmp         get_char          ;get another character
all_done:     close       fcb               ;see Function 10H
```

RandomRead

Random Read

Function Call 21H

Performs a random read of a record. The current block (offset ØCH) and current record (offset 2ØH) fields in the FCB are set to agree with the relative record field (offset 21H). The record addressed by these fields is then loaded at the Disk Transfer Address.

Entry Conditions:

AH = 21H
DS:DX = *pointer to the opened FCB of the file to read*

Exit Conditions:

If AL = ØØH, the read was completed successfully.
If AL = Ø1H, end of file was encountered; no data is in the record.
If AL = Ø2H, there was not enough room at the Disk Transfer Address to read one record; the read was canceled.
If AL = Ø3H, end of file was encountered; a partial record was read and padded to the record length with zeroes.

Macro Definition:

```
read_ran   macro  fcb
           mov    dx,offset fcb
           mov    ah,21H
           int    21H
           endm
```

Example:

The following program prompts for a letter, converts the letter to its alphabetic sequence (A = 1, B = 2, etc.), and then reads and displays the corresponding record from a file named ALPHABET.DAT on the disk in Drive B. The file contains 26 records; each record is 28 bytes long.

```
record_size       equ    14          ;offset of Record Size
                                     ;field of FCB
relative_record   equ    33          ;offset of Relative Record
                                     ;field of FCB
                  .
                  .
fcb          db      2,"ALPHABETDAT"
             db      25 dup (?)
buffer       db      34 dup(?),"$"
prompt       db      "Enter letter: $"
crlf         db      13,10,"$"
                  .
                  .
func_21H:  set_dta          buffer            ;see Function 1AH
           open             fcb               ;see Function 0FH
           mov              fcb[record_size],28  ;set record size
get_char:  display          prompt            ;see Function 09H
           read_kbd_and_echo                  ;see Function 01H
           cmp              al,0DH            ;just a CR?
           je               all_done          ;yes, go home
           sub              al,41H            ;convert ASCII code
                                              ;to record #
           mov              fcb[relative_record],al   ;set relative
                                              ;record
           display          crlf              ;see Function 09H
           read_ran         fcb               ;THIS FUNCTION
           display          buffer            ;see Function 09H
           display          crlf              ;see Function 09H
           jmp              get_char          ;get another char.
all_done:  close            fcb               ;see Function 10H
```

Random Write Function Call 22H

Performs a random write of a record. The current block (offset 0CH) and current record (offset 20H) fields in the FCB are set to agree with the relative record field (offset 21H). The record addressed by these fields is then written from the Disk Transfer Address. If the record size is smaller than a sector (512 bytes), the records are buffered until a full sector is ready to write.

Entry Conditions:

AH = 22H
DS:DX = *pointer to the opened FCB of the file to write*

Exit Conditions:

If AL = 00H, the write was completed successfully.
If AL = 01H, the disk is full.
If AL = 02H, there was not enough room at the Disk Transfer Address to write one record; the write was canceled.

Macro Definition:

```
write_ran  macro  fcb
           mov    dx,offset fcb
           mov    ah,22H
           int    21H
           endm
```

Example:

The following program prompts for a letter, converts the letter to its alphabetic sequence (A = 1, B = 2, etc.), and then reads and displays the corresponding record from a file named ALPHABET.DAT on the disk in Drive B. After displaying the record, it prompts the user to enter a changed record. If the user types a new record, it is written to the file; if the user simply presses (ENTER), the record is not replaced. The file contains 26 records; each record is 28 bytes long.

```
record_size        equ  14     ;offset of Record Size
                               ;field of FCB
relative_record    equ  33     ;offset of Relative Record
                               ;field of FCB
                .
                .
fcb          db     2,"ALPHABETDAT"
             db     25 dup (?)
buffer       db     26 dup(?),13,10,"$"
prompt1      db     "Enter letter: $"
prompt2      db     "New record (RETURN for no change): $"
crlf         db     13,10,"$"
reply        db     28 dup (32)
blanks       db     26 dup (32)
                .
                .
func_22H:  set_dta          buffer            ;see Function 1AH
           open             fcb               ;see Function 0FH
           mov              fcb[record_size],32   ;set record size
get_char:  display          prompt1           ;see Function 09H
           read_kbd_and_echo                  ;see Function 01H
           cmp              al,0DH            ;just a CR?
           je               all_done          ;yes, go home
           sub              al,41H            ;convert ASCII
                                              ;code to record #
           mov              fcb[relative_record],al
                                              ;set relative record
           display          crlf              ;see Function 09H
           read_ran         fcb               ;THIS FUNCTION
           display          buffer            ;see Function 09H
           display          crlf              ;see Function 09H
           display          prompt2           ;see Function 09H
           get_string       27,reply          ;see Function 0AH
           display           crlf             ;see Function 09H
           cmp              reply[1],0        ;was anything typed
                                              ;besides CR?
           je               get_char          ;no
                                              ;get another char.
           xor              bx,bx             ;to load a byte
           mov              bl,reply[1]       ;use reply length as
                                              ;counter
           move_string      blanks,buffer,26  ;see chapter end
           move_string      reply[2],buffer,bx     ;see chapter end
           write_ran        fcb               ;see Function 21H
           jmp              get_char          ;get another character
all_done:  close            fcb               ;see Function 10H
```

File Size

Function Call 23H

Searches the disk directory for the first matching entry for a specified FCB. If a matching directory entry is found, the relative record field (offset 21H) is set to the number of records in the file, calculated from the total file size in the directory entry (offset 1CH) and the record size field (offset ØEH) of the FCB.

If the value of the record size field of the FCB does not match the actual number of characters in a record, this function does not return the correct file size. If the default record size (128) is not correct, you must set the record size field to the correct value before using this function.

Entry Conditions:

AH = 23H
DS:DX = *pointer to the file's unopened FCB*

Exit Conditions:

If AL = ØØH, a directory entry was found.
If AL = FFH, no directory entry was found.

Macro Definition:

```
file_size   macro  fcb
            mov    dx,offset fcb
            mov    ah,23H
            int    21H
            endm
```

Example:

The following program prompts for the name of a file, opens the file to fill in the Record Size field of the FCB, issues a File Size function call, and displays the file size and number of records in hexadecimal format.

```
fcb         db            37 dup (?)
prompt      db            "File name: $"
msg1        db            "Record length:      ",13,10,"$"
msg2        db            "Records:      ",13,10,"$"
crlf        db            13,10,"$"
reply       db            17 dup(?)
sixteen     db            16
            .
            .
func_23H:   display prompt              ;see Function 09H
            get_string    17,reply      ;see Function 0AH
            cmp           reply[1],0    ;just a CR?
            jne           get_length    ;no, keep going
            jmp           all_done      ;yes, go home
get_length: display       crlf          ;see Function 09H
            parse         reply[2],fcb  ;see Function 29H
            open          fcb           ;see Function 0FH
            file_size     fcb           ;THIS FUNCTION
            mov           si,33         ;offset to Relative
                                        ;Record field
            mov           di,9          ;reply in msg_2
convert_it: cmp           fcb[si],0     ;digit to convert?
            je            show_it       ;no, prepare message
            convert       fcb[si],sixteen,msg_2[di]
            inc           si            ;bump n-o-r index
            inc           di            ;bump message index
            jmp           convert_it    ;check for a digit
show_it:    convert       fcb[14],sixteen,msg_1[15]
            display       msg_1         ;see Function 09H
            display       msg_2         ;see Function 09H
            jmp           func_23H      ;get a filename
all_done:   close         fcb           ;see Function 10H
```

SetRelRec

Set Relative Record　　　Function Call 24H

Sets the relative record field (offset 21H) in a specified FCB to the same file address that is indicated by the current block (offset ØCH) and current record (offset 2ØH) fields.

Entry Conditions:

AH = 24H
DS:DX = *pointer to an opened FCB*

Macro Definition:

```
set_relative_record  macro  fcb
                     mov    dx,offset fcb
                     mov    ah,24H
                     int    21H
                     endm
```

Example:

The following program copies a file using the Random Block Read and Random Block Write function calls. It speeds the copy by setting the record length equal to the file size and the record count to 1, and using a buffer of 32K bytes. It positions the file pointer by setting the current record field (offset 2ØH) to 1 and using the Set Relative Record function call to make the relative record field (offset 21H) point to the same record as the combination of the current block (offset ØCH) and current record (offset 2ØH) fields.

```
current_record    equ    32     ;offset of Current Record
                                ;field of FCB
file_size         equ    16     ;offset of File Size
                                ;field of FCB
                  .
                  .
fcb          db          37 dup (?)
filename     db          17 dup(?)
prompt1      db          "File to copy: $"    ;see Function Ø9H for
prompt2      db          "Name of copy: $" ;explanation of $
crlf         db          13,1Ø,"$"
```

```
file_length  dw             ?
buffer       db             32767 dup(?)
             .
             .
func_24H:    set_dta        buffer                ;see Function 1AH
             display        prompt1               ;see Function 09H
             get_string     15,filename           ;see Function 0AH
             display        crlf                  ;see Function 09H
             parse          filename[2],fcb       ;see Function 29H
             open           fcb                   ;see Function 0FH
             mov            fcb[current_record],0   ;set Current Record
                                                  ;field
             set_relative_record      fcb         ;THIS FUNCTION
             mov            ax,word ptr fcb[file_size]     ;get file size
             mov            file_length,ax        ;save it for
             ran_block_read        fcb,1,ax       ;ran_block_write
                                                  ;see Function 27H
             display        prompt2               ;see Function 09H
             get_string     15,filename           ;see Function 0AH
             display        crlf                  ;see Function 09H
             parse          filename[2],fcb       ;see Function 29H
             create         fcb                   ;see Function 16H
             mov            fcb[current_record],0   ;set Current Record
                                                  ;field
             set_relative_record      fcb         ;THIS FUNCTION
             mov            ax,file_length        ;get original file
                                                  ;length
             ran_block_write     fcb,1,ax         ;see Function 28H
             close          fcb                   ;see Function 10H
```

Setvector

Set Interrupt Vector

Function Call 25H

Sets a particular interrupt vector. The operating system can then manage the interrupts on a per-process basis. This call sets the address in the vector table for the specified interrupt to the address of the interrupt-handling routine in AL.

Note that programs should *never* set interrupt vectors by writing them directly in the low memory vector table.

Entry Conditions:

AH = 25H
AL = *number of the interrupt to set*
DS:DX = *address of the interrupt-handling routine*

Macro Definition:

```
set_vector  macro   interrupt,seg_addr,off_addr
            push    ds
            mov     ax,seg_addr
            mov     ds,ax
            mov     dx,off_addr
            mov     al,interrupt
            mov     ah,25H
            int     21H
            pop     ds
            endm
```

Example:

```
lds         dx,intvector
mov         ah,25H
mov         al,intnumber
int         21H
;There are no errors returned
```

RBRead

Random Block Read   Function Call 27H

Reads the specified number of records (calculated from the record size field at offset ØEH of the FCB), starting at the record specified by the relative record field (offset 21H). The records are placed at the Disk Transfer Address. The current block (offset ØCH), current record (offset 2ØH), and relative record (offset 21H) fields are set to address the next record.

If the number of records to read is specified as zero, the call returns without reading any records (no operation).

Entry Conditions:

AH = 27H
CX = *number of records to read*
DS:DX = *pointer to the opened FCB of the file to read*

Exit Conditions:

CX = *actual number of records read*
If AL = ØØH, all records were read successfully.
If AL = Ø1H, end of file was encountered before all records were read; the last record is complete.
If AL = Ø2H, wrap-around above address FFFFH in the disk transfer segment would occur if all records were read; therefore, only as many records were read as was possible without wrap-around.
If AL = Ø3H, end of file was encountered before all records were read; the last record is partial.

Macro Definition:

```
ran_block_read      macro  fcb,count,rec_size
                    mov    dx,offset fcb
                    mov    cx,count
                    mov    word ptr fcb[14],rec_size
                    mov    ah,27H
                    int    21H
                    endm
```

Example

The following program copies a file using the Random Block Read function call. It speeds the copy by specifying a record count of 1 and a record length equal to the file size, and using a buffer of 32K bytes; the file is read as a single record. (Compare this example with the sample program for Function 28H, which specifies a record *length* of 1 and a record *count* equal to the file size.)

```
current_record     equu  32    ;offset of Current Record field
file_size          equ   16    ;offset of File Size field
                   .
                   .
fcb          db           37 dup (?)
filename     db           17 dup(?)
prompt1      db           "File to copy:   $"  ;see Function 09H
                                               ;for explanation
prompt2      db           "Name of copy: $"    ;of $
crlf         db           13,10,"$"
file_length  dw           ?
buffer       db           32767 dup(?)
                   .
                   .
func_27H:    set_dta      buffer          ;see Function 1AH
             display      prompt1         ;see Function 09H
             get_string   15,filename     ;see Function 0AH
             display      crlf            ;see Function 09H
             parse        filename[2],fcb ;see Function 29H
             open         fcb             ;see Function 0FH
             mov          fcb[current_record],0   ;set Current
                                          ;Record field
             set_relative_record    fcb   ;see Function 24H
             mov          ax, word ptr    fcb[file_size]
                                          ;get file size
             mov          file_length,ax  ;save it for
                          fcb,1,ax        ;ran_block_write
             ran_block_read               ;THIS FUNCTION
             display      prompt2         ;see Function 09H
             get_string   15,filename     ;see Function 0AH
             display      crlf            ;see Function 09H
             parse        filename[2],fcb ;see Function 29H
             create       fcb             ;see Function 16H
             mov          fcb[current_record],0
                                          ;set Current Record
                                          ;field
```

```
set__relative__record    fcb          ;see Function 24H
mov               ax, file__length ;get original file
                                   ;size
ran__block__write    fcb,1,ax      ;see Function 28H
close             fcb              ;see Function 10H
```

Random Block Write

Function Call 28H

Writes the specified number of records (calculated from the record size field at offset ØEH of the FCB) from the Disk Transfer Address. The records are written to the file starting at the record specified in the relative record field (offset 21H). The current block (offset ØCH), current record (offset 2ØH), and relative record (offset 21H) are then set to address the next record.

If the number of records is specified as zero, no records are written, but the file size field of the directory entry (offset 1CH) is set to the number of records specified by the relative record field of the FCB (offset 21H). Allocation units are allocated or released, as required.

Entry Conditions:

AH = 28H
DS:DX = *pointer to the opened FCB of the file to write*
CX = *number of records to write (non-zero)*
or
CX = Ø (sets the file size field; see above)

Exit Conditions:

CX = *actual number of records written*
If AL = ØØH, all records were written successfully.
If AL = Ø1H, no records were written because there is insufficient space on the disk.

Macro Definition:

```
ran_block_write   macro  fcb,count,rec_size
                  mov    dx,offset fcb
                  mov    cx,count
                  mov    word ptr fcb[14],rec_size
                  mov    ah,28H
                  int    21H
                  endm
```

Example:

The following program copies a file using the Random Block Read and Random Block Write function calls. It speeds the copy by specifying a record count equal to the file size and a record length of 1, and using a buffer of 32K bytes; the file is copied quickly with one disk access each to read and write. (Compare this example with the sample program for Function 27H, which specifies a record *count* of 1 and a record *length* equal to file size.)

```
current_record    equ   32    ;offset of Current Record field
file_size         equ   16    ;offset of File Size field
                  .
                  .
fcb          db          37 dup (?)
filename     db          17 dup(?)
prompt1      db          "File to copy:     $"    ;see Function 09H for
prompt2      db          "Name of copy:     $"    ;explanation of $
crlf         db          13,10,"$"
num_recs     dw          ?
buffer       db          32767 dup(?)
             .
             .
func_28H:    set_dta      buffer            ;see Function 1AH
             display      prompt1           ;see Function 09H
             get_string   15,filename       ;see Function 0AH
             display      crlf              ;see Function 09H
             parse        filename[2],fcb   ;see Function 29H
             open         fcb               ;see Function 0FH
             mov          fcb[current_record],0
                                            ;set Current Record
                                            ;field
             set_relative_record fcb        ;see Function 24H
             mov          ax, word ptr fcb [file_size]
                                            ;get file size
             mov          num_recs,ax       ;save it for
                                            ;ran_block_write
             ran_block_read     fcb,num_recs,1      ;THIS FUNCTION
             display      prompt2           ;see Function 09H
             get_string   15,filename       ;see Function 0AH
             display      crlf              ;see Function 09H
             parse        filename[2],fcb   ;see Function 29H
             create       fcb               ;see Function 16H
             mov          fcb[current_record],0    ;set Current
                                            ;Record field
             set_relative_record   fcb      ;see Function 24H
```

```
mov              ax, file__length  ;get size of original
ran__block__write   fcb,num__recs,1        ;see Function 28H
close            fcb               ;see Function 10H
```

Parse Filename Function Call 29H

Parses a string for a filename of the form d:filename.ext. If one is found, a corresponding unopened FCB is created at a specified location.

Bits 0-3 of AL control the parsing and processing (bits 4-7 are ignored):

Bit	Value	Meaning
0	0	All parsing stops if a file separator is encountered.
	1	Leading separators are ignored.
1	0	The drive number in the FCB is set to 0 (default drive) if the string does not contain a drive number.
	1	The drive number in the FCB is not changed if the string does not contain a drive number.
2	0	The filename in the FCB is set to 8 blanks if the string does not contain a filename.
	1	The filename in the FCB is not changed if the string does not contain a filename.
3	0	The extension in the FCB is set to 3 blanks if the string does not contain an extension.
	1	The extension in the FCB is not changed if the string does not contain an extension.

If the filename or extension includes an asterisk (*), all remaining characters in the name or extension are set to question mark (?).

The filename separators are:

: . ; , = + [ ] \ < > | space tab

Filename terminators include all the filename separators plus all control characters. A filename cannot contain a filename terminator; if one is encountered, parsing stops.

Entry Conditions:

AH = 29H
DS:SI = *pointer to string to parse*
ES:DI = *pointer to a portion of memory to fill in with an unopened FCB*
AL = *controls parsing (see above)*

Exit Conditions:

If AL = 00H, then no wild card characters appeared in the filename or extension.
If AL = 01H, then wild card characters appeared in the filename or extension.
DS:SI = *pointer to the first byte after the string that was parsed*
ES:DI = *unopened FCB*

Macro Definition:

```
parse       macro  string,fcb
            mov    si,offset string
            mov    di,offset fcb
            push   es
            push   ds
            pop    es
            mov    al,0FH ;bits 0, 1, 2, 3 on
            mov    ah,29H
            int    21H
            pop    es
            endm
```

Example:

The following program verifies the existence of the file named in reply to the prompt.

```
fcb         db      37 dup (?)
prompt      db      "Filename: $"
reply       db      17 dup(?)
yes         db      "FILE EXISTS",13,10,"$"
no          db      "FILE DOES NOT EXIST",13,10,"$"
                    .
                    .
func_29H:   display        prompt         ;see Function 09H
            get_string     15,reply       ;see Function 0AH
            parse          reply[2],fcb   ;THIS FUNCTION
            search_first   fcb            ;see Function 11H
            cmp            al,0FFH        ;dir. entry found?
            je             not_there      ;no
            display        yes            ;see Function 09H
            jmp            continue
not_there:  display        no
continue:   .
            .
```

Get Date

Function Call 2AH

Returns the current date set in the operating system. The date is returned as binary numbers.

Entry Conditions:

AH = 2AH

Exit Conditions:

CX = *year (198Ø-2Ø99)*
DH = *month (1 = January, 2 = Febuary, etc.)*
DL = *day of the month (1-31)*
AL = *day of the week (Ø = Sunday, 1 = Monday, etc.)*

Macro Definition:

```
get_date   macro
           mov    ah,2AH
           int    21H
           endm
```

Example:

The following program gets the date, increments the day, increments the month or year, if necessary, and sets the new date.

