USER'S GUIDE TO

56K

VECTOR GRAPHIC SYSTEMS

USING MDOS

MDOS System Diskette version 8.5

USER'S GUIDE

Revision B

October 18, 1979

IMPORTANT: This manual is for MDOS System Diskettes 8.5 ONLY.

This manual AND Diskette 8.5 are for use only with systems having 56K of contiguous memory.

Please turn to the ERRATA following the title page.

To start up a system using MDOS, see first page of Chapter 2.

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ERRATA

The following sheets describe the differences between the 8.4 MDOS manual and the 8.5 manual. The change occurs because of a very significant change to the system and the MDOS System Disk. Because of printing schedules, the manual text is NOT modified. Please make the appropriate changes in the text. The disk, however, is ready to use.

Most of the differences derive from inclusion in the system of a 64K RAM board which provides the user with 56K of contiguous memory. (8K are not used.) To accomplish this, all other boards having on-board memory have been readdressed (Flashwriter, Disk Controller, and PROM/RAM boards). The Extended Systems Monitor has been changed to accomodate this, and the version of the Monitor used with the Flashwriter board has been enhanced in other ways as well. The MDOS operating system and utilities have also been modified as required by the change, and two new utilities added.

Change the following in the manual text:

If your system is a System B, the Extended Systems Monitor Executive will prompt the operator with "MON>". In other systems, the Monitor prompt is still "*". Make this change in the text wherever you find it. It appears in many places.

Page **Change**

1-1 The system has a 64K board, not a 48K board. The user has access to 56K of this.

1-9 Change the chart as follows:

FF4Ø-FFFF	Monitor stack area (on PROM RAM board)
FCØØ-FF3F	RAM available to user (on PROM RAM board)
F8ØØ-FBFF	Disk Bootstrap ROM and Disk Controller RAM
FØØØ-F7FF	Flashwriter video buffer
ECØØ-EFFF	1K optional PROM
E8ØØ-EBFF	1K optional PROM
EØØØ-E7FF	Extended Systems Monitor
ØØØØ-EØØØ	56K available to user

1-1Ø Top of RAM is DFFF.

1-11 Remove NOESCAPE, change FLASH7 to FLASH8, add UPDATE-RES and WORM utilities (both type EC.)

UPDATE-RES is used to convert MDOS System Diskettes 8.4 and before into diskettes that can run on the Update-64 systems as the 8.5 diskette can. Simply put the diskette you want to update in drive Ø (remove any write protect tab), put the 8.5 diskette in drive 1, and type 1:UPDATE-RES (return) while in the MDOS Executive.

WORM is a utility which tests memory more thoroughly than any other test, including MDIAG. It erases all of memory, so make sure you have saved your data on a diskette before using it. To use, type WORM (return) while in the MDOS Executive. Allow it to repeat 5 times. It will report any errors in memory.

2-2 N causes EØØØ, not CØØØ, to be displayed if the system is working properly.

2-3 and 2-13 Some systems have a Bitstreamer I board and some systems have a Bitstreamer II board. All configuration instructions in Chapter II apply to the Bitstreamer I board. Consult the Bitstreamer II manual or Vector Graphic or its agents for instructions on interfacing with the Bitstreamer II. Basically, it has 3 serial ports