```
month       db        31,28,31,3Ø,31,3Ø,31,31,3Ø,31,3Ø,31
            .
            .
func_2AH:   get_date                    ;see above
            inc          dl             ;increment day
            xor          bx,bx          ;so BL can be used as
                                        ;index
            mov          bl,dh          ;move month to index
                                        ;register
            dec          bx             ;month table starts with Ø
            cmp          dl,month[bx]   ;past end of month?
            jle          month_ok       ;no, set the new date
            mov          dl,1           ;yes, set day to 1
            inc          dh             ;and increment month
            cmp          dh,12          ;past end of year?
            jle        month__ok     ;no, set the new date
            mov        dh,1          ;yes, set the month to 1
            inc        cx            ;increment year
month__ok:  set__date  cx,dh,dl      ;see Function 2BH
```

Set Date

Function Call 2BH

Sets the date to a valid date in binary given in CX and DX.

Entry Conditions:

AH = 2BH
CX = *year (1980-2099)*
DH = *month (1 = January, 2 = February, etc.)*
DL = *day of the month (1-31)*

Exit Conditions:

If AL = 00H, the date was valid.
If AL = FFH, the date was not valid and the function was canceled.

Macro Definition:

```
set_date    macro  year,month,day
            mov    cx,year
            mov    dh,month
            mov    dl,day
            mov    ah,2BH
            int    21H
            endm
```

Example:

The following program gets the date, increments the day, increments the month or year, if necessary, and sets the new date.

```
month       db      31,28,31,30,31,30,31,31,30,31,30,31
            .
            .
func_2BH:   get_date                  ;see Function 2AH
            inc         dl            ;increment day
            xor         bx,bx         ;so BL can be used as
                                      ;index
            mov         bl,dh         ;move month to index
                                      ;register
```

```
                dec         bx              ;month table starts with 0
                cmp         dl,month[bx]    ;past end of month?
                jle         month_ok        ;no, set the new date
                mov         dl,1            ;yes, set day to 1
                inc         dh              ;and increment month
                cmp         dh,12           ;past end of year?
                jle         month_ok        ;no, set the new date
                mov         dh,1            ;yes, set the month to 1
                inc         cx              ;increment year
month_ok:       set_date    cx,dh,dl        ;THIS FUNCTION
```

Get Time Function Call 2CH

Returns the current time set in the operating system as binary numbers.

Entry Conditions:

AH = 2CH

Exit Conditions:

CH = *hour (Ø-23)*
CL = *minutes (Ø-59)*
DH = *seconds (Ø-59)*
DL = *hundredths of a second (Ø-99)*

Macro Definition:

```
get_time    macro
            mov     ah,2CH
            int     21H
            endm
```

Example:

The following program continuously displays the time until any key is pressed.

```
time        db      "ØØ:ØØ:ØØ.ØØ",13,1Ø,"$"
ten         db      1Ø
                    .
                    .
func_2CH:     get_time                      ;THIS FUNCTION
              convert ch,ten,time           ;see end of chapter
              convert cl,ten,time[3]        ;see end of chapter
              convert dh,ten,time[6]        ;see end of chapter
              convert dl,ten,time[9]        ;see end of chapter
              display time                  ;see Function Ø9H
              check_kbd_status              ;see Function ØBH
              cmp     al,ØFFH               ;has a key been pressed?
              je      all_done              ;yes, terminate
              jmp     func_2CH              ;no, display time
all_done:     ret
```

Set Time

Function Call 2DH

Sets the time to a valid time in binary given in CX and DX.

Entry Conditions:

AH = 2DH
CH = *hour (Ø-23)*
CL = *minutes (Ø-59)*
DH = *seconds (Ø-59)*
DL = *hundredths of a second (Ø-99)*

Exit Conditions:

If AL = ØØH, the time specified on entry is valid.
If AL = FFH, the time was not valid; the function was canceled.

Macro Definition:

```
set_time    macro   hour,minutes,seconds,hundredths
            mov     ch,hour
            mov     cl,minutes
            mov     dh,seconds
            mov     dl,hundredths
            mov     ah,2DH
            int     21H
            endm
```

Example:

The following program sets the system clock to Ø and continuously displays the time. When a character is typed, the display freezes; when another character is typed, the clock is reset to Ø and the display starts again.

```
time        db      "ØØ:ØØ:ØØ.ØØ",13,1Ø,"$"
ten         db      1Ø
                .
                .
func_2DH:   set_time Ø,Ø,Ø,Ø               ;THIS FUNCTION
```

```
read__clock: get__time                 ;see Function 2CH
             convert ch,ten,time       ;see end of chapter
             convert cl,ten,time[3]    ;see end of chapter
             convert dh,ten,time[6]    ;see end of chapter
             convert dl,ten,time[9]    ;see end of chapter
             display time              ;see Function 09H
             dir__console__io FFH      ;see Function 06H
             cmp     al,00H            ;was a char. typed?
             jne     stop              ;yes, stop the timer
             jmp     read__clock       ;no keep timer on
stop:        read__kbd                 ;see Function 08H
             jmp     func__2DH         ;keep displaying time
```

SetVerify

Set/Reset Verify Flag

Function Call 2EH

Specifies whether each disk write is to be verified or not. MS-DOS checks this flag each time it writes to a disk.

The verify flag is normally off; you may wish to turn it on when writing critical data to disk. Because disk errors are rare and verification slows writing, you will probably want to leave it off at other times.

Entry Conditions:

AH = 2EH
AL = *verify flag*
  ØØH = do not verify
  Ø1H = verify

Macro Definition:

```
verify    macro  switch
          mov    al,switch
          mov    ah,2EH
          int    21H
          endm
```

Example:

The following program copies the contents of a single-sided disk in Drive A to the disk in Drive B, verifying each write. It uses a buffer of 32K bytes.

```
on          equ   1
off         equ   Ø
            .
            .
prompt      db    "Source in A, target in B",13,1Ø
            db    "Any key to start. $"
start       dw    Ø
buffer      db    64 dup (512 dup(?))    ;64 sectors
            .
            .
```

```
func_2DH:   display prompt              ;see Function 09H
            read_kbd                    ;see Function 08H
            verify on                   ;THIS FUNCTION
            mov   cx,5                  ;copy 64 sectors
                                        ;5 times
copy:       push  cx                    ;save counter
            abs_disk_read      0,buffer,64,start
                                        ;see Interrupt 25H
            abs_disk_write     1,buffer,64,start
                                        ;see Interrupt 26H
            add      start,64           ;do next 64 sectors
            pop      cx                 ;restore counter
            loop     copy               ;do it again
            verify   off                ;THIS FUNCTION
disk_read   0,buffer,64,start           ;see Interrupt 25H
            abs_disk_write    1,buffer,64,start
                                        ;see Interrupt 26H
            add      start,64           ;do next 64 sectors
            pop      cx                 ;restore counter
            loop     copy               ;do it again
            verify   off
```

GetDTA

Get Disk Transfer Address Function Call 2FH

Returns the Disk Transfer Address.

Entry Conditions:

AH = 2FH

Exit Conditions:

ES:BX = *pointer to current Disk Transfer Address*

Error Returns:

None.

Example:

```
Get DTA     equ     2FH
            mov     ah,GetDTA
            int     21H
```

GetVersion

Get Version Number

Function Call 3ØH

Returns the MS-DOS version number. AL:AH contains the two-part version designation on return. For example, for MS-DOS 2.Ø, AL would contain 2 and AH would contain Ø.

Entry Conditions:

AH = 3ØH

Exit Conditions:

AL = *major version number*
AH = *minor version number*
BH = *OEM (original equipment manufacturer) number*
BL:CX = *24-bit user number*

Error Returns:

None.

Example:

```
GetVersion  equ   3ØH
            mov   ah,GetVersion
            int   21H
```

Keep Process

Function Call 31H

Terminates the current process and attempts to set the initial allocation block to the specified size in paragraphs. No other allocation blocks belonging to that process are freed up. The exit code passed in AX is retrievable by the parent via function call 4DH.

This method is preferred over Interrupt 27H and has the advantage of allowing more than 64K to be kept.

Entry Conditions:

AH = 31H
AL = *exit code*
DX = *memory size in paragraphs*

Error Returns:

None.

Example:

```
KeepProcess   equ    31H
              mov    al,exitcode
              mov    dx,parasize
              mov    ah,KeepProcess
              int    21H
```

SetCtrlCTrapping

CONTROL-C Check

Function Call 33H

MS-DOS ordinarily checks for a CONTROL-C on the controlling device only when performing function call operations 01H-0CH to that device. Function Call 33H allows you to expand this checking to include any system call. For example, with the CONTROL-C trapping off, all disk I/O proceeds without interruption; with CONTROL-C trapping on, the CONTROL-C interrupt is given at the system call that initiates the disk operation.

Note: Programs that wish to use Function Calls 06H or 07H to read CONTROL-Cs as data must ensure that the CONTROL-C check is off.

Entry Conditions:

AH = 33H
AL = *function*
  00H = Return current state
  01H = Set state
DL = *switch (if setting state)*
  00H = Off
  01H = On

Exit Conditions:

DL = *current state*
  00H = Off
  01H = On

Error Return:

AL = FFH
The function passed in AL was not in the range 00H-01H.

Example:

```
SetCtrlCTrapping    equu    33H
                    mov     dl,val
                    mov     al,func
                    mov     al,SetCtrlCTrapping
```

GetVector

Get Interrupt Vector Function Call 35H

Returns the interrupt vector associated with a specified interrupt. Note that programs should never get an interrupt vector by reading the low memory vector table directly.

Entry Conditions:

AH = 35H
AL = *interrupt number*

Exit Conditions:

ES:BX = *pointer to interrupt routine*

Error Returns:

None.

Example:

```
GetVector   equ    35H
            mov    al,interrupt
            mov    ah,GetVector
            int    21H
```

GetFreeSpace

Get Disk Free Space

Function Call 36H

Returns the amount of free space on the disk along with additional information about the disk.

Entry Conditions:

AH = 36H
DL = *drive (Ø = default, 1 = A, etc.)*

Exit Conditions:

BX = *number of free allocation units on drive*
DX = *total number of allocation units on drive*
CX = *bytes per sector*
AX = *sectors per allocation unit* or
AX = FFFF (if drive number is invalid)

Error Returns:

AX = FFFFH
The drive number given in DL was invalid.

Example:

```
GetFreespace   equ    36H
               mov    dl,drive
               mov    ah,GetFreespace
               int    21H
```

Return Country-Dependent Information

Function Call 38H

Returns information pertinent to international applications in a buffer pointed to by DX:DS. The information is specific to the country indicated in AL. The value passed in AL is either 0 (for current country) or a country code. Country codes are typically the international telephone prefix code for the country.

If DX = -1, this call sets the current country to the country code in AL. If the country code is not found, the current country is not changed.

This function is fully supported only in versions of MS-DOS 2.01 and higher. It exists in MS-DOS 2.0, but is not fully implemented.

This function returns, in the block of memory pointed to by DS:DX, the following information:

WORD Date/time format
5-BYTE ASCIIZ string Currency symbol
2-BYTE ASCIIZ string Thousands separator
2-BYTE ASCIIZ string Decimal separator
2-BYTE ASCIIZ string Date separator
2-BYTE ASCIIZ string Time separator
1-BYTE Bit field
1-BYTE Currency places
DWORD Case Mapping call
2-BYTE ASCIIZ string Data list separator

The format of most of these entries is ASCIIZ (a NUL-terminated ASCII string), but a fixed size is allocated for each field for easy indexing into the table.

The date/time format has the following values:

0 - USA standard	h:m:s m/d/y
1 - Europe standard	h:m:s d/m/y
2 - Japan standard	y/m/d h:m:s

The bit field contains 8 bit values. Any bit not currently defined must be assumed to have a random value.

Bit 0	= 0	If currency symbol precedes the currency amount.
	= 1	If currency symbol comes after the currency amount.
Bit 1	= 0	If the currency symbol immediately precedes the currency amount.
	= 1	If there is a space between the currency symbol and the amount.

The time format has the following values:

0 =	12-hour time
1 =	24-hour time

The currency places field indicates the number of places which appear after the decimal point on currency amounts.

The Case Mapping call is a FAR procedure which performs country-specific lower-to-upper-case mapping on character values from 80H to FFH. It is called with the character to be mapped in AL. It returns the correct upper-case code for that character, if any, in AL. AL and the FLAGS are the only registers altered. It is allowable to pass codes below 80H to this routine; however, nothing is done to characters in this range. In the case where there is no mapping, AL is not altered.

Entry Conditions:

AH = 38H
DS:DX = *pointer to 32-byte memory area*
AL = *country code* (In MS-DOS 2.0, this must be 0.)

Exit Conditions:

Carry set:
AX = *error code*

Carry not set:
DX:DS = *country data*

Error returns:

AX = 2
File not found. The country passed in AL was not found (no table exists for the specified country).

Example:

```
lds         dx, blk
mov         ah, 38H
mov         al, country_code
int         21H
    ;AX = country code of country returned
```

MkDir

Create Sub-Directory

Function Call 39H

Creates a new directory entry at the end of a specified pathname.

Entry Conditions:

AH = 39H
DX:DS = *pointer to ASCIIZ pathname*

Exit Conditions:

Carry set:
  AX = *error code*
Carry not set:
  No error.

Error Returns:

AX = 3
  Path not found. The path specified was invalid or not found.
AX = 5
  Access denied. The directory could not be created (no room in the parent directory), the directory/file already existed, or a device name was specified.

Example:

```
MkDir     equu  39H
          lds   dx,pathname
          mov   ah,MkDir
          int   21H
```

RmDir

Remove a Directory Entry Function Call 3AH

Removes a specified directory from its parent directory.

Entry Conditions:

AH = 3AH
DS:DX = *pointer to ASCIIZ pathname*

Exit Conditions:

Carry set:
    AX = *error code*
Carry not set:
    No error.

Error Returns:

AX = 3
    Path not found. The path specified was invalid or not found.
AX = 5
    Access denied. The path specified was not empty, was not a directory, was the root directory, or contained invalid information.
AX = 16
    Current directory. The path specified was the current directory on a drive.

Example:

```
RmDir   equu    3AH
        lds     dx,pathname
        mov     ah,RmDir
        int     21H
```

ChDir

Change the Current Directory

Function Call 3BH

Sets the current directory to the directory specified. If any member of the specified pathname does not exist, then the current directory is unchanged.

Entry Conditions:

AH = 3BH
DS:DX = *pointer to ASCIIZ pathname*

Exit Conditions:

Carry set:
  AX = *error code*
Carry not set:
  No error.

Error Returns:

A = 3
  Path not found. The path specified either indicated a file or the path was invalid.

Example:

```
ChDir       equ     3BH
            lds     dx,pathname
            mov     ah,ChDir
            int     21H
```

Create

Create a File

Function Call 3CH

Creates a new file or truncates an old file to zero length in preparation for writing. If the file did not exist, then the file is created in the appropriate directory and the file is given the attribute(s) found in CX. (See the section "Disk Directory" in Chapter 4 for a discussion of file attributes.) The file handle returned has been opened for read/write access.

Entry Conditions:

AH = 3CH
DS:DX = *pointer to ASCIIZ pathname*
CX = *file attribute(s)*

Exit Conditions:

Carry set:
 AX = *error code*
Carry not set:
 AX = *file handle number*

Error Returns:

AX = 5
 Access denied. The attributes specified in CX included one that could not be created (directory, volume ID), a file already existed with a more inclusive set of attibutes, or a directory existed with the same name.
AX = 3
 Path not found. The path specified was invalid.
AX = 4
 Too many open files. The file was created with the specified attributes but there were no free handles available for the process, or the internal system tables were full.

Example:

```
Creat       equu    3CH
            lds     dx,pathname
            mov     cx,attribute
            mov     ah,Creat
            int     21H
```

Open

Open a File Function Call 3DH

Opens a file. The following values are allowed for the access code:

0 - The file is opened for reading.
1 - The file is opened for writing.
2 - The file is opened for both reading and writing.

The read/write pointer is set at the first byte of the file and the record size of the file is 1 byte. The returned file handle must be used for subsequent I/O to the file.

Entry Conditions:

AH = 3DH
DS:DX = *pointer to ASCIIZ pathname for file to open*
AL = *access code (0 = read, 1 = write, 2 = read and write)*

Exit Conditions:

Carry set:
AX = *error code*
Carry not set:
AX = *file handle number*

Error Returns:

AX = 12
Invalid access. The access specified in AL was not in the range 0 - 2.
AX = 2
File not found. The path specified was invalid or not found.
AX = 5
Access denied. The user attempted to open a directory or volume ID, or open a read-only file for writing.
AX = 4
Too many open files. There were no free handles available in the current process or the internal system tables were full.

Example:

```
Open    equ     3DH
        lds     dx,pathname
        mov     al,access
        mov     ah,Open
        int     21H
```

Close

Close a File Handle

Function Call 3EH

Closes the file associated with a specified file handle. Internal buffers are flushed.

Entry Conditions:

AH = 3EH
BX = *file handle for file to close*

Exit Conditions:

Carry set:
AX = *error code*
Carry not set:
No error.

Error Return:

AX = 6
Invalid handle. The handle passed in BX was not currently open.

Example:

```
Close       equ    3EH
            mov     bx,handle
            mov     ah,Close
            int     21H
```

Read from a File or Device Function Call 3FH

Transfers a specified number of bytes from a file into a buffer location. It is not guaranteed that all bytes will be read; for example, reading from the keyboard will read at most one line of text. If the returned value for number of bytes read is zero, then the program tried to read from the end of file.

All I/O is done using normalized pointers; no segment wrap-around will occur. (This means that MS-DOS takes the pointer you specify in DS:DX and modifies it so that DX is 000FH or smaller.)

Entry Conditions:

AH = 3FH
DS:DX = *pointer to buffer*
CX = *number of bytes to read*
BX = *file handle for the file to read*

Exit Conditions:

Carry set:
AX = *error code*
Carry not set:
AX = *number of bytes read*

Error Returns:

AX = 6
Invalid handle. The handle passed in BX is not currently open.

AX = 5
Access denied. The handle passed in BX was opened in a mode that did not allow reading.

Example:

```
Read        equu    3FH
            lds     dx,buffer
            mov     cx,count
            mov     bx,handle
            mov     ah,Read
            int     21H
```

Write to a File or Device Function Call 4ØH

Transfers a specified number of bytes from a buffer into a file. If the number of bytes written is not the same as the number requested, then an error has occurred.

If the number of bytes to be written is zero, the file size is set to the current position. Allocation units are allocated or released as required.

All I/O is done using normalized pointers; no segment wrap-around will occur. (This means that MS-DOS takes the pointer you specify in DS:DX and modifies it so that DX is ØØØFH or smaller.)

Entry Conditions:

AH = 4ØH
DS:DX = *pointer to buffer*
CX = *number of bytes to write*
BX = *file handle for file to write*

Exit Conditions:

Carry set:
  AX = *error code*
Carry not set:
  AX = *number of bytes written*

Error Returns:

AX = 6
  Invalid handle. The handle passed in BX is not currently open.
AX = 5
  Access denied. The handle passed in BX was opened in a mode that did not allow writing.

Example:

```
Write       equ     40H
            lds     dx,buffer
            mov     cx,count
            mov     bx,handle
            mov     ah,Write
            int     21H
```

Unlink

Delete a Directry Entry Function Call 41H

Removes a directory entry associated with a specified filename.

Entry Conditions:

AH = 41H
DS:DX = *pointer to pathname*

Exit Conditions:

Carry set:
  AX = *error code*
Carry not set:
  No error.

Error Returns:

AX = 2
  File not found. The path specified was invalid or not found.

AX = 5
  Access denied. The path specified was a directory or was read only.

Example:

```
Unlink    equ     41H
          lds     dx,pathname
          mov     ah,Unlink
          int     21H
```

LSeek

Move a File Pointer Function Call 42H

Moves the read/write pointer a specified number of bytes according to the following methods:

- 0 - The pointer is moved to the specified offset from the beginning of the file.
- 1 - The pointer is moved to the current location plus the offset.
- 2 - The pointer is moved to the end of file plus the offset.

Entry Conditions:

AH = 42H
CX:DX = *distance to move the pointer, offset in bytes (CX contains the most significant part)*
AL = *method of moving (0, 1, or 2; see above)*
BX = *file handle*

Exit Conditions:

Carry set:
 AX = *error code*
Carry not set:
 DX:AX = *new file pointer position*

Error Returns:

AX = 6
 Invalid handle. The handle passed in BX is not currently open.
AX = 1
 Invalid function. The function passed in AL was not in the range 0-2.

Example:

```
LSeek   equ   42H
        mov   dx,offsetlow
        mov   cx,offsethigh
        mov   al,method
        mov   bx,handle
        mov   ah,LSeek
        int   21H
```

ChMod

Change Attributes

Function Call 43H

Gets the attributes of a file, or sets the attributes of a file to those specified. (See the section "Disk Directory" in Chapter 4 for a description of file attributes.)

Entry Conditions:

AH = 43H
DS:DX = *pointer to ASCIIZ pathname of file*
AL = *function number*
  Ø1H = set file's attributes to those in CX
  ØØH = return file's attributes in CX
CX = *attribute(s) to be set*

Exit Conditions:

Carry set:
  AX = *error code*
Carry not set:
  CX = *current attribute(s) (if AL = ØØH on entry)*

Error Returns:

AX = 3
  Path not found. The path specified was invalid.
AX = 5
  Access denied. The attributes specified in CX included one that could not be changed (directory, volume ID).
AX = 1
  Invalid function. The function passed in AL was not in the range Ø-1.

Example:

```
ChMod   equ   43H
        lds   dx,pathname
        mov   dx,attribute
        mov   al,function
        mov   ah,43H
        int   21H
```

Ioctl

I/O Control for Devices

Function Call 44H

Gets or sets device information associated with an open handle, or sends or receives a control string to a device handle or device.

The following values are allowed for the function code passed in AL:

Ø	— Get device information (returned in DX).
1	— Set device information (as determined by DX).
2	— Read the number of bytes indicated in CX from the device control channel into buffer pointed to by DS:DX. (BX = file handle.)
3	— Write the number of bytes indicated in CX to the device control channel from the buffer pointed to by DS:DX. (BX = file handle.)
4	— Same as 2, but use the drive number in BL.
5	— Same as 3, but use the drive number in BL.
6	— Get input status.
7	— Get output status.

You can use this system call to get information about device channels. In addition, you can make calls on regular files using function values Ø, 6, and 7; other function values return an "Invalid function" error.

Calls AL = Ø and AL = 1:

The bits of DX are defined as follows. Note that the upper byte must be zero on a set call (A = 1).

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Res	CTRL	Reserved						ISDEV	EOF	RAW	SPECL	ISCLK	ISNUL	ISCOT	ISCIN

ISDEV	= 1 if this channel is a device.
	= Ø if this channel is a disk file (bits 8-15 = Ø in this case)
If ISDEV	= 1:
EOF	= Ø if end of file on input.
RAW	= 1 if this device is in Raw mode (literal mode with no interpretation given to characters).
	= Ø if this device is cooked (normal mode where the device interprets the characters).
SPECL	= 1 if this device is special.
ISCLK	= 1 if this device is the clock device.
ISNUL	= 1 if this device is the null device.
ISCOT	= 1 if this device is the console output.
ISCIN	= 1 if this device is the console input.
CTRL	= Ø if this device cannot process control strings via calls AL = 2 and AL = 3.
CTRL	= 1 if this device can process control strings via calls AL = 2 and AL = 3. Note that the CTRL bit cannot be set by the Ioctl system call.
If ISDEV	= Ø:
EOF	= Ø if channel has been written.
	Bits Ø-5 are the block device number for the channel (Ø = A, 1 = B, etc.).

Bits 4, 8-13, and 15 are reserved and should not be altered.

Calls AL = 2, AL = 3, AL = 4, and AL = 5:

These four calls allow arbitrary control strings to be sent or received from a device. The call syntax is the same as for the read and write calls, except for calls AL = 4 and AL = 5 which pass a drive number in BL instead of a handle in BX.

An "Invalid function" error is returned if the CTRL bit is zero. An "Access denied" error is returned by calls AL = 4 and AL = 5 if the drive number is invalid.

Calls AL = 6 and AL = 7:

These calls allow you to check to see if a file handle is ready for input or output. Checking the status of handles open to a device is the intended use of these calls. Checking the status of a handle open to a disk file is also allowed, and is defined as follows:

Input:	Always ready (AL = FFH) until end of file is reached, then always not ready (AL = ØØH) unless the current position is changed via the Move a File Pointer function call (42H).
Output:	Always ready (even if disk is full).

NOTE: The status is defined at the time the system is called. In future versions of MS-DOS, by the time control is returned to the user from the system, the status returned may not correctly reflect the true current state of the device or file.

Entry Conditions:

AH = 44H
BX = *handle*
BL = *drive (Ø = default, 1 = A, etc.)* (for calls AL = 4, 5)
DS:DX = *pointer to data or buffer*
CX = number of bytes to read or write
AL = function code (Ø-7; see below)

Exit Conditions:

Carry set:
    AX = *error code*
Carry not set:
    For calls AL = 2, 3, 4, 5:
        AX = *number of bytes transferred*
    For calls AL = 6,7:
        AX = ØØH (not ready)
            or
        AX = FFH (ready)

Error Returns:

AX = 6
    Invalid handle. The handle passed in BX is not currently open.
AX = 1
    Invalid function. The function passed in AL was not in the range Ø-7.
AX = 13
    Invalid data.

AX = 5
    Access denied (for calls AL = 4, 5, 6, 7).

Example:

```
Ioctl          equ   44H
               mov   bx, handle
           (or mov   bl, drive           for calls AL = 4,5)
               mov   dx, data
           (or lds   dx, buffer          and
               mov   dx, count           for calls AL = 2,
                                         3, 4, 5)
               mov   al, function
               mov   ah, Ioctl
               int   21H
```

Dup

Duplicate a File Handle

Function Call 45H

Takes an already opened file handle and returns a new handle that refers to the same file at the same position.

Entry Conditions:

AH = 45H
BX = *file handle to duplicate*

Exit Conditions:

Carry set:
  AX = *error code*
Carry not set:
  AX = *new file handle*

Error Returns:

AX = 6
  Invalid handle. The handle passed in BX is not currently open.

AX = 4
  Too many open files. There were no free handles available in the current process or the internal system tables were full.

Example:

```
Dup     equ   45H
        mov   bx, handle
        mov   ah, Dup
        int   21H
```

Dup2

Force a Duplicate of a File Handle

Function Call 46H

Takes an already opened file handle and returns a new handle that refers to the same file at the same position. If there was already a file open on the handle specified in CX, it is closed first.

Entry Conditions:

AH = 46H
BX = *existing file handle*
CX = *new file handle*

Exit Conditions:

Carry set:
    AX = *error code*
Carry not set:
    No error.

Error Returns:

AX = 6
    Invalid handle. The handle passed in BX is not currently open.
AX = 4
    Too many open files. There were no free handles available in the current process or the internal system tables were full.

Example:

```
Dup2    equ     46H
        mov     bx, handle
        mov     cx, newhandle
        mov     ah, Dup2
        int     21H
```

CurrentDir

Return Text of Current Directory

Function Call 47H

Returns the current directory for a particular drive. The directory is root-relative and does not contain the drive specifier or leading path separator.

Entry Conditions:

AH = 47H
DS:SI = *pointer to 64-byte memory area to receive directory*
DL = *drive (Ø=default, 1=A, 2=B, etc.)*

Exit Conditions:

Carry set:
  AX = *error code*
Carry not set:
  DS:DI = *pointer to 64-byte area containing directory*

Error Returns:

AX = 15
  Invalid drive. The drive specified in DL was invalid.

Example:

```
CurrentDir  equ    47H
            lds    si, area
            mov    dl, drive
            mov    ah, CurrentDir
            int    21H
```

Alloc

Allocate Memory

Function Call 48H

Returns a pointer to a free block of memory that has the requested size in paragraphs.

Entry Conditions:

AH = 48H
BX = *size of memory to be allocated, in paragraphs*

Exit Conditions:

Carry set:
BX = *maximum size that could be allocated, in paragraphs (if the requested size was not available)*

Carry not set:
AX:∅ = *pointer to the allocated memory*

Error Returns:

AX = 8
Not enough memory. The largest available free block is smaller than that requested or there is no free block.

AX = 7
Arena trashed. The internal consistency of the memory arena has been destroyed. This is due to a user program changing memory that does not belong to it.

Example:

```
Alloc     equ    48H
          mov    bx, size
          mov    ah, Alloc
          int    21H
```

Dealloc

Free Allocated Memory

Function Call 49H

Returns to the system pool a piece of memory that was allocated by the Allocate Memory function call (48H).

Entry Conditions:

AH = 49H
ES = *segment address of memory area to be freed*

Exit Conditions:

Carry set:
  AX = *error code*
Carry not set:
  No error.

Error Returns:

AX = 9
  Invalid block. The block passed in ES is not one allocated via the Allocate Memory function call (48H).

AX = 7
  Arena trashed. The internal consistency of the memory arena has been destroyed. This is due to a user program changing memory that does not belong to it.

Example:

```
Dealloc     equ    49H
            mov     es, block
            mov     ah, Dealloc
            int     21H
```

SetBlock

Modify Allocated Memory Blocks

Function Call 4AH

Attempts to "grow" or "shrink" an allocated block of memory.

Entry Conditions:

AH = 4AH
ES = *segment address of memory area*
BX = *requested memory area size, in paragraphs*

Exit Conditions:

Carry set:
 BX = *maximum size possible, in paragraphs (if the requested size was not available on a grow request)*
Carry not set:
 No error.

Error Returns:

AX = 9
 Invalid block. The block specified in ES is not one allocated via this call.
AX = 7
 Arena trashed. The internal consistency of the memory arena has been destroyed. This is due to a user program changing memory that does not belong to it.
AX = 8
 Not enough memory. There was not enough free memory after the specified block to satisfy the grow request.

Example:

```
SetBlock    equ    4AH
            mov    es, block
            mov    bx, newsize
            mov    ah, SetBlock
            int    21H
```

Load and Execute a Program Function Call 4BH

Allows a program to load another program into memory and optionally begin execution of it.

A function code is passed in AL:

0	-	Load and execute the program. A Program Segment Prefix is established for the program and the terminate and CONTROL-C addresses are set to the instruction after the Exec function call.
3	-	Load the program, do not create the program segment prefix, and do not begin execution. This is useful in loading program overlays.

For each value of AL, the parameter block pointed to by ES:BX has the following format:

AL = 0 Load and execute program

WORD segment address of environment string
DWORD pointer to command line to be placed at PSP + 80H
DWORD pointer to default FCB to be passed at PSP + 5CH
DWORD pointer to default FCB to be passed at PSP + 6CH

AL = 3 Load overlay

WORD segment address where file will be loaded
WORD relocation factor to be applied to the image

For function AL = Ø, there must be enough free memory for MS-DOS to load the program. For function AL = 3, it is assumed that the program doing the loading will load the overlay into its own memory space, so no free memory is needed.

Note that all open files of a process are duplicated in the child process after an Exec call. This is extremely powerful; the parent process has control over the meanings of stdin, stdout, stderr, stdaux, and stdprn. The parent could, for example, write a series of records to a file, open the file as standard input, open a listing file as standard output, and then Exec a sort program that takes its input from stdin and writes to stdout.

Also inherited (or passed from the parent) is an "environment." This is a block of text strings (less than 32K bytes total) that convey various configuration parameters. The format of the environment is as follows:

(paragraph boundary)

BYTE ASCIIZ string 1
BYTE ASCIIZ string 2
...
BYTE ASCIIZ string n
BYTE of zero

Typically the environment strings have the form:

parameter = value

For example, COMMAND.COM might pass its execution search path as:

PATH = A: BIN;B: BASIC LIB

A zero value of the environment address causes the child process to inherit a copy of the parent's environment unchanged.

Entry Conditions:

AH = 4BH
DS:DX = *pointer to ASCIIZ pathname*
ES:BX = *pointer to parameter block*
AL = *function code*
  ØØH = load and execute program
  Ø3H = load program

Exit Conditions:

Carry set:
  AX = *error code*
Carry not set:
  No error.

Error Returns:

AX = 1
  Invalid function. The function passed in AL was not Ø, 1, or 3.
AX = 1Ø
  Bad environment. The environment was larger than 32K bytes.
AX = 11
  Bad format. The file pointed to by DS:DX was an EXE format file and contained information that was internally inconsistent.
AX = 8
  Not enough memory. There was not enough memory for the process to be created.
AX = 2
  File not found. The path specified was invalid or not found.

Example:

```
Exec        equ    4BH
            lds    dx, pathname
            les    bx, block
            mov    al, function
            mov    ah, Exec
            int    21H
```

Exit

Terminate a Process

Function Call 4CH

Terminates the current process and transfers control to the invoking process. In addition, a return code may be sent. All files open at the time are closed.

This method is preferred over all others (Interrupt 20H, JMP 0).

Entry Conditions:

AH = 4CH
AL = *return code*

Error Returns:

None.

Example:

```
Exec     equu   4CH
         mov    al, code
         mov    ah, Exit
         int    21H
```

Wait

Retrieve the Return Code of a Child

Function Call 4DH

Returns the Exit code specified by a child process. It returns this Exit code only once. The low byte of this code is that sent by the Keep Process function call (31H). The high byte indicates the circumstances that caused the child to terminate, and is one of the following:

0	-	Terminate/abort
1	-	CONTROL-C
2	-	Hard error
3	-	Terminate and stay resident

Entry Conditions:

AH = 4DH

Exit Conditions:

AH = *exit code*

Error Returns:

None.

Example:

```
Wait        equ     4DH
            mov     ah, Wait
            int     21H
```

FindFirst

Find Matching File Function Call 4EH

Takes a pathname with wild-card characters in the filename portion and a set of attributes and attempts to find a file that matches the pathname and has a subset of the required attributes. If one is found, a data block at the current Disk Transfer Address is written. The block contains information in the following form:

21 bytes	- Reserved for MS-DOS use on subsequent FindNext function calls (4FH)
1 byte	- Attribute found
2 bytes	- Time of file
2 bytes	- Date of file
2 bytes	- Least significant word of file size
2 bytes	- Most significant word of file size
13 bytes	- Packed filename and extension

To obtain the subsequent matches of the pathname, see the description of the FindNext function call (4FH).

Entry Conditions:

AH = 4EH
DS:DX = *pointer to ASCIIZ pathname*
CX = *search attributes*

Exit Conditions:

Carry set:
    AX = *error code*
Carry not set:
    No error.

Error Returns:

AX = 2
    File not found. The path specified in DS:DX was an invalid path.
AX = 18
    No more files. There were no files matching this specification.

Example:

```
FindFirst   equu  4EH
            lds   dx, pathname
            mov   cx, attribute
            mov   ah, FindFirst
            int   21H
```

FindNext

Find Next Matching File Function Call 4FH

Finds the next matching entry in a directory. The current Disk Transfer Address must contain the block returned by the FindFirst function call (4EH).

Entry Conditions:

AH = 4FH

Exit Conditions:

Carry set:
  AX = *error code*
Carry not set:
  No error.

Error Returns:

AX = 18
  No more files. There are no more files matching this pattern.

Example:

```
FindNext    equ    4FH
                   ;DTA contains block returned by
                   ;FindFirst
            mov    ah, FindNext
            int    21H
```

GetVerifyFlag

Return Current Setting of Verify

Function Call 54H

Returns the current setting of the verify flag.

Entry Conditions:

AH = 54H

Exit Conditions:

AL = *current verify flag value*

ØØH	=	off
Ø1H	=	on

Error Returns:

None.

Example:

```
GetVerifyFlag     equ    54H
                  mov    ah, GetVerifyFlag
                  int    21H
```

Rename

Move a Directory Entry

Function Call 56H

Renames a file and/or moves it to another directory. This is done by giving the file a new filename, path, or both. The drive for both paths must be the same.

Entry Conditions:

AH = 56H
DS:DX = *pointer to ASCIIZ pathname of existing file*
ES:DI = *pointer to new ASCIIZ pathname*

Exit Conditions:

Carry set:
  AX = *error code*
Carry not set:
  No error.

Error Returns:

AX = 2
  File not found. The filename specified by DS:DX was not found.
AX = 17
  Not same device. The source and destination are on different drives.
AX = 5
  Access denied. The path specified in DS:DX was a directory, the file specified by ES:DI already exists, or the destination directory entry could not be created.

Example:

```
Rename   equu   56H
         lds    dx, source
         les    di, destination
         mov    ah, Rename
         int    21H
```

Get or Set a File's Date and Time

Function Call 57H

Returns or sets the date and time of last write for a file handle. The date and time are not recorded until the file is closed.

Entry Conditions:

AH = 57H
AL = *function code*
  ØØH = get date and time
  Ø1H = set date and time
BX = *file handle*
CX = *time to be set (if AL = Ø1H)*
DX = *date to be set (if AL = Ø1H)*

Exit Conditions:

Carry set:
  AX = *error code*
Carry not set:
  If AL = ØØH on entry:
    CX = *time of last write*
    DX = *date of last write*

Error Returns:

AX = 1
  Invalid function. The function passed in AL was not Ø or 1.
AX = 6
  Invalid handle. The handle passed in BX was not currently open.

Example:

```
FileTimes   equ    57H
            mov    al, function
            mov    bx, handle
                   ;if al = 1 then the next two are
                   ;mandatory
            mov    cx, time
            mov    dx, date
            mov    ah, FileTimes
            int    21H
```

Macro Definitions for MS-DOS System Call Examples

Interrupts

```
terminate macro                                 ;PROGRAM_TERMINATE
   int          20H                             ;interrupt 20H
   endm

                                                ;ABS_DISK_READ
abs_disk_read macro disk,buffer,num_sectors,first_sector
   mov          al,diskmov                      bx,offset buffer
   mov          cx,num_sectors
   mov          dx,first_sector
   int          25H                             ;interrupt 25H
   popf
   endm

                                                ;ABS_DISK_WRITE
abs_disk_write macro disk,buffer,num_sectors,first_sector
   mov          al,disk
   mov          bx,offset buffer
   mov          cx,num_sectors
   mov          dx,first_sector
   int          26H                             ;interrupt 26H
   popf
   endm

stay_resident macro last_instruc                ;STAY_RESIDENT
   mov          dx,offset last_instruc
   inc          dx
   int          27H                             ;interrupt 27H
   endm
```

Functions

```
terminate_program macro                         ;TERMINATE PROGRAM
   xor          ah,ah                           ;function 00H
   int          21H
   endm

read_kbd_and_echo macro                         ;READ_KBD_AND_ECHO
   mov          ah,1                            ;function 01H
   int          21H
   endm
```

```
display_char macro character           ;DISPLAY_CHAR
    mov         dl,character
    mov         ah,2                   ;function 02H
    int         21H
    endm

aux_input macro                        ;AUX_INPUT
    mov         ah,3                   ;function 03H
    int         21H
    endm

aux_output macro                       ;AUX_OUTPUT
    mov         dl,character
    mov         ah,4                   ;function 04H
    int         21H
    endm

print_char macro character             ;PRINT_CHAR
    mov         dl,character
    mov         ah,5                   ;function 05H
    int         21H
    endm

dir_console_io macro switch            ;DIR_CONSOLE_IO
    mov         dl,switch
    mov         ah,6                   ;function 06H
    int         21H
    endm

dir_console_input macro                ;DIR_CONSOLE_INPUT
    mov         ah,7                   ;function 07H
    int         21H
    endm

read_kbd macro                         ;READ_KBD
    mov         ah,8                   ;function 08H
    int         21H
    endm

display macro string                   ;DISPLAY
    mov         dx,offset string
    mov         ah,9                   ;function 09H
    int         21H
    endm
```

```
get_string macro limit,string           ;GET_STRING
    mov         dx,offset string
    mov         string,limit
    mov         ah,0AH                  ;function 0AH
    int         21H
    endm

check_kbd_status macro                  ;CHECK_KBD_STATUS
    mov         ah,0BH                  ;function 0BH
    int         21H
    endm

flush_and_read_kbd macro switch         ;FLUSH_AND_READ_KBD
    mov         al,switch
    mov         ah,0CH                  ;function 0CH
    int         21H
    endm

reset_disk macro disk                   ;RESET DISK
    mov         ah,0DH                  ;function 0DH
    int         21H
    endm

select_disk macro disk                  ;SELECT_DISK
    mov         dl,disk[-65]
    mov         ah,0EH                  ;function 0EH
    int         21H
    endm

open macro fcb                          ;OPEN
    mov         dx,offset fcb
    mov         ah,0FH                  ;function 0FH
    int         21H
    endm

close macro fcb                         ;CLOSE
    mov         dx,offset fcb
    mov         ah,10H                  ;function 10H
    int         21H
    endm

search_first macro fcb                  ;SEARCH_FIRST
    mov         dx,offset fcb
    mov         ah,11H                  ;Function 11H
    int         21H
    endm
```

```
search_next macro fcb                    ;SEARCH_NEXT
    mov         dx,offset fcb
    mov         ah,12H                   ;function 12H
    int         21H
    endm

delete macro fcb                         ;DELETE
    mov         dx,offset fcb
    mov         ah,13H                   ;function 13H
    int         21H
    endm

read_seq macro fcb                       ;READ_SEQ
    mov         dx,offset fcb
    mov         ah,14H                   ;function 14H
    int         21H
    endm

write_seq macro fcb                      ;WRITE_SEQ
    mov         dx,offset fcb
    mov         ah,15H                   ;function 15H
    int         21H
    endm

create macro fcb                         ;CREATE
    mov         dx,offset fcb
    mov         ah,16H                   ;function 16H
    int         21H
    endm

rename macro fcb,newname                 ;RENAME
    mov         dx,offset fcb
    mov         ah,17H                   ;function 17H
    int         21H
    endm

current_disk macro                       ;CURRENT_DISK
    mov         ah,19H                   ;function 19H
    int         21H
    endm

set_dta macro buffer                     ;SET_DTA
    mov         dx,offset buffer
    mov         ah,1AH                   ;function 1AH
    int         21H
    endm
```

```
read__ran macro fcb                         ;READ__RAN
   mov          dx,offset fcb
   mov          ah,21H                      ;function 21H
   int          21H
   endm

write__ran macro fcb                        ;WRITE__RAN
   mov          dx,offset fcb
   mov          ah,22H                      ;function 22H
   int          21H
   endm

file__size macro fcb                        ;FILE__SIZE
   mov          dx,offset fcb
   mov          ah,23H                      ;function 23H
   int          21H
   endm

set__relative__record macro fcb             ;SET__RELATIVE__RECORD
   mov          dx,offset fcb
   mov          ah,24H                      ;function 24H
   int          21H
   endm

set__vector  macro  interrupt,seg__addr,off__addr  ;SET__VECTOR
   push         ds
   mov          ax,seg__addr
   mov          ds,ax
   mov          dx,off__addr
   mov          al,interrupt
   mov          ah,25H                      ;function 25H
   int          21H
   pop          ds
   endm

ran__block__read macro fcb,count,rec__size   ;RAN__BLOCK__READ
   mov          dx,offset fcb
   mov          cx,count
   mov          word ptr fcb[0EH],rec__size
   mov          ah,27H                      ;function 27H
   int          21H
   endm
```

```
ran_block_write macro fcb,count,rec_size   ;RAN_BLOCK_WRITE
    mov         dx,offset fcb
    mov         cx,count
    mov         word ptr fcb[0EH],rec_size
    mov         ah,28H                     ;function 28H
    int         21H
    endm

parse macro string,fcb                     ;PARSE
    mov         si,offset string
    mov         di,offset fcb
    push        es
    push        ds
    pop         es
    mov         al,0FH
    mov         ah,29H                     ;function 29H
    int         21H
    pop         es
    endm

get_date macro                             ;GET_DATE
    mov         ah,2AH                     ;function 2AH
    int         21H
    endm

set_date macro    year,month,day           ;SET_DATE
    mov         cx,year
    mov         dh,month
    mov         dl,day
    mov         ah,2BH                     ;function 2BH
    int         21H
    endm

get_time macro                             ;GET_TIME
    mov         ah,2CH                     ;function 2CH
    int         21H
    endm
                                           ;SET_TIME
set_time macro hour,minutes,seconds,hundredths
    mov         ch,hour
    mov         cl,minutes
    mov         dh,seconds
    mov         dl,hundredths
    mov         ah,2DH                     ;function 2DH
    int         21H
    endm
```

```
verify  macro  switch                  ;VERIFY
   mov         al,switch
   mov         ah,2EH                  ;function 2EH
   int         21H
   endm
```

General

```
move_string   macro   source,destination,num_bytes
                                       ;MOVE_STRING
              push        es
              mov         ax,ds
              mov         es,ax
              assume      es:data
              mov         si,offset source
              mov         di,offset destination
              mov         cx,num_bytes
          rep movs        es:destination,source
              assume      es:nothing
              pop         es
              endm


convert       macro       value,base,destination     ;CONVERT
              local       table,start
              jmp         start
table         db          "0123456789ABCDEF"
start:        mov         al,value
              xor         ah,ah
              xor         bx,bx
              div         base
              mov         bl,al
              mov         al,cs:table[bx]
              mov         destination,al
              mov         bl,ah
              mov         al,cs:table[bx]
              mov         destination[1],al
              endm

convert_to_binary   macro   string,number,value
                                       ;CONVERT_TO_BINARY
              local                   ten,start,calc,mult,no_mult
              jmp         start
ten           db          10
```

```
start:          mov         value,0
                xor         cx,cx
                mov         cl,number
                xor         si,si
calc:           xor         ax,ax
                mov         al,string[si]
                sub         al,48
                cmp         cx,2
                jl          no_mult
                push        cx
                dec         cx
mult:           mul         cs:ten
                loop        mult
                pop         cx
no_mult:        add         value,ax
                inc         si
                loop        calc
                endm

convert_date macro          dir_entry ;CONVERT DATE
                mov         dx,word ptr dir_entry[25]
                mov         cl,5
                shr         dl,cl
                mov         dh,dir_entry[25]
                and         dh,1fh
                xor         cx,cx
                mov         cl,dir_entry[26]
                shr         cl,1
                add         cx,1980
                endm
```

Extended Example of MS-DOS System Calls

```
title DISK DUMP
zero                equ   0
disk_B              equ   1
sectors_per_read equu 9
cr                  equ   13
blank               equ   32
period              equ   46
tilde               equ   126
          INCLUDE     B:CALLS.EQU
;
subttl DATA SEGMENT
page +
data            segment
;
input_buffer    db    9 dup(512 dup(?))
output_buffer   db    77 dup(" ")
                db     0DH,0AH,"$"
start_prompt    db    "Start at sector: $"
sectors_prompt  db    "Number of sectors: $"
continue_prompt db    "RETURN to continue $"
header          db    "Relative sector $"
end_string      db     0DH,0AH,0AH,07H,"ALL DONE$"
                      ;DELETE THIS
crlf            db    0DH,0AH,"$"
table           db    "0123456789ABCDEF$"
;
ten             db    10
sixteen         db    16
;
start_sector    dw    1
sector_num      label byte
sector_number   dw    0
sectors_to_dump dw    sectors_per_read
sectors_read    dw    0
;
buffer          label byte
max_length      db    0
current_length  db    0
digits          db    5 dup(?)
;
data            ends
;
subttl STACK SEGMENT
page +
stack           segment      stack
                dw           100 dup(?)
stack_top       label        word
stack           ends
;
subttl MACROS
page +
;
        INCLUDE B:CALLS.MAC
;BLANK LINE
blank_line      macro        number
                local        print_it
                push         cx
                call         clear_line
                mov          cx,number
```

```
print_it:         display       output_buffer
                  loop          print_it
                  pop           cx
                  endm
;
subttl ADDRESSABILITY
page +
code              segment
                  assume        cs:code,ds:data,ss:stack
start:            mov           ax,data
                  mov           ds,ax
                  mov           ax,stack
                  mov           ss,ax
                  mov           sp,offset stack_top
;
                  jmp           main_procedure
subttl PROCEDURES
page +
;
;  PROCEDURES
;  READ_DISK
read_disk         proc;
                  cmp           sectors_to_dump,zero
                  jle           done
                  mov           bx,offset input_buffer
                  mov           dx,start_sector
                  mov           al,disk_b
                  mov           cx,sectors_per_read
                  cmp           cx,sectors_to_dump
                  jle           get_sector
                  mov           cx,sectors_to_dump
 get_sector:      push          cx
                  int           disk_read
                  popf
                  pop           cx
                  sub           sectors_to_dump,cx
                  add           start_sector,cx
                  mov           sectors_read,cx
                  xor           si,si
 done:            ret
 read_disk        endp
 ;CLEAR_LINE
 clear_line       proc;
                  push          cx
                  mov           cx,77
                  xor           bx,bx
  move_blank:     mov           output_buffer[bx], ' '
```

```
                inc             bx
                loop            move__blank
                pop             cx
                ret
clear__line     endp
;
;PUT__BLANK
put__blank      proc;
                mov             output__buffer[di],“ ”
                inc             di
                ret
put__blank      endp
;
;
setup           proc;
                display          start__prompt
                get__string     4,buffer
                display         crlf
                convert__to__binary digits,
                current__length,start__sector
                mov             ax,start__sector
                mov             sector__number,ax
                display         sectors__prompt
                get__string     4,buffer
                convert__to__binary digits,
                current__length,sectors__to__dump
                ret
setup           endp
;
;CONVERT__LINE
convert__line   proc;
                push            cx
                mov             di,9
                mov             cx,16
convert__it:    convert         input__buffer[si],sixteen,
                                output__buffer[di]
                inc             si
                add             di,2
                call            put__blank
                loop            convert__it
                sub             si,16
                mov             cx,16
                add             di,4
display__ascii: mov             output__buffer[di],period
                cmp             input__buffer[si],blank
                jl              non__printable
                cmp             input__buffer[si],tilde
                jg              non_printable
printable:      mov             dl,input_buffer[si]
                mov             output_buffer[di],dl
non_printable:  inc             si
                inc             di
                loop            display_ascii
                pop             cx
                ret
convert_line    endp
;
;DISPLAY_SCREEN
display_screen  proc;
                push            cx
                call            clear_line

;
                mov             cx,17
;I WANT length header
                dec             cx
;minus 1 in cx
                xor             di,di
move_header:    mov             al,header[di]
                mov             output_buffer[di],al
                inc             di
                loop            move_header   ;FIX THIS!

;
                convert         sector_num[1],sixteen,
                                output_buffer[di]

                add             di,2
                convert         sector_num,sixteen,
                                output_buffer[di]

                display         output_buffer
                blank_line      2
                mov             cx,16
dump_it:        call            clear_line
                call            convert_line
                display         output_buffer
                loop            dump_it
                blank_line      3
                display         continue_prompt
                get_char_no_echo
                display         crlf
                pop             cx
                ret
display_screen  endp
;
;
```

```
;  END PROCEDURES
subttl MAIN PROCEDURE
page +
main__procedure: call           setup
check__done:     cmp            sectors__to__dump,zero
                 jng            all__done
                 call           read__disk
                 mov            cx,sectors__read
display__it:     call           display__screen
                 call           display__screen
                 inc            sector__number
                 loop           display__it
                 jmp            check__done
all__done:       display        end__string
                 get__char__no__echo
code             ends
                 end            start
```

Chapter 2

MS-DOS Control Blocks and Work Areas

File Control Block (FCB)

The Program Segment Prefix includes room for two FCBs at offsets 5CH and 6CH. The system call descriptions refer to unopened and opened FCBs. An unopened FCB is one that contains only a drive specifier and filename, which can contain wild card characters (* and ?). An opened FCB contains all fields filled by the Open File function call (Function 0FH) or the Create File function call (16H).

The user program must set bytes 00H-0FH and 20H-24H. The operating system sets bytes 10H-1FH; they must not be altered by the user program.

The fields of the FCB are as follows:

Offset	**Function**
00H	Drive number. 1 means Drive A, 2 means Drive B, etc. If the FCB is to be used to create or open a file, this field can be set to 0 to specify the default drive; the Open File function call (Function 0FH) sets the field to the number of the default drive.
01H-08H	Filename. Consists of eight characters, left-justified and padded (if necessary) with blanks. If you specify a reserved device name (such as LPT1), do not include the optional colon.
09H-0BH	Filename extension. Consists of three characters, left-justified and padded (if necessary) with blanks. This field can be all blanks (no extension).
0CH-0DH	Current block. This is the number of the block (group of 128 records) that contains the current record. This field and the current record field (offset 20H) are used for sequential reads and writes. This field is set to 0 by the Open File function call.

0EH-0FH Logical record size in bytes. Set to 128 by the Open File function call. If the record size is not 128 bytes, you must set this field after opening the file.

10H-13H File size in bytes. The first word of this field is the low-order part of the size.

14H-15H Date of last write. The date the file was created or last updated. The year, month, and day are mapped into two bytes as follows:

Offset 15H

Y	Y	Y	Y	Y	Y	Y	M
15	14	13	12	11	10	9	8

Offset 14H

M	M	M	D	D	D	D	D
7	6	5	4	3	2	1	0

16H-17H Time of last write. The time the file was created or last updated. The hour, minutes, and seconds are mapped into two bytes as follows:

Offset 17H

H	H	H	H	H	M	M	M
15	14	13	12	11	10	9	8

Offset 16H

M	M	M	S	S	S	S	S
7	6	5	4	3	2	1	0

18H-1FH Reserved for system use.

20H Current record number. This is one of the 128 records (0 - 127) in the current block. This field and the current block field (offset 0CH) are used for sequential reads and writes. This field is not initialized by the Open File function call. You must set it before doing a sequential read or write to the file.

21H-24H Relative record number. This is the number of the currently selected record relative to the beginning of the file (starting with 0). This field is not initialized by the Open File function call. You must set it before doing a random read or write to the file.

If the record size is less than 64 bytes, both words of this field are used. If the record size is 64 bytes or more, only the first three bytes are used. Note that if you use the FCB at offset 5CH of the Program Segment Prefix, the last byte of the relative record field is also the first byte of the unformatted parameter area that starts at offset 8ØH (the default Disk Transfer Address).

Extended File Control Block

The Extended File Control Block is used to create or search for files in the disk directory that have special attributes. It adds the following 7-byte prefix to the FCB:

Byte	**Function**
-7	Flag byte. Contains FFH to indicate that this is an extended FCB.
-6 to -2	Reserved.
-1	Attribute byte. See the section on the disk directory under "MS-DOS Disk Allocation" for the meaning of this byte.

If an extended FCB is referenced by a function call, the register containing the reference should point to the first byte of the prefix.

Memory Map

The memory map addresses given below are in segment:offset format. For example, 0090:0000 is absolute address 0900H.

User memory is allocated from the lowest end of available memory that will meet the allocation request.

0000:0000	Interrupt vector table
XXXX:0000	IO.SYS - MS-DOS interface to hardware
XXXX:0000	MSDOS.SYS - MS-DOS interrupt handlers, service routines (Interrupt 21H functions)
	MS-DOS buffers, control areas, and installed device drivers
XXXX:0000	Resident part of COMMAND.COM - Interrupt handlers for Interrupts 22H (Terminate Address), 23H (CONTROL-C Exit Address), 24H (Fatal Error Abort Address), and code to reload the transient portion
XXXX:0000	External command or utility (.COM or .EXE file)
XXXX:0000	User stack for .COM files (256 bytes)
XXXX:0000	Transient part of COMMAND.COM - Command interpreter, internal commands, batch processor

Program Segment

When you enter an external command or execute a program through the EXEC function call, MS-DOS determines the lowest available free memory address to use as the start of the program. This area is called the Program Segment.

At offset Ø within the Program Segment, MS-DOS builds the 256-byte Program Segment Prefix control block. At offset 2ØØH, EXEC loads the program. An .EXE file with minalloc and maxalloc both set to zero is loaded as high as possible.

The program returns from EXEC by one of four methods:

- By a long jump to offset Ø in the Program Segment Prefix.
- By issuing an INT 2ØH with CS:Ø pointing at the PSP
- By issuing an INT 21H with AH =Ø and with CS:Ø pointing at the PSP, or with AH = 4CH
- By a long call to location 5ØH in the Program Segment Prefix with AH = Ø or 4CH

It is the responsibility of all programs to ensure that the CS register contains the segment address of the Program Segment Prefix when terminating via any of these methods except function call 4CH. For this reason, using function call 4CH is the preferred method.

All four methods result in transferring control to the program that issued the EXEC. During this returning process, interrupt vectors 22H, 23H, and 24H (Terminate Address, CONTROL-C Exit Address, and Fatal Error Abort Address) are restored from the values saved in the Program Segment Prefix of the terminating program. Control is then given to the terminate address. If this is a program returning to COMMAND.COM, control transfers to its resident portion. If a batch file was in process, it is continued. Otherwise, COMMAND.COM performs a checksum on the transient portion, reloads it if necessary, issues the system prompt, and waits for you to type the next command.

When a program receives control, the following conditions are in effect:

For all programs:

- The segment address of the passed environment is contained at offset 2CH in the Program Segment Prefix.

  The environment is a series of ASCII strings (totaling less than 32K) in the form:

  NAME =*parameter*

  Each string is terminated by a byte of zeroes, and the set of strings is terminated by another byte of zeroes. The environment built by the command processor contains at least a COMSPEC= string. (The parameters on COMSPEC define the path used by MS-DOS to locate COMMAND.COM on disk.) The last PATH and PROMPT commands issued will also be in the environment, along with any environment strings defined with the MS-DOS SET command.

  The environment that is passed is a copy of the invoking process environment. If your application uses a "keep process" concept, you should be aware that the copy of the environment passed to you is static. That is, it will not change even if subsequent SET, PATH, or PROMPT commands are issued.

- Offset 50H in the Program Segment Prefix contains code to call the MS-DOS function dispatcher. By placing the desired function call number in AH, a program can issue a far call to offset 50H to invoke an MS-DOS function, rather than issuing an Interrupt 21H. Since this is a call and not an interrupt, MS-DOS may place any code appropriate to making a system call at this position. This makes the process of calling the system portable.

- The Disk Transfer Address (DTA) is set to 80H (the default DTA in the Program Segment Prefix).

- File control blocks at 5CH and 6CH are formatted from the first two parameters typed when the command was entered. If either parameter contained a pathname, then the corresponding FCB contains only a valid drive number. The filename field will not be valid.

- An unformatted parameter area at 81H contains all the characters typed after the command (including leading and imbedded delimiters), with the byte at 8ØH set to the number of characters. If the <, >, or parameters were typed on the command line, they (and the filenames associated with them) will not appear in this area; redirection of standard input and output is transparent to applications.

- Offset 6 (one word) contains the number of bytes available in the segment.

- Register AX indicates whether or not the drive specifiers (entered with the first two parameters) are valid, as follows:

  AL = FFH if the first parameter contained an invalid drive specifier (otherwise, AL = ØØH).

  AH = FFH if the second parameter contained an invalid drive specifier (otherwise, AH = ØØH).

- Offset 2 (one word) contains the segment address of the first byte of unavailable memory. Programs must not modify addresses beyond this point unless they were obtained by allocating memory via the Allocate Memory function call (48H).

For executable (.EXE) programs:

- Registers DS and ES are set to point to the Program Segment Prefix.

- Registers CS, IP, SS, and SP are set to the values passed by MS-LINK.

For executable (.COM) programs:

- All four segment registers contain the segment address of the initial allocation block that starts with the Program Segment Prefix control block.

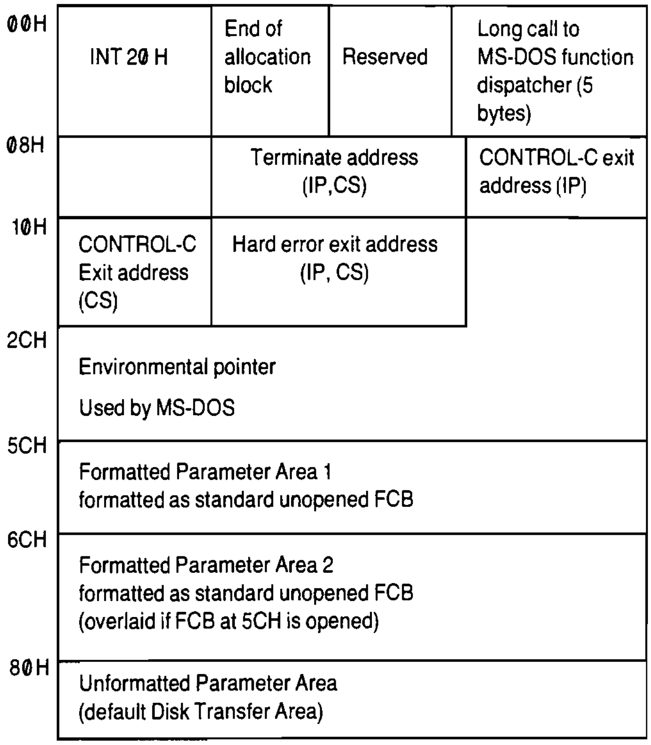
- All of user memory is allocated to the program. If the program invokes another program through the EXEC function call (4BH), it must first free some memory through the Set Block function call (4AH) to provide space for the program being executed.

- The Instruction Pointer (IP) is set to 1ØØH.

- The Stack Pointer register is set to the end of the program's segment. The segment size at offset 6 is reduced by 100H to allow for a stack of that size.
- A word of zeroes is placed on top of the stack. This is to allow a user program to exit to COMMAND.COM by doing a RET instruction last. This assumes, however, that the user has maintained stack and code segments for the program.

Program Segment Prefix

The format of the Program Segment Prefix is illustrated below. Programs must not alter any part of the PSP below offset 5CH.


00H
INT 20 H
End of allocation block
Reserved
Long call to MS-DOS function dispatcher (5 bytes)
08H
Terminate address (IP,CS)
CONTROL-C exit address (IP)
10H
CONTROL-C Exit address (CS)
Hard error exit address (IP, CS)
2CH
Environmental pointer
Used by MS-DOS
5CH
Formatted Parameter Area 1 formatted as standard unopened FCB
6CH
Formatted Parameter Area 2 formatted as standard unopened FCB (overlaid if FCB at 5CH is opened)
80H
Unformatted Parameter Area (default Disk Transfer Area)

Chapter 3

MS-DOS Initialization and Command Processor

MS-DOS Initialization

When the system is reset or started with an MS-DOS disk in Drive A, the ROM (Read Only Memory) bootstrap gains control. The boot sector is read from the disk into memory and given control. The IO.SYS and MSDOS.SYS files are then read into memory, and the boot process begins.

The Command Processor

The command processor supplied with MS-DOS (file COMMAND.COM) consists of three parts:

1. A resident portion resides in memory immediately following MSDOS.SYS and its data area. This portion contains routines to process Interrupts 23H (CONTROL-C Exit Address) and 24H (Fatal Error Abort Address), as well as a routine to reload the transient portion, if needed. All standard MS-DOS error handling is done within this portion of COMMAND.COM. This includes displaying error messages and processing the Abort, Retry, or Ignore message replies.

2. An initialization portion follows the resident portion. During start-up, the initialization portion is given control. It contains the AUTOEXEC file processor setup routine. The initialization portion determines the segment address at which programs can be loaded. It is overlaid by the first program COMMAND.COM loads because it is no longer needed.

3. A transient portion is loaded at the high end of memory. This part contains all of the internal command processors and the batch file processor. The transient part of the command processor produces the system prompt (such as A>), reads the command from the keyboard (or batch file), and causes the command to be executed. For external commands, it builds a command line and issues the EXEC function call (function call 4BH) to load and transfer control to the program.

Chapter 4

MS-DOS Disk Allocation

The MS-DOS area on a diskette is formatted as follows:

Reserved area - variable size
First copy of File Allocation Table - variable size
Second copy of File Allocation Table - variable size (optional)
Additional copies of File Allocation Table - variable size (optional)
Root directory - variable size
File data area

Space for a file in the data area is not pre-allocated. The space is allocated one cluster at a time, as needed. A cluster consists of one or more consecutive sectors. All of the clusters for a file are "chained" together in the File Allocation Table (FAT).

A second copy of the FAT is usually kept for consistency. If the disk should develop a bad sector in the first FAT, the second can be used. This prevents loss of data due to an unusable disk.

The clusters are arranged on disk to minimize head movement for multi-sided media. All of the space on a track (or cylinder) is allocated before moving on to the next track. This is done by allocating all the sectors sequentially on the lowest-numbered head, then all the sectors on the next head, and so on until all sectors on all heads of the track are used. The next sector to use will be sector 1 on head 0 of the next track.

For diskettes, the following table can be used:

Number of Sides	Sectors per Track	FAT size in Sectors	Directory Sectors	Directory Entries	Sectors per Cluster
1	8	1	4	64	1
2	8	1	7	112	2
1	9	2	4	64	1
2	9	2	7	112	2

MS-DOS Disk Directory

FORMAT builds the root directory for all disks. Its location on disk and the maximum number of entries are dependent on the media.

Since directories other than the root directory are regarded as files by MS-DOS, there is no limit to the number of entries they may contain.

All directory entries are 32 bytes in length, and are in the following format:

00H-07H Filename. Eight characters, left-aligned and padded, if necessary, with blanks. The first byte of this field indicates the file status as follows:

00H The directory entry has never been used. This is used to limit the length of directory searches, for performance reasons.

E5H The directory entry has been used, but the file has been erased.

2EH The entry is for a directory. If the second byte is also 2EH, then the cluster field contains the cluster number of this directory's parent directory (0000H if the parent directory is the root directory). Otherwise, bytes 01H through 0AH are all spaces, and the cluster field contains the cluster number of this directory.

Any other character is the first character of a filename.

08H-0AH Filename extension.

0B File attribute. The attribute byte is mapped as follows:

- 01H File is marked read only. An attempt to open the file for writing using the Open File function call (function call 3DH) results in an error code returned. This value can be used along with other values below. Attempts to delete the file with the Delete File (13H) or Delete a Directory Entry (41H) function call will also fail.
- 02H Hidden file. The file is excluded from normal directory searches.
- 04H System file. The file is excluded from normal directory searches.
- 08H The entry contains the volume label in the first 11 bytes. The entry contains no other usable information (except date and time of creation) and may exist only in the root directory.
- 10H The entry defines a sub-directory, and is excluded from normal directory searches.
- 20H Archive bit. The bit is set to 1 whenever the file has been written to and closed.

  Note: The system files (IO.SYS and MSDOS.SYS) are marked as read only, hidden, and system files. Files can be marked hidden when they are created. Also, the read only, hidden, system, and archive attributes may be changed through the Change Attributes function call (43H).

0CH-15H Reserved.

16H-17H Time the file was created or last updated. The hour, minutes, and seconds are mapped into two bytes as follows:

Offset 17H

H	H	H	H	H	M	M	M
7	6	5	4	3	2	1	0

```
Offset 16H
| M | M | M | S | S | S | S | S |
  7   6   5   4   3   2   1   Ø
```

where:

HHHHH is the binary number of hours (Ø-23)
MMMMMM is the binary number of minutes (Ø-59)
SSSSS is the binary number of two-second increments

18H-19H Date the file was created or last updated. The year, month, and day are mapped into two bytes as follows:

```
Offset 19H
| Y | Y | Y | Y | Y | Y | Y | M |
  7   6   5   4   3   2   1   Ø

Offset 18H
| M | M | M | D | D | D | D | D |
  7   6   5   4   3   2   1   Ø
```

where:

YYYYYYY is Ø-119 (198Ø-2Ø99)
MMMM is 1-12
DDDDD is 1-31

1AH-1BH Starting cluster; the cluster number of the first cluster in the file.

Note that the first cluster for data space on all disks is cluster ØØ2.

The cluster number is stored with the least significant byte first.

Note: Refer to the section "How to Use the File Allocation Table" for details about converting cluster numbers to logical sector numbers.

1CH-1FH File size in bytes. The first word is the low-order part of the size.

File Allocation Table (FAT)

This section is included for system programmers who wish to write installable device drivers. It explains how MS-DOS uses the File Allocation Table to convert the cluster numbers of a file to logical sector numbers. The driver is then responsible for locating the logical sector on disk. Programs must use the MS-DOS file management function calls for accessing files. Programs that access the FAT are not guaranteed to be upwardly compatible with future releases of MS-DOS.

The File Allocation Table contains a 12-bit entry (1.5 bytes) for each cluster on the disk. The first two FAT entries map a portion of the directory; these FAT entries indicate the size and format of the disk.

The second and third bytes always contain FFH.

The third FAT entry, which starts at offset Ø4H, begins the mapping of the data area (cluster ØØ2). Files in the data area are not always written sequentially on the disk. The data area is allocated one cluster at a time, skipping over clusters already allocated. The first free cluster found will be the next cluster allocated, regardless of its physical location on the disk. This permits the most efficient utilization of disk space because clusters made available by the erasing of files can be allocated for new files.

Each FAT entry contains three hexadecimal characters. Any of the following combinations is possible:

ØØØ	The cluster is unused and available.
FF7	The cluster has a bad sector in it. MS-DOS will not allocate such a cluster. CHKDSK counts the number of bad clusters for its report. These bad clusters are not part of any allocation chain.
FF8-FFF	Indicates the last cluster of a file.
XXX	Any other characters that are the cluster number of the next cluster in the file. The cluster number of the first cluster in the file is kept in the file's directory entry.

The File Allocation Table always begins on the first sector after the reserved sectors. If the FAT is larger than one sector, the sectors are contiguous. Two copies of the FAT are usually written for data integrity. The FAT is read into one of the MS-DOS buffers whenever needed (open, read, write, etc.). For performance reasons, this buffer is given a high priority to keep it in memory as long as possible.

How to Use the File Allocation Table

To find the starting cluster of the file, use the directory entry. Next, to locate each subsequent cluster of the file:

1. Multiply the cluster number just used by 1.5 (each FAT entry is 1.5 bytes long).
2. The whole part of the product is an offset into the FAT, pointing to the entry that maps the cluster just used. That entry contains the cluster number of the next cluster of the file.
3. Use a MOV instruction to move the word at the calculated FAT offset into a register.
4. If the last cluster used was an even number, keep the low-order 12 bits of the register by ANDing it with FFF; otherwise, keep the high-order 12 bits by shifting the register right 4 bits with a SHR instruction.
5. If the resultant 12 bits are FF8H-FFFH, the file contains no more clusters. Otherwise, the 12 bits contain the cluster number of the next cluster in the file.

To convert the cluster number to a logical sector number (relative sector, such as that used by Interrupts 25H and 26H and by DEBUG):

1. Subtract 2 from the cluster number.
2. Multiply the result by the number of sectors per cluster.
3. Add to this result the logical sector number of the beginning of the data area.

Chapter 5

Device Drivers

A device driver is a binary file with all of the code in it to manipulate the hardware and provide a consistent interface to MS-DOS. It has a special header at the beginning that identifies it as a device, defines the strategy and interrupt entry points, and describes various attributes of the device.

Note: For device drivers, the .COM file must not use the ORG 1ØØH. Because it does not use the Program Segment Prefix, the device driver is simply loaded; therefore, the file must have an origin of zero (ORG Ø or no ORG statement).

Types of Devices

There are two kinds of devices:

- Character devices
- Block devices

Character devices are designed to perform serial character I/O. These devices have names, such as CON, AUX, and CLOCK, and you can open channels (handles or FCBs) to do I/O to them.

Block devices are the "disk drives" on the system. They can perform random I/O in pieces called blocks (usually the physical sector size). These devices are not named as the character devices are, and therefore cannot be opened directly. They are identified instead via the drive letters (A, B, C, etc.).

Block devices can consist of one or more units; thus, a single driver may be responsible for one or more disk drives. For example, block device driver ALPHA may be responsible for Drives A, B, C, and D. This means that it has four units (Ø-3) defined and takes up four drive letters. The position of the driver in the list of all drivers determines which units correspond to which drive letters. If driver ALPHA is the first first block driver in the device list, and it defines 4 units (Ø-3), then they will be A, B, C, and D. If BETA is the second block driver and defines three units (Ø-2), then they will be E, F, and G, and so on. The theoretical limit is 63 block devices, but after 26 the drive letters are unconventional (such as], /, and ^).

Device Headers

A Device Header is required at the beginning of a device driver. A Device Header looks like this:

WORD	Pointer to next Device Header (Must be set to −1)
WORD	Attributes Bit 15 = 0 if block device Bit 15 = 1 if character device If bit 15 is 1: Bit 0 = 1 if current sti device Bit 1 = 1 if current sto device Bit 2 = 1 if current NUL device Bit 3 = 1 if current CLOCK device Bit 4 = 1 if special Bits 5-12 Reserved; must be set to 0 Bit 14 is the IOCTL bit Bit 13 is the NON IBM FORMAT bit
WORD	Pointer to device strategy entry point
WORD	Pointer to device interrupt entry point
8 BYTES	Character device name field. Character devices set a device name. For block devices the first byte is the number of units.

Note that the device entry points are words. They must be offsets from the same segment number used to point to this table. For example, if XXX:YYY points to the start of this table, then XXX:strategy and XXX:interrupt are the entry points.

Pointer To Next Device Header Field

The pointer to the next Device Header field is a double word field (offset followed by segment) that is set by MS-DOS to point at the next driver in the system list at the time the device driver is loaded. It is important that this field be set to −1 prior to load (when it is on the disk as a file) unless there is more than one device driver in the file. If there is more than one driver in the file, the first word of the double word pointer should be the offset of the next driver's Device Header.

Note: If there is more than one device driver in the .COM file, the *last* driver in the file must have the pointer to the next Device Header field set to −1.

Attribute Field

The attribute field tells the system whether this device is a block or character device (bit 15). Most other bits are used to give selected character devices certain special treatment. (Note that these bits mean nothing on a block device.) For example, suppose you have a new device driver that you want to be the standard input and output. Besides installing the driver, you must tell MS-DOS that you want your new driver to override the current standard input and standard output (the CON device). You do this by setting bits 0 and 1 to 1. Similarly, you could install a new CLOCK device by setting that attribute bit.

Although there is a NUL device attribute, the NUL device cannot be reassigned. This attribute exists so that MS-DOS can determine if the NUL device is being used.

The NON IBM FORMAT bit applies only to block devices and affects the operation of the BUILD BPB (Bios Parameter Block) device call. (Refer to "MEDIA CHECK and BUILD BPB" later in this chapter for further information on this call.)

The other bit of interest is the IOCTL bit, which has meaning on both character and block devices. This bit tells MS-DOS whether the device can handle control strings (via the IOCTL function call, Function 44H).

If a driver cannot process control strings, it should initially set the IOCTL bit to 0. This tells MS-DOS to return an error if an attempt is made (via Function 44H) to send or receive control strings to this device. A device which can process control strings should initialize the IOCTL bit to 1. For drivers of this type, MS-DOS will make calls to the IOCTL input and output device functions to send and receive IOCTL strings.

The IOCTL functions allow data to be sent and received by the device for its own use (for example, to set baud rate, stop bits, and form length), instead of passing data over the device channel as does a normal read or write. It is up to the device to interpret the passed information, but it must not be treated as a normal I/O request.

Strategy and Interrupt Routines

These two fields are the pointers to the entry points of the strategy and interrupt routines. They are word values, so they must be in the same segment as the Device Header.

Name Field

This 8-byte field contains the name of a character device or the number of units of a block device. If it is a block device, the number of units can be put in the first byte. This is optional, because MS-DOS will fill in this location with the value returned by the driver's INIT code. Refer to "Installation of Device Drivers" in this chapter for more information.

Creating a Device Driver

In order to create a device driver that MS-DOS can install, you must write a binary file with a Device Header at the beginning of the file. Note that for device drivers, the code should not be originated at 1ØØH, but rather at Ø. The link field (pointer to the next Device Header) should be —1, unless there is more than one device driver in the file. The attribute field and entry points must be set correctly.

If it is a character device, the name field should be filled in with the name of that character device. The name can be any legal 8-character filename.

MS-DOS always processes installable device drivers before handling the default devices, so to install a new CON device, simply name the device CON and set the standard input device and standard output device bits in the attribute word on a new CON device. The scan of the device list stops on the first match, so the installable device driver takes precedence.

Note: Because MS-DOS can install the driver anywhere in memory, care must be taken in any far memory references. You should not expect that your driver will always be loaded in the same place every time.

Installation of Device Drivers

MS-DOS allows new device drivers to be installed dynamically at boot time. This is accomplished by INIT code in the BIOS, which reads and processes the CONFIG.SYS file.

MS-DOS calls a device driver by making a far call to its strategy entry point, and passes in a Request Header the information describing the functions of the device driver.

This structure allows you to program an interrupt-driven device driver. For example, you may want to perform local buffering in a printer.

MS-DOS passes a pointer to the Request Header in ES:BX. This is a fixed-length header, followed by data pertinent to the operation being performed. Note that it is the device driver's responsibility to preserve the machine state (for example, save all registers on entry and restore them on exit). There is enough room on the stack to do about 2Ø pushes. If more stack space is needed, the driver should set up its own stack.

Request Header

BYTE	Length of record Length in bytes of this Request Header
BYTE	Unit code The subunit the operation is for (minor device) (no meaning on character devices)
BYTE	Command code
WORD	Status
8 bytes	RESERVED

Unit Code Field

The unit code field identifies which unit in your device driver the request is for. For example, if your device driver has 3 units defined, then the possible values of the unit code field would be Ø, 1, and 2.

Command Code Field

The command code field in the Request header can have the following values:

Command Code	Function
0	INIT
1	MEDIA CHECK (block only, NOP for character)
2	BUILD BPB (block only, NOP for character)
3	IOCTL input (called only if IOCTL bit is 1)
4	INPUT (read)
5	NON-DESTRUCTIVE INPUT NO WAIT (character devices only)
6	INPUT STATUS (character devices only)
7	INPUT FLUSH (character devices only)
8	OUTPUT (write)
9	OUTPUT (write) with verify
10	OUTPUT STATUS (character devices only)
11	OUTPUT FLUSH (character devices only)
12	IOCTL output (called only if IOCTL bit is 1)

MEDIA CHECK and BUILD BPB

MEDIA CHECK and BUILD BPB are used with block devices only.

MS-DOS calls MEDIA CHECK first for a drive unit. MS-DOS passes its current media descriptor byte (refer to the section "Media Descriptor Byte" later in this chapter). MEDIA CHECK returns one of the following results:

- Media Not Changed - current DBP (Disk Parameter Block) and media byte are OK.
- Media Changed - Current DPB and media are wrong. MS-DOS invalidates any buffers for this unit and calls the device driver to build the DPB with media byte and buffer.
- Not Sure - If there are dirty buffers (buffers with changed data, not yet written to disk) for this unit, MS-DOS assumes the DBP and media byte are OK (media not changed). If nothing is dirty, MS-DOS assumes the media

has changed. It invalidates any buffers for the unit and calls the device driver to build the BPB with media byte and buffer.

- Error - If an error occurs, MS-DOS sets the error code accordingly.

MS-DOS will call BUILD BPB under the following conditions:

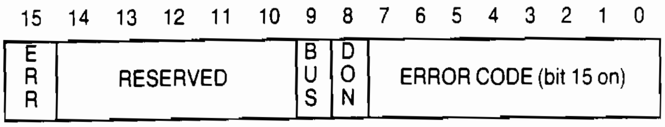
- If "Media Changed" is returned
- If "Not Sure" is returned and there are no dirty buffers

The BUILD BPB call also gets a pointer to a one-sector buffer. What this buffer contains is determined by the NON IBM FORMAT bit in the attribute field. If the bit is zero (device is IBM format-compatible), then the buffer contains the first sector of the first FAT. The FAT ID byte is the first byte of this buffer.

Note: The BPB must be the same, as far as location of the FAT is concerned, for all possible media because this first FAT sector must be read *before* the actual BPB is returned. If the NON IBM FORMAT bit is set, then the pointer points to one sector of scratch space (which may be used for anything).

Status Field

The following figure illustrates the status word in the Request Header:



The status word is zero on entry and is set by the driver interrupt routine on return.

Bit 8 is the done bit. When set, it means the operation is complete. The driver sets it to 1 when it exits.

Bit 15 is the error bit. If it is set, then the low 8 bits indicate the error. The errors are:

00H	Write Protect Violation
01H	Unknown Unit
02H	Drive Not Ready
03H	Unknown Command
04H	CRC Rrror
05H	Bad Drive Request Structure Length
06H	Seek Error
07H	Unknown Media
08H	Sector Not Found
09H	Printer Out of Paper
0AH	Write Fault
0BH	Read Fault
0CH	General Failure

Bit 9 is the busy bit, which is set only by status calls.

For output on character devices: If bit 9 is 1 on return, a write request (if made) would wait for completion of a current request. If it is 0, there is no current request, and a write request (if made) would start immediately.

For input on character devices with a buffer: If bit 9 is 1 on return, a read request (if made) would go to the physical device. If it is 0 on return, then there are characters in the device buffer and a read would return quickly. It also indicates that the user has typed something. MS-DOS assumes that all character devices have an input type-ahead buffer. Devices that do not have a type-ahead buffer should always return busy = 0 so that MS-DOS will not continuously wait for something to get into a buffer that does not exist.

One of the functions defined for each device is INIT. This routine is called only once, when the device is installed. The INIT routine returns a location (DS:DX), which is a pointer to the first free byte of memory after the device driver (similar to "Keep Process"). This pointer method can be used to delete initialization code after it has been used in order to save space.

Block devices are installed the same way and also return a first free byte pointer as described above. Additional information is also returned, such as the number of units.

The number of units determines logical device names. For example, if the current maximum logical device letter is F at the time of the install call and the INIT routine returns 4 as the number of units, then the units will have logical names G, H, I and J. This mapping is determined by the position of the driver in the device list and the number of units on the device (stored in the first byte of the device name field).

A pointer to a BPB (BIOS Parameter Block) pointer array is also returned. There is one table for each unit defined. These blocks will be used to build an internal DOS data structure for each of the units. The pointer passed to the DOS from the driver points to an array of n word pointers to BPBs, where n is the number of units defined. In this way, if all units are the same, all of the pointers can point to the same BPB, in order to save space.

Note that this array must be protected (below the free pointer set by the return), since an internal DOS structure will be built starting at the byte pointed to by the free pointer. The sector size defined must be less than or equal to the maximum sector size defined at default BIOS INIT time. If it isn't, the install will fail.

The last thing that INIT of a block device must pass back is the media descriptor byte. This byte means nothing to MS-DOS, but is passed to devices so that they know what parameters MS-DOS is currently using for a particular drive unit.

Block devices may take several approaches; they may be *dumb* or *smart*. A dumb device defines a unit (and therefore an internal DOS structure) for each possible media drive combination. For example, unit Ø = drive Ø single side, unit 1 = drive Ø double side. For this approach, media descriptor bytes mean nothing. A smart device allows multiple media per unit. In this case, the BPB table returned at INIT must define space large enough to accommodate the largest possible media supported. Smart drivers will use the media descriptor byte to pass information about what media is currently in a unit.

Function Call Parameters

All strategy routines are called with ES:BX pointing to the Request Header. The interrupt routines get the pointers to the Request Header from the queue that the strategy routines store them in. The command code in the Request Header tells the driver which function to perform.

Note: All DWORD pointers are stored offset first, then segment.

INIT

Command code = 0

ES:BX

13-BYTE	Request Header
BYTE	Number of units
DWORD	Break address
DWORD	Pointer to BPB array (Not set by character devices)

The number of units, break address, and BPB pointer are set by the driver. On entry, the DWORD that is to be set to the BPB array (on block devices) points to the character after the ' = ' on the line in CONFIG.SYS that loaded this device. This allows drivers to scan the CONFIG.SYS invocation line for arguments.

Note: If there are multiple device drivers in a single .COM file, the ending address returned by the last INIT called will be the one MS-DOS uses. It is recommended that all of the device drivers in a single .COM file return the same ending address.

MEDIA CHECK

Command Code = 1

ES:BX

13-BYTE	Request Header
BYTE	Media descriptor from DPB
BYTE	Returned

In addition to setting the status word, the driver must set the return byte to one of the following:

−1	Media has been changed
0	Don't know if media has been changed
1	Media has not been changed

If the driver can return −1 or 1 (by having a door-lock or other interlock mechanism), MS-DOS performance is enhanced because MS-DOS does not need to re-read the FAT for each directory access.

BUILD BPB (BIOS Parameter Block)

Command code = 2

ES:BX

13-BYTE Request Header
BYTE Media descriptor from DPB
DWORD transfer address (Points to one sector worth of scratch space or first sector of FAT depending on the value of the NON IBM FORMAT bit)
DWORD pointer to BPB

If the NON IBM FORMAT bit of the device is set, then the DWORD transfer address points to a one-sector buffer, which can be used for any purpose. If the NON IBM FORMAT bit is 0, then this buffer contains the first sector of the first FAT and the driver must not alter this buffer.

If IBM compatible format is used (NON IBM FORMAT BIT = 0), then the first sector of the first FAT must be located at the same sector on all possible media. This is because the FAT sector will be read *before* the media is actually determined. Use this mode if all you want is to read the FAT ID byte.

In addition to setting status word, the driver must set the pointer to the BPB on return.

The information relating to the BPB for a particular piece of media is kept in the boot sector for the media. In particular, the format of the boot sector is:

	3-BYTE	Near JUMP to boot code
	8 BYTES	OEM name and version
↑	WORD	Bytes per sector
	BYTE	Sectors per allocation unit
	WORD	Reserved sectors
B	BYTE	Number of FATs
P	WORD	Number of root directory entries
B	WORD	Number of sectors in logical image
	BYTE	Media descriptor
↓	WORD	Number of FAT sectors
	WORD	Sectors per track
	WORD	Number of heads
	WORD	Number of hidden sectors

The three words at the end (sectors per track, number of heads, and number of hidden sectors) are intended to help the BIOS understand the media. Sectors per track may be redundant (could be calculated from total size of the disk). Number of heads is useful for supporting different multi-head drives which have the same storage capacity but different numbers of surfaces. Number of hidden sectors may be used to support drive-partitioning schemes.

Media Descriptor Byte

The last two digits of the FAT ID are called the media descriptor byte. Currently, the media descriptor byte has been defined for a few media types, including 5-1/4" and 8" standard disks.

Although these media bytes map directly to FAT ID bytes (which are constrained to the 8 values F8H-FFH), media bytes can, in general, be any value in the range ØØH-FFH.

READ or WRITE

Command codes = 3,4,8,9, and 12

ES:BX (Including IOCTL)

13-BYTE	Request Header
BYTE	Media descriptor from DPB
DWORD	Transfer address
WORD	Byte/sector count
WORD	Starting sector number (Ignored on character devices)

In addition to setting the status word, the driver must set the sector count to the actual number of sectors (or bytes) transferred. No error check is performed on an IOCTL I/O call. The driver must correctly set the return sector (byte) count to the actual number of bytes transferred.

The following applies to block device drivers:

Under certain circumstances the BIOS may be asked to perform a write operation of 64K bytes that seems to be a "wrap-around" of the transfer address in the BIOS I/O packet. This request arises because of an optimization added to the write code in MS-DOS. It occurs only on user writes that are within a sector size of 64K bytes on files "growing" past the current end of file. It is allowable for the BIOS to ignore the balance of the write that wraps around, if it so chooses. For example, a write of 10000H bytes' worth of sectors with a transfer address of XXXX:1 could ignore the last two bytes. A user program can never request an I/O of more than FFFFH bytes and cannot wrap around (even to 0) in the transfer segment. Therefore, in this case, the last two bytes can be ignored.

NON-DESTRUCTIVE READ NO WAIT

Command code = 5

ES:BX

13-BYTE	Request Header
BYTE	Read from device

If the character device returns busy bit = 0 (characters in buffer), then the next character that would be read is returned. This character is not removed from the input buffer (hence the term non-destructive read). This call allows MS-DOS to look ahead one input character.

STATUS

Command codes = 6 and 10

ES:BX

13-BYTE	Request Header

All the driver must do is set the status word and the busy bit.

FLUSH

Command codes = 7 and 11

ES:BX

13-BYTE	Request Header

The FLUSH call tells the driver to flush (terminate) all pending requests. This call is used to flush the input queue on character devices.

The CLOCK Device

One of the most popular add-on boards is the real time clock board. To allow this board to be integrated into the system for TIME and DATE, there is a special device (determined by the attribute word) called the CLOCK device. The CLOCK device defines and performs functions like any other character device. Most functions will be: "set done bit, reset error bit, return."

When a read or write to this device occurs, exactly 6 bytes are transferred. The first two bytes are a word, which is the count of days since 1-1-8Ø. The third byte is minutes, the fourth hours, the fifth 1/1ØØ seconds, and the sixth seconds. Reading the CLOCK device gets the date and time; writing to it sets the date and time.

Chapter 6

BIOS Services

Device I/O Services

Introduction

The BIOS (Basic Input/Output System) is the lowest-level interface between other software (application programs and the operating system itself) and the hardware. The BIOS routines provide various device input/output services, as well as other services such as boot strap and print screen. Some of the services that BIOS provides are not available through the operating system, such as the graphics routines and keyboard reset.

All calls to the BIOS are made through software interrupts (that is, by means of assembly language "INT x" instructions). Each I/O device is provided with two different software interrupts, both of which transfer execution to the same routine. One interrupt number is the same as that used for the IBM PC/XT (for compatibility purposes); the other is a newly-assigned software interrupt.

Entry parameters to BIOS routines are normally passed in CPU registers. Similarly, exit parameters are generally returned from these routines to the caller in CPU registers. To insure BIOS compatibility with other machines, the register usage and conventions are, for the most part, identical.

The following pages describe the entry and exit requirements of each BIOS routine. To execute a BIOS call, load the registers as indicated under the "Entry Conditions." (Register AH will contain the function number in cases where a single interrupt can perform more than one operation.) Then issue one of the two interrupts given for the call. For example, either of the following can be used to read a character from the keyboard:

```
MOV AH,0          or       MOV AH,0
INT 16H                    INT 51H
```

Upon return, AL contains the ASCII character and AH the keyboard scan code.

Note: All registers except those used to return parameters to the caller are saved and restored by the BIOS routines.

Below is a quick reference list of software interrupts for all device I/O, special function, and system status services.

Service	**Software Interrupts**
Keyboard	16 hex (22 dec) 51 hex (81 dec)
Video Display	10 hex (16 dec) 52 hex (82 dec)
Serial Communications	14 Hex (20 dec) 53 hex (83 dec)
Line Printer	17 hex (23 dec) 54 hex (84 dec)
System Clock	1A hex (26 dec) 55 hex (85 dec)
Floppy Disk	13 hex (19 dec) 56 hex (86 dec)
Floppy Disk Parameter Pointer	1E hex (30 dec)
Floppy and Hard Disk	13 hex (19 dec)
Floppy Disk I/O With Hard Disk Present	40 hex (64 dec)
Hard Disk Parameter Pointer	41 hex (65 dec)
Boot Strap	19 hex (25 dec) 49 hex (73 dec)
Print Screen	05 hex (5 dec) 4A hex (74 dec)
Equipment	11 hex (17 dec) 4B hex (75 dec)
Memory Size	12 hex (18 dec) 4C hex (76 dec)

Keyboard

These routines provide an interface to the keyboard, which is the input half of the console (CON) device. MS-DOS considers the keyboard to be the default standard input (STDIN) device.

Software Interrupts:

16 hex (22 dec)
or
51 hex (81 dec)

Function Summary:

AH = Ø: Read Keyboard (destructive with wait)
AH = 1: Scan Keyboard (nondestructive, no wait)
AH = 2: Get Current Shift Status
AH = 3: Flush Keyboard Buffer
AH = 4: Reset Keyboard

Function Descriptions:

Read Keyboard

Read the next character typed at the keyboard. Return the ASCII value of the character and the keyboard scan code, removing the entry from the keyboard buffer (destructive read).

Entry Conditions:

AH = Ø

Exit Conditions:

AL = *ASCII value of character*
AH = *keyboard scan code*

Scan Keyboard

Set up the zero flag (Z flag) to indicate whether or not a character is available to be read from the keyboard. If a character is available, return the ASCII value of the character and the keyboard scan code. The entry remains in the keyboard buffer (non-destructive read).

Entry Conditions:

AH = 1

Exit Conditions:

Z = no character is available
NZ = a character is available, in which case:
AL = *ASCII value of character*
AH = *keyboard scan code*

Get Shift Status

Return the current shift status.

Entry Conditions:

AH = 2

Exit Conditions:

AL = *current shift status (bit settings: set = true, reset = false)*

bit Ø	=	RIGHT SHIFT key depressed
bit 1	=	LEFT SHIFT key depressed
bit 2	=	CTRL (control) key depressed
bit 3	=	ALT (alternate mode) key depressed
bit 4	=	SCROLL state active
bit 5	=	NUMBER lock engaged
bit 6	=	CAPS lock engaged
bit 7	=	INSERT state active

Flush Keyboard Buffer

Flush (clear) the keyboard buffer.

Entry Conditions:

AH = 3

Reset Keyboard

Reset the keyboard. This call automatically flushes the keyboard buffer.

Entry Conditions:

AH = 4

Video Display

These routines provide an interface to the video display, which is the output half of the console (CON) device. MS-DOS considers the video display to be the default standard output (STDOUT) device.

Note: The early versions of MS-DOS may not have the following functions implemented: smooth scroll, side scroll, scroll in a line, 8 text video pages.

Software Interrupts:

10 hex (16 dec)
or
52 hex (82 dec)

Function Summary:

Control Routines:
- AH = 0: Set CRT Mode
- AH = 1: Set Cursor Type
- AH = 2: Set Cursor Position
- AH = 3: Get Cursor Position
- AH = 5: Select Active Page
- AH = 6: Scroll Up
- AH = 7: Scroll Down

Text Routines:
- AH = 8: Read Attribute/Character
- AH = 9: Write Attribute/Character
- AH = 10: Write Character Only

Graphics Routines:
- AH = 11: Set Color Palette
- AH = 12: Write Dot
- AH = 13: Read Dot

Other Routines:
- AH = 14: Write TTY*
- AH = 15: Get CRT Mode
- AH = 16: Get/Set Character Fonts
- AH = 17: Write Attribute or Color Only
- AH = 18: Additional Scroll Functions

*Screen width is determined by the mode previously set. Some "control" characters (ASCII 00H-1FH) perform the usual special terminal function. These include (but are not limited to) NUL (00H), BEL (07H), BS (08H), HT (09H), LF (0AH), FF (0CH), and CR (0DH).

Function Descriptions:

Set CRT Mode

Entry Conditions:

AH = 0
AL = *mode value, as follows:*

Alpha Modes
AL = 0: 40x25 black and white
AL = 1: 40x25 color
AL = 2: 80x25 black and white
AL = 3: 80x25 color

Graphics Modes
AL = 4: 320x200 color graphics
AL = 5: 320x200 black and white graphics
AL = 6: 640x200 black and white graphics
AL = 7: Reserved

Additional Modes
AL = 8: 640x400 color graphics
AL = 9: 640x400 black and white graphics
AL = 10: 160x200 color graphics

Note: Graphics modes require a graphics hardware option. Color modes require a color graphics hardware option.

Set Cursor Type

Set the cursor type and attribute.

Entry Conditions:

```
AH  =  1
CH  =  bit values:
       bit 5 (blink bit):   0 = blinking cursor
                            1 = steady cursor
       bit 6 (display bit): 0 = visible
                            1 = invisible
       bits 4-0 = start line for cursor within character
       cell
CL  =  bit values:
       bits 4-0 = end line for cursor within character
       cell
```

All other bits of CH and CL are reserved for future use and should have a value of zero. The start and end lines for the cursor determine the choice of block or underline cursor in the case of the monochrome display. For the high-resolution and medium-resolution graphics options, the start and end lines are scaled to the size of the character cell.

Set Cursor Position

Write (set) cursor position.

Entry Conditions:

```
AH  =  2
BH  =  page number (must be 0 for graphics modes)
DH  =  row (0 = top row)
DL  =  column (0 = leftmost column)
```

Get Cursor Position

Read (get) cursor position.

Entry Conditions:

```
AH  =  3
BH  =  page number (must be 0 for graphics modes)
```

Exit Conditions:

DH = *row of current cursor position (Ø = top row)*
DL = *column of current cursor position (Ø = leftmost column)*
CH = *cursor type currently set [1]:*
  bit 5 (blink bit): Ø = blinking cursor
    1 = steady cursor
  bit 6 (display bit): Ø = visible
    1 = invisible
  bits 4-Ø = *start line for cursor within character cell*
CL = *bit values:*
  bits 4-Ø = *end line for cursor within character cell*

See Set Cursor Type (AH = 1) above.

Select Active Page

Select active display page (valid only for black and white alpha modes).

Entry Conditions:

AH = 5
AL = *new page value (Ø-7 for modes Ø and 1, Ø-3 for modes 2 and 3)*

Scroll Up

Scroll active page up.

Entry Conditions:

AH = 6
AL = *number of lines to scroll (Ø means blank entire window)*
CH = *row of upper left corner of scroll window*
CL = *column of upper left corner of scroll window*
DH = *row of lower right corner of scroll window*
DL = *column of lower right corner of scroll window*
BH = *attribute (alpha modes) or color (graphics modes) to be used on blank line*

Attributes:

7ØH	=	reverse video
Ø8H	=	high intensity
8ØH	=	blink
Ø1H	=	underline
ØØH	=	invisible
Ø7H	=	normal

Color:

See Set Color Palette (AH = 11).

Scroll Down

Scroll active page down.

Entry Conditions:

AH	=	7
AL	=	*number of lines to scroll (Ø means blank entire window)*
CH	=	*row of upper left corner of scroll window*
CL	=	*column of upper left corner of scroll window*
DH	=	*row of lower right corner of scroll window*
DL	=	*column of lower right corner of scroll window*
BH	=	*attribute (alpha modes) or color (graphics modes) to be used on blank line. See Scroll Up (AH = 6) for attribute values and Set Color Palette (AH = 11) for color values.*

Read Attribute or Color/Character

Read a character and its attribute or color at the current cursor position.

Entry Conditions:

AH	=	8
BH	=	*display page number (not used in graphics modes; ØFFH means remain in current page)*

Exit Conditions:

AL	=	*character read*
AH	=	*attribute of character (alpha modes) or color of character (graphics modes). See Scroll Up (AH = 6) for attribute values and Set Color Palette (AH = 11) for color values.*

Write Attribute or Color/Character

Write a character and its attribute or color at the current cursor position.

Entry Conditions:

AH	=	9
BH	=	*display page number (not used in graphics modes; ØFFH means remain in current page)*
CX	=	*number of characters to write*
AL	=	*character to write*
BL	=	*attribute of character (for alpha modes) or color of character (for graphics modes; if bit 7 of BL is set, the the color of the character is XOR'ed with the color value). See Scroll Up (AH = 6) for attribute values and Set Color Palette (AH = 11) for color values.*

Write Character Only

Write character only at current cursor position.

Entry Conditions:

AH	=	1Ø
BH	=	*display page number (valid for black and white alpha modes only; ØFFH means remain in current page)*
CX	=	*number of characters to write*
AL	=	*character to write*

Set Color Palette [3]

Select the color palette.

Entry Conditions:

AH = 11
BH = 0 Set background color (0-15) to color value in BL.
BL = *color value* (0 = black / 1 = blue / 2 = green / 3 = cyan / 4 = red / 5 = magenta / 6 = yellow / 7 = gray / 8 = black / 9 = light blue / 10 = light green / 11 = light cyan / 12 = light red / 13 = light magenta / 14 = light yellow / 15 = white)

or

BH = 1 Set default palette to the number (0 or 1) in BL.
BL = 0 (1 = green / 2 = red / 3 = yellow / 4 = white / 5 = light cyan / 6 = light blue / 7 = light yellow)
BL = 1 (1 = cyan / 2 = magenta / 3 = white / 4 = light red / 5 = light green / 6 = light blue / 7 = light yellow)

Write Dot

Write a pixel (dot).

Entry Conditions:

AH = 12
DX = *row number*
CX = *column number*
AL = *color value (When bit 7 of AL is set, the resultant color value of the dot is the exclusive OR of the current dot color value and the value in AL.)*

Read Dot

Read a pixel (dot).

Entry Conditions:

AH = 13
DX = *row number*
CX = *column number*

Exit Conditions:

AL	=	*color value of dot read*

Write TTY

Write a character in teletype fashion. (Control characters are interpreted in the normal manner.)

Entry Conditions:

AH	=	14
AL	=	*character to write*
BL	=	*foreground color (graphics mode)*

Get CRT Mode

Get the current video mode.

Entry Conditions:

AH	=	15

Exit Conditions:

AL	=	*current video mode; see Set CRT Mode (AH = Ø) above for values*

Get/Set Character Fonts

This service allows application programs to change character sets (fonts). The "control" value passed in AL determines whether the service will get (read) the pointer to the character fonts or set (change) it.

Entry Conditions:

AH = 16
AL = *control value, with bits having the following meanings:*

bit Ø: if reset, read pointer to current character set
if set, change pointer to new character set
bit 1: if reset, references ASCII codes Ø-127 only
if set, references ASCII codes 128-255 only
bit 2: if reset, references fonts for 8x8 cells only
if set, references fonts for 8x16 cells only
bits 3-7: ignored

ES:BX = *pointer to new character set to use, if bit Ø of AL is set*

Exit Conditions:

ES:BX = *pointer to current character set in use, if bit Ø of AL is reset*

The 8x8 character fonts are used by the medium-resolution graphics option board only. The pointer ES:BX points to a 1K-byte table of 128 "cells", each of which occupies 8 consecutive bytes. Each byte descibes a horizontal scan line; the bits within the byte specify whether pixels are to be set or reset on the video display. The most significant bit corresponds to the left-most pixel and the least significant bit to the right-most pixel. The first of the 8 consecutive bytes is mapped to the top scan line of the 8x8 cell and the last to the bottom.

The 8x16 character fonts are used for the monochrome display and the high-resolution graphics option board. The pointer ES:BX points to a 2K-byte table of 128 "cells", each occupying 16 consecutive bytes. These 8x16 cells are mapped in exactly the same way as the 8x8 cells described above.

Write Attribute Only

Write the attribute only at the current cursor position.

Entry Conditions:

AH	=	17
BL	=	*attribute of character (alpha modes) or color of character (graphics modes). See Scroll Up (AH = 6) for attribute values and Set Color Palette (AH = 11) for color values.*
CX	=	*number of attributes to write*

Additional Scroll Functions

Scroll in any of four directions.

Entry Conditions:

AH	=	18
CH	=	*row of upper left corner of window*
CL	=	*column of upper left corner of window*
DH	=	*row of lower right corner of window*
DL	=	*column of lower right corner of window*
BL	=	*direction of scroll* Ø = up 1 = down 2 = left 3 = right
BH	=	*buffer use flag* Ø = data in user's buffer 1 = no input data; use blanks with current attribute
ES:SI	=	*pointer to data buffer containing character/-attribute pairs (if BH = Ø)*

Note: The buffer must be arranged by rows; that is, all character/attribute pairs in row 1 are first, all pairs in row 2 are second, etc., regardless of direction of the scroll as indicated by the value in BL.

Serial Communications

These routines provide asynchronous byte stream I/O from and to the RS-232C serial communications port. This device is labeled the auxiliary (AUX) I/O device in the device list maintained by MS-DOS.

Software Interrupts:

14 hex (2Ø dec)
or
53 hex (83 dec)

Function Summary:

AH = Ø:	Reset Comm Port
AH = 1:	Transmit Character
AH = 2:	Receive Character
AH = 3:	Get Current Comm Status
AH = 4:	Flash Comm Buffer

Function Descriptions:

Reset Comm Port

Reset (or initialize) the communication port according to the parameters in AL, DL, and DH.

Entry Conditions:

AH = 0
AL = *RS-232C parameters, as follows:*

7 6 5	4 3	2	1 0
Baud Rate	Parity	Stop Bits	Word Length

000 = 110 baud	x0 = none	0 = 1 sb	00 = 5 bits
001 = 150 baud	01 = odd	1 = 2 sb	01 = 6 bits
010 = 300 baud	11 = even		10 = 7 bits
011 = 600 baud			11 = 8 bits
100 = 1200 baud			
101 = 2400 baud			
110 = 4800 baud			
111 = 9600 baud			

DL = *comm port (channel) to be used; currently ignored*
DH = *comm protocol to be used, as follows (set = true):*
bit 0 = use XON/XOFF protocol when receiving (a la TERMINAL)
bit 1 = use XON/XOFF protocol when transmitting (a la HOST)

Exit Conditions:

AX = *RS-232 status; see Get Current Comm Status (AH = 3) below*

Transmit Character

Transmit (output) the character in AL (which is preserved).

Entry Conditions:

AH = 1
AL = *character to transmit*

Exit Conditions:

AH = *RS-232 status; see Get Current Comm Status (AH = 3) below* (If bit 7 is set, the routine was unable to transmit the character because of a timeout error.)
DL = *comm port (channel) to be used; currently ignored*

Receive Character

Receive (input) a character in AL (wait for a character, if necessary). On exit, AH will contain the RS-232 status, except that only the error bits (1,2,3,4,7) may be set; the timeout bit (7), if set, indicates that data set ready was not received. Thus, AH is non-zero only when an error occurred.

Entry Conditions:

AH = 2

Exit Conditions:

AL = *character received*
AH = *RS-232 status; see Get Current Comm Status (AH = 3) below*
DL = *comm port (channel) to be used; currently ignored.*

Get Current Comm Status

Read the communication status into AX.

Entry Conditions:

AH = 3
DL = *comm port (channel) to be used; currently ignored*

Exit Conditions:

AH = *RS-232 status, as follows (set = true):*

bit 0	=	data ready
bit 1	=	overrun error
bit 2	=	parity error
bit 3	=	framing error
bit 4	=	break detect
bit 5	=	transmitter holding register empty
bit 6	=	transmitter shift register empty
bit 7	=	timeout occurred

AL = *modem status, as follows (set = true):*

bit 0	=	delta clear to send
bit 1	=	delta data set ready
bit 2	=	trailing edge ring detector
bit 3	=	delta receive line signal detect
bit 4	=	clear to send
bit 5	=	data set ready
bit 6	=	ring indicator
bit 7	=	receive line signal detect

Flush Comm Buffer

Flush (clear) the serial interface buffer.

Entry Conditions:

AH = 4
DL = *comm port (channel) to be used; currently ignored*
DH = *comm protocol to be used, as follows (set = true):*

bit 0	=	use XON/XOFF protocol when receiving (a la TERMINAL)
bit 1	=	use XON/XOFF protocol when transmitting (a la HOST)

Line Printer

These routines provide an interface to the parallel line printer. This device is labeled "PRN" in the device list maintained by the operating system.

Software Interrupts:

17 hex (23 dec)
or
54 hex (84 dec)

Function Summary:

AH = Ø: Print Character
AH = 1: Reset Printer Port
AH = 2: Get Current Printer Status

Function Descriptions:

Print Character

Print a character.

Entry Conditions:

AH = Ø
AL = *character to print*
DX = *printer to be used (Ø-2); currently ignored*

Exit Conditions:

AH = *printer status; see Get Current Printer Status (AH = 2) below*
(If bit Ø is set, the character could not be printed because of a timeout error.)

Reset Printer Port

Reset (or initialize) the printer port.

Entry Conditions:

AH = 1
DX = *printer to be used (Ø-2); currently ignored*

Exit Conditions:

AH = *printer status; see Get Current Printer Status (AH = 2) below*

Get Current Printer Status

Read the printer status into AH.

Entry Conditions:

AH = 2

Exit Conditions:

DX = *printer to be used (Ø-2); currently ignored*
AH = *printer status, as follows (set = true):*

bit Ø	=	timeout occurred
bit 1	=	[unused]
bit 2	=	[unused]
bit 3	=	I/O error
bit 4	=	selected
bit 5	=	out of paper
bit 6	=	acknowledge
bit 7	=	busy

System Clock

These routines provide methods of reading and setting the clock maintained by the system. This device is labeled "CLOCK" in the device list of the operating system.

Software Interrupts:

1A hex (26 dec)
or
55 hex (85 dec)

Function Summary:

AH = Ø:	Get Time Of Day
AH = 1:	Set Time Of Day
AH = 2:	Get Date And Time
AH = 3:	Set Date And Time

Function Descriptions:

Get Time Of Day

Get (read) the time of day in binary format.

Entry Conditions:

AH = Ø

Exit Conditions:

CX = *high (most significant) portion of clock count*
DX = *low (least significant) portion of clock count*
AL = Ø if the clock was read or written (via AH = Ø,1,2,3) within the current 24-hour period; otherwise, AL > Ø

The clock runs at a rate of 2Ø ticks per second.

Set Time Of Day

Set (write) the time of day using binary format.

Entry Conditions:

AH	=	1
CX	=	*high (most significant) portion of clock count*
DX	=	*low (least significant) portion of clock count*

This call resets the 24-hour rollover flag. It does not, however, change the date. To do this, use the Set Date and Time function (AH = 3) below.

Get Date and Time

Get the current date and time in system (MS-DOS) format.

Entry Conditions:

AH	=	2

Exit Conditions:

BX	=	*days since January 1, 198Ø (Ø-65535)*
CH	=	*hours (Ø-23)*
CL	=	*minutes (Ø-59)*
DH	=	*seconds (Ø-59)*
DL	=	*hundredths of a second (Ø-99)*

Set Date and Time

Set the current date and time in system (MS-DOS) format.

Entry Conditions:

AH	=	3
BX	=	*days since January 1, 198Ø (Ø-65535)*
CH	=	*hours (Ø-23)*
CL	=	*minutes (Ø-59)*
DH	=	*seconds (Ø-59)*
DL	=	*hundredths of a second (Ø-99)*

Floppy and Hard Disk

The floppy and hard disk I/O interface described below is provided for compatibility with existing applications software and new software for the Model 2000. The areas of support are divided into two groups:

- Floppy disk only system configuration
- Floppy and hard disk system configuration

The system determines the hardware configuration at boot time for any given machine so that the appropriate software support will be available at run time.

Disk I/O Support for the Floppy Only System Configuration

Software Interrupt:

13 hex (19 dec)
or
56 hex (86 dec)

Function Summary:

AH = 0: Reset Floppy Disk
AH = 1: Return Status of Last Floppy Disk Operation
AH = 2: Read Sector(s) from Floppy Disk
AH = 3: Write Sector(s) to Floppy Disk
AH = 4: Verify Sector(s) on Floppy Disk
AH = 5: Format Track on Floppy Disk

Function Descriptions:

Reset Floppy Disk

Reset the diskette system. Resets associated hardware and recalibrates all diskette drives.

Entry Conditions:

AH = 0

Exit Conditions:

See "Exits From All Calls" below.

Return Status of Last Floppy Disk Operation

Return the diskette status of the last operation in AL.

Entry Conditions:

AH = 1

Exit Conditions:

AL = *status of the last operation; see "Exits From All Calls" below for values*

Read Sector(s) from Floppy Disk

Read the desired sector(s) from disk into RAM.

Entry Conditions:

AH	=	2
DL	=	*drive number (Ø-1)*
DH	=	*head number (Ø-1)*
CH	=	*cylinder number (Ø-79)*
CL	=	*sector number (1 to number of sectors per track)*
AL	=	*sector count (1 to number of sectors per track)*
ES:BX	=	*pointer to disk buffer*

Exit Conditions:

See "Exits From All Calls" below.
AL = *number of sectors read*

Write Sector(s) to Floppy Disk

Write the desired sector(s) from RAM to disk.

Entry Conditions:

AH	=	3
DL	=	*drive number (Ø-1)*
DH	=	*head number (Ø-1)*
CH	=	*cylinder number (Ø-79)*
CL	=	*sector number (1 to number of sectors per track)*
AL	=	*sector count (1 to number of sectors per track)*
ES:BX	=	*pointer to disk buffer*

Exit Conditions:

See "Exits From All Calls" below.
AL = *number of sectors written*

Verify Sector(s) on Floppy Disk

Verify the desired sector(s).

Entry Conditions:

AH	=	4
DL	=	*drive number (Ø-1)*
DH	=	*head number (Ø-1)*
CH	=	*cylinder number (Ø-79)*
CL	=	*sector number (1 to number of sectors per track)*
AL	=	*sector count (1 to number of sectors per track)*

Exit Conditions:

See "Exits From All Calls" below.
AL = *number of sectors verified*

Format Track on Floppy Disk

Format the desired track.

Entry Conditions:

AH	=	5
DL	=	*drive number (Ø-1)*
DH	=	*head number (Ø-1)*
CH	=	*cylinder number (Ø-79)*
CL	=	*number of sectors per track*
ES:BX	=	*pointer to a group of address fields for each track.* Each address field is made up of 4 bytes. These are C, H, R, and N, where:

C	=	cylinder number
H	=	head number
R	=	sector number
N	=	the number of bytes per sector (Ø1 = 256, Ø2 = 512, Ø3 = 1Ø24)

There is one entry for every sector on a given track.

Exit Conditions:

See "Exits From All Calls" below.

Exits From All Calls:

AH = *status of operation, where set = true:*
bit Ø = bad command or command parameter error
bit 1 = address mark not found error
bit 2 = sector not found error
bit 3 = DMA overrun error
bit 4 = CRC error
bit 5 = FDC failure
bit 6 = seek error
bit 7 = timeout error

[NC] = operation successful (AH = Ø)
[C] = operation failed (AH = error status)

Software Interrupt:

1E hex (3Ø dec)

Function Summary:

Floppy Disk Parameter Pointer

This is a double word pointer to the current floppy disk parameter block. This parameter block is required for floppy disk operation. To change the way the floppy disk driver operates, you should build another parameter block and load the segment and offset of this parameter block into the software interrupt 1E hex vector area.

The Floppy Disk Parameter Pointer points to a parameter table similar to the following:

```
DB111ØØØØ1B    ;SRT = E, HD UNLOAD = Ø1 - 1st fdc specify byte
DB1ØØØ11ØØB    ;HD LOAD = 8C, MODE = DMA - 2nd fdc specify byte
DB ?           ;not used
DB ?           ;bytes per sector 1 = 256, 2 = 512, 3 = 1Ø24
DB ?           ;sectors per track (eot)
DB ?           ;Gap length
DB ?           ;DTL (Data Transfer Length)
DB ?           ;Gap length for format
DB ?           ;Fill byte for format
DB ?           ;Head settling time (in milliseconds)
DB ?           ;Motor start time (in 1/8 second intervals)
```

Disk I/O Support for the Floppy & Hard Disk System Configuration

Software Interrupt:

13 hex (19 dec)

Function Summary:

AH	=	0: Reset Hard Disk
AH	=	1: Return Status of Last Hard Disk Operation
AH	=	2: Read Sector(s) from Hard Disk
AH	=	3: Write Sector(s) to Hard Disk
AH	=	4: Verify Sector(s) on Hard Disk
AH	=	5: Format Track on Hard Disk
AH	=	8: Return Hard Disk Drive Parameters
AH	=	9: Initialize Hard Disk Drive Parameters
AH	=	12: Perform Seek on Hard Disk
AH	=	13: Reset Hard Disk System
AH	=	14: Read Hard Disk Sector Buffer
AH	=	15: Write Hard Disk Sector Buffer
AH	=	16: Hard Disk Drive Ready Test
AH	=	18: not used
AH	=	19: not used
AH	=	20: not used

Function Descriptions:

Note: If bit 7 in register DL is set on entry to software interrupt 13 hex, hard disk I/O will occur. If bit 7 in register DL is not set on entry, floppy disk I/O will occur through interrupt 40 hex (see Interrupt 40 hex below).

Reset Hard Disk

Reset the hard disk system. Reset associated hardware and recalibrate all hard disk drives.

Entry Conditions:

AH = Ø
DL = *drive number (with bit 7 set to indicate hard disk)*

Exit Conditions:

See "Exits From All Calls" below.

Return Status of Last Hard Disk Operation

Return the hard disk status of the last operation in AL.

Entry Conditions:

AH = 1
DL = *drive number (with bit 7 set to indicate hard disk)*

Exit Conditions:

AL = *status of the last operation; see "Exits From All Calls" below for values*

Read Sector(s) from Hard Disk

Read the specified sector(s) from a hard disk into RAM.

Entry Conditions:

AH = 2
DL = *drive number (with bit 7 set to indicate hard disk)*
DH = *drive head number (Ø-7 allowed, but may not be more than the maximum number of heads per drive)*
CL bits 7,6 = *most significant part of cylinder number*
CH = *least significant part of cylinder number* (bits 7,6 of CL plus bits 7-Ø of CH equals the 1Ø-bit cylinder number)
CL bits 5-Ø = *sector number (1 to the number of sectors per track)*
AL = *sector count (must not exceed the number of sectors per track)*
ES:BX = *pointer to disk buffer*

Exit Conditions:

See "Exits From All Calls" below.
AL = *number of sectors read*

Write Sector(s) to Hard Disk

Write the specified sector(s) from RAM to a hard disk.

Entry Conditions:

AH = 3
DL = *drive number (with bit 7 set to indicate hard disk)*
DH = *drive head number (Ø-7 allowed, but may not be more than the maximum number of heads per drive)*
CL bits 7,6 = *most significant part of cylinder number*
CH = *least significant part of cylinder number*
(bits 7,6 of CL plus bits 7-Ø of CH equals the 1Ø-bit cylinder number)
CL bits 5-Ø = *sector number (1 to the number of sectors per track)*
AL = *sector count (must not exceed the number of sectors per track)*
ES:BX = *pointer to disk buffer*

Exit Conditions:

See "Exits From All Calls" below.
AL = *number of sectors written*

Verify Sector(s) on Hard Disk

Verify the specified sector(s)

Entry Conditions:

AH = 4
DL = *drive number (with bit 7 set to indicate hard disk)*
DH = *drive head number (Ø-7 allowed, but may not be more than the maximum number of heads per drive)*
CL bits 7,6 = *most significant part of cylinder number*
CH = *least significant part of cylinder number*
(bits 7,6 of CL plus bits 7-Ø of CH equals the 1Ø-bit cylinder number)

CL bits 5-0 = *sector number (1 to the number of sectors per track)*
AL = *sector count (must not exceed the number of sectors per track)*

Exit Conditions

See "Exits From All Calls" below.
AL = *number of sectors written and verified*

Format Track on Hard Disk

Format the specified hard disk track.

Entry Conditions:

AH = 5
DL = *drive number (with bit 7 set to indicate hard disk)*
DH = *drive head number (0-7 allowed, but may not be more than the maximum number of heads per drive)*
CL bits 7,6 = *most significant part of cylinder number*
CH = *least significant part of cylinder number*
(bits 7,6 of CL plus bits 7-0 of CH equals the 10-bit cylinder number)
CL bits 5-0 = *sector number (1 to the number of sectors per track)*
AL = *interrecord gap value (normally 4EH)*
ES:BX = *address of sector format table (512 bytes)*

Exit Conditions:

See "Exits From All Calls" below.

Return Hard Disk Drive Parameters

Return the parameters associated with the hard disk drive(s).

Entry Conditions:

AH = 8
DL = *drive number (with bit 7 set to indicate hard disk)*

Exit Conditions:

See "Exits From All Calls" below.
DL = *number of hard disk drives*

DH = *number of drive heads*
CL bits 7,6 = *most significant part of maximum cylinder number*
CH = *least significant part of maximum cylinder number*
(bits 7,6 of CL plus bits 7-0 of CH equals the 10-bit maximum cylinder number)
CL bits 5-0 = *maximum number of sectors per track*

Initialize Hard Disk Drive Parameters

Initialize the hard disk drive parameters associated with the specified hard disk drive.

Entry Conditions:

AH = 9
DL = *drive number (with bit 7 set to indicate hard disk)*

Exit Conditions:

See "Exits From All Calls" below.

Perform Seek on Hard Disk

Seek the specified hard disk track.

Entry Conditions:

AH = 12
DL = *drive number (with bit 7 set to indicate hard disk)*
DH = *drive head number (0-7 allowed, but may not be more than the maximum number of heads per drive)*
CL bits 7,6 = *most significant part of cylinder number*
CH = *least significant part of cylinder number*
(bits 7,6 of CL plus bits 7-0 of CH equals the 10-bit cylinder number)

Exit Conditions:

See "Exits From All Calls" below.

Reset Hard Disk System

Reset the hard disk system. Reset associated hardware and recalibrate all hard disk drives. This call has the same effect as Reset Hard Disk (AH = Ø).

Entry Conditions:

AH = 13

Exit Conditions:

See "Exits From All Calls" below.

Read Hard Disk Sector Buffer

Read the hard disk sector buffer.

Entry Conditions:

AH = 14
DL = *drive number (with bit 7 set to indicate hard disk)*
ES:BX = *pointer to buffer*

Exit Conditions:

See "Exits From All Calls" below.

Write Hard Disk Sector Buffer

Write the hard disk sector buffer.

Entry Conditions:

AH = 15
DL = *drive number (with bit 7 set to indicate hard disk)*
ES:BX = *pointer to buffer*

Exit Conditions:

See "Exits From All Calls" below.

Hard Disk Drive Ready Test

Check to see if the specified hard disk drive is ready.

Entry Conditions:

AH	=	16
DL	=	*drive number (with bit 7 set to indicate hard disk)*

Exit Conditions:

See "Exits From All Calls" below.

Exits From All Calls:

AH = *status of operation, where set = true:*

bit 0	=	bad command or command parameter error
bit 1	=	address mark not found error
bit 2	=	sector not found error
bit 3	=	DMA overrun error
bit 4	=	CRC error
bit 5	=	FDC failure
bit 6	=	seek error
bit 7	=	timeout error

[NC]	=	operation successful (AH = 0)
[C]	=	operation failed (AH = error status)

Software Interrupt:

40 hex (64 dec)

Function Summary:

This is the interrupt vector for floppy disk I/O when one or more hard disks are present.

Function Description:

If the high bit (bit 7) of DL is not set and hard disk(s) are present, control is passed to the floppy drives via this software interrupt.

Software Interrupt:

41 hex (65 dec)

Function Summary:

Hard Disk Parameter Pointer

This is a double word pointer to the current hard disk parameter block. This parameter block is required for proper hard disk operation. To change the way the hard disk operates, you should build another parameter block and load the segment and offset of this parameter block into the software interrupt 41 hex vector area.

The Hard Disk Parameter Pointer points to a parameter table similar to the following:

dw	?	number of cylinders
db	?	number of heads
dw	?	reserved, not used
dw	?	write precompensation cylinder number
db	?	reserved, not used
db	?	reserved, not used
db	?	time out value
db	?	format time out value
db	?	test time out value
dd	?	reserved, not used

Special Function Services

Introduction

These additional BIOS services provide a way to perform certain "special functions" under software control. Those which are currently implemented are described on the following pages.

Boot Strap

This special function re-boots the operating system. It is a "cold boot" in the sense that the power-on sequence is executed.

Software Interrupts:

19 hex (25 dec)
or
49 hex (73 dec)

Print Screen

This special function prints an image of the current video screen on the line printer.

Software Interrupts:

Ø5 hex (5 dec)
or
4A hex (74 dec)

System Status Services

Introduction

These BIOS services provide callers with the ability to determine, and in certain cases change, the overall status of the operating system and/or the BIOS. Those which are currently implemented are described on the following pages.

Equipment

This service returns the "equipment flag" (hardware configuration of the computer system) in the AX register.

Software Interrupts:

11 hex (17 dec)
or
4B hex (75 dec)

The "equipment flag" returned in the AX register has the meanings listed below for each bit:

Reset	=	the indicated equipment is not in the system
Set	=	the indicated equipment is in the system

bit Ø	TV/joystick option
bit 1	Monochrome graphics option
bit 2	Monochrome graphics with color option
bit 3	Floppy disk drive #1
bit 4	Floppy disk drive #2
bit 5	[reserved]
bit 6	[reserved]
bit 7	[unused]
bit 8	Black and white monitor
bit 9	Color monitor
bit 1Ø	TV monitor
bit 11	[reserved]
bit 12	Joysticks
bit 13	Printer
bit 14	[reserved]
bit 15	[unused]

Memory Size

This service returns the total number of kilobytes of RAM in the computer system (contiguous starting from address Ø) in the AX register.

Software Interrupts:

12 hex (18 dec)
or
4C hex (76 dec)

Appendix A

Extended Screen and Keyboard Control

This appendix describes how you can change graphics functions, move the cursor, and reassign the meaning of any key on the keyboard by issuing special character sequences from within your program. These sequences are valid only when issued through MS-DOS function calls 1, 2, 6, and 9.

Before these special functions can be used, the extended screen and keyboard control device driver must be installed. To do this, place the following command in your CONFIG.SYS file (see Appendix C in the *MS-DOS Commands Reference Manual* for information on the configuration file):

```
DEVICE = ANSI.SYS
```

In the control sequences described below, the following apply:

- The symbol " * " represents a decimal number that you provide, specified with ASCII characters.
- The default value is used when no explicit value or a value of zero is specified.
- ESC represents the 1-byte code for ESC (1BH). For example, you could create ESC[5;9H under DEBUG as follows:

  ```
  E1ØØ 1B "[5;9H"
  ```

Cursor Control

Cursor Position (CUP)

ESC [*;*H

Moves the cursor to the position specified by the parameters. The first parameter specifies the line number and the second parameter specifies the column number. The default value for * is 1. If no parameter is given, the cursor is moved to the home position (upper left corner).

Horizontal and Vertical Position (HVP)

ESC [*;*f

Moves the cursor in the same way as Cursor Position (CUP), described above.

Cursor Up (CUU)

ESC [*A

Moves the cursor up one or more lines without changing columns. The value of * determines the number of lines moved. The default value for * is 1. This sequence is ignored if the cursor is already on the top line.

Cursor Down (CUD)

ESC [*B

Moves the cursor down one or more lines without changing columns. The value of * determines the number of lines moved. The default value for * is 1. This sequence is ignored if the cursor is already on the bottom line.

Cursor Forward (CUF)

ESC [*C

Moves the cursor forward one or more columns without changing lines. The value of * determines the number of columns moved. The default value for * is 1. This sequence is ignored if the cursor is already in the rightmost column.

Cursor Backward (CUB)

ESC [*D

Moves the cursor back one or more columns without changing lines. The value of * determines the number of columns moved. The default value for * is 1. This sequence is ignored if the cursor is already in the leftmost column.

Device Status Report (DSR)

ESC [6n

The console driver outputs a Cursor Position Report (CPR) sequence on receipt of DSR (see below).

Cursor Position Report (CPR)

ESC [*;*R

Reports current cursor position through the standard input device. The first parameter specifies the current line and the second parameter specifies the current column.

Save Cursor Position (SCP)

ESC [s

Saves the current cursor position. You can restore this position with the Restore Cursor Position (RCP) sequence (see below).

Restore Cursor Position (RCP)

ESC [u

Restores the cursor position to the value it had when the console driver received the SCP sequence.

Erasing

Erase Display (ED)

ESC [2J

Erases the screen and sends the cursor to the home position (upper left corner).

Erase Line (EL)

ESC [K

Erases from the cursor to the end of the line (including the cursor position).

Modes of Operation

Set Graphics Rendition (SGR)

ESC [*;...;*m

Sets the character attribute(s) specified by the parameter(s) described below. The attributes remain in effect until the next occurrence of an SGR escape sequence.

Parameter	**Meaning**
0	All attributes off (normal white on black)
1	Highlight on (high intensity)
4	Underline on (monochrome display only)
5	Blink on
7	Reverse video on
8	Concealed on (invisible)
30	Black foreground
31	Red foreground
32	Green foreground
33	Yellow foreground
34	Blue foreground
35	Magenta foreground
36	Cyan foreground
37	White foreground
40	Black background
41	Red background
42	Green background
43	Yellow background
44	Blue background
45	Magenta background
46	Cyan background
47	White background

Set Mode (SM)

```
   ESC [=*H
or ESC [=H
or ESC  =Øh
or ESC [?7h
```

Sets the screen width or type specified by the parameter.

Parameter	**Meaning**
Ø	4Ø x 25 black and white
1	4Ø x 25 color
2	8Ø x 25 black and white
3	8Ø x 25 color
4	32Ø x 2ØØ color
5	32Ø x 2ØØ black and white
6	64Ø x 2ØØ black and white
7	wrap-around at end of line (new line starts when old line filled)
8	64Ø x 4ØØ color graphics
9	64Ø x 4ØØ black and white
1Ø	162Ø x 2ØØ color graphic

Reset Mode (RM)

```
   ESC [=*1
or ESC [=1
or ESC [=Ø1
or ESC [?71
```

Parameters are the same as for Set Mode (SM) except that parameter 7 resets the wrap-around mode (characters past end-of-line are thrown away).

Keyboard Key Reassignment

```
   ESC [*;*;...*p
or ESC ["string";p
or ESC [*;"string";*;*;"string";*p
or any other combination of strings and decimal
   numbers
```

Changes the meaning of a key on the keyboard. The first ASCII code in the control sequence defines which code is being mapped. The remaining numbers define the sequence of ASCII codes generated when this key is intercepted. However, if the first code in the sequence is zero (NUL), then the first and second codes make up an extended ASCII re-definition. (See Appendix B for a list of ASCII and extended ASCII codes.)

Examples:

1. Reassign the Q and q key to the A and a key (and vice versa):

```
ESC [65;81p        A becomes Q
ESC [97;113p        a becomes q
ESC [81;65p        Q becomes A
ESC [113;97p        q becomes a
```

2. Reassign the F10 key to a DIR command followed by a carriage return:

```
ESC [0;68;"dir";13p
```

The 0;68 is the extended ASCII code for the F10 key. 13 decimal is a carriage return.

Appendix B

Keyboard ASCII and Scan Codes

The table in this appendix lists the keys on the Model 2ØØØ keyboard in scan code order, along with the ASCII codes they generate. For each key, the following entries are given:

Scan Code — A value in the range Ø1H-5AH which uniquely identifies the physical key on the keyboard that is pressed.

Keyboard Legend — The physical marking(s) on the key. If there is more than one marking, the upper one is listed first.

ASCII Code — The ASCII codes associated with the key. The four modes are:

Normal — The normal ASCII value (returned when only the indicated key is depressed).

SHIFT — The shifted ASCII value (returned when SHIFT is also depressed).

CTRL — The control ASCII value (returned when CTRL is also depressed).

ALT — The alternate ASCII value (returned when ALT is also depressed).

Remarks — Any remarks or special functions.

The following special symbols appear in the table:

x	Values preceded by "x" are extended ASCII codes (codes preceded by an ASCII NUL, ØØ).
—	No ASCII code is generated.
*	No ASCII code is generated, but the special function described in the Remarks column is performed.
[ ]	The ASCII codes listed are the same as those generated by corresponding keys on the IBM PC keyboard *except* for those enclosed by square brackets. Codes in brackets are additional codes; that is, the IBM PC keyboard generates no ASCII code in any of these cases.

Note: All numeric values in the table are expressed in hexadecimal.

Scan Code	Keyboard Legend	ASCII Codes Normal	SHIFT	CTRL	ALT	Remarks
Ø1	ESC	1B	1B	1B	[x8B]	
Ø2	! 1	31	21	—	x78	
Ø3	@ 2	32	4Ø	xØ3	x79	
Ø4	# 3	33	23	—	x7A	
Ø5	$ 4	34	24	—	x7B	
Ø6	% 5	35	25	—	x7C	
Ø7	^ 6	36	5E	1E	x7D	
Ø8	& 7	37	26	—	x7E	
Ø9	* 8	38	2A	—	x7F	
ØA	(9	39	28	—	x8Ø	
ØB	) Ø	3Ø	29	—	x81	
ØC	_ –	2D	5F	1F	x82	
ØD	+ =	3D	2B	—	x83	
ØE	BACK SPACE	Ø8	Ø8	7F	[x8C]	
ØF	TAB	Ø9	xØF	[x8D]	[x8E]	
1Ø	Q	71	51	11	x1Ø	
11	W	77	57	17	x11	
12	E	65	45	Ø5	x12	
13	R	72	52	12	x13	
14	T	74	54	14	x14	
15	Y	79	59	19	x15	
16	U	75	55	15	x16	
17	I	69	49	Ø9	x17	
18	O	6F	4F	ØF	x18	
19	P	7Ø	5Ø	1Ø	x19	
1A	{ [	5B	7B	1B	—	
1B	}]	5D	7D	1D	—	
1C	ENTER	ØD	ØD	ØA	[X8F]	(main keyboard)
1D	CTRL	*	*	*	*	control mode
1E	A	61	41	Ø1	x1E	
1F	S	73	53	13	x1F	
2Ø	D	64	44	Ø4	x2Ø	
21	F	66	46	Ø6	x21	
22	G	67	47	Ø7	x22	
23	H	68	48	Ø8	x23	
24	J	6A	4A	ØA	x24	
25	K	6B	4B	ØB	x25	
26	L	6C	4C	ØC	x26	
27	: ;	3B	3A	—	—	
28	" '	27	22	—	—	

Scan	Keyboard	ASCII Codes				Remarks
Code	Legend	Normal	SHIFT	CTRL	ALT	
29	↑	x48	[x85]	[x90]	[x91]	
2A	SHIFT	*	*	*	*	left SHIFT
2B	←	x4B	[x87]	x73	[x92]	
2C	Z	7A	5A	1A	x2C	
2D	X	78	58	18	x2D	
2E	C	63	43	03	x2E	
2F	V	76	56	16	x2F	
30	B	62	42	02	x30	
31	N	6E	4E	0E	x31	
32	M	6D	4D	0D	x32	
33	< ,	2C	3C	—	—	
34	> .	2E	3E	—	—	
35	? /	2F	3F	—	—	
36	SHIFT	*	*	*	*	right SHIFT
37	PRINT	10	*	x72	[x46]	print screen toggle
38	ALT	*	*	*	*	alternate mode
39	(space bar)	20	20	20	20	
3A	CAPS	*	*	*	*	caps lock
3B	F1	x3B	x54	x5E	x68	
3C	F2	x3C	x55	x5F	x69	
3D	F3	x3D	x56	x60	x6A	
3E	F4	x3E	x57	x61	x6B	
3F	F5	x3F	x58	x62	x6C	
40	F6	x40	x59	x63	x6D	
41	F7	x41	x5A	x64	x6E	
42	F8	x42	x5B	x65	x6F	
43	F9	x43	x5C	x66	x70	
44	F10	x44	x5D	x67	x71	
45	NUM LOCK	*	*	*	*	number lock
46	HOLD	*	*	*	*	freeze display
47	\ 7	37	5C	[x93]	*	†
48	~ 8	38	7E	[x94]	*	†
49	PG UP 9	39	x49	x84	*	†
4A	↓	x50	[x86]	[x96]	[x97]	
4B	| 4	34	7C	[x95]	*	†
4C	5	35	—	—	*	†
4D	6	36	—	—	*	†
4E	→	x4D	[x88]	x74	*	smooth scroll toggle

Scan Code	Keyboard Legend	ASCII Codes Normal	SHIFT	CTRL	ALT	Remarks
4F	END 1	31	x4F	x75	*	†
5Ø	` 2	32	6Ø	[x9A]	*	†
51	PG DN 3	33	x51	x76	*	†
52	Ø	3Ø	[x9B]	[x9C]	*	†
53	DELETE	x53	[x8A]	[x9D]	[x9E]	
54	BREAK	xØØ	xØØ	*	xØØ	BREAK routine (INT 1BH)
55	INSERT	x52	[x89]	[x9F]	[xAØ]	
56		2E	[xA1]	[xA4]	[xA5]	(numeric keypad)
57	ENTER	ØD	ØD	ØA	[x8F]	(numeric keypad)
58	HOME	x47	[x4A]	x77	[xA6]	
59	F11	[x98]	[xA2]	[xAC]	[xB6]	
5A	F12	[x99]	[xA3]	[xAD]	[xB7]	

† The ALT key provides a way to generate the ASCII codes of decimal numbers between 1 and 255. Hold down the ALT key while you type *on the numeric keypad* any decimal number between 1 and 255. When you release ALT, the ASCII code of the number typed is generated and displayed.

Note: When the NUM LOCK light is off, the Normal and SHIFT columns for these keys should be reversed.

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Entries which are **bold** are system calls.

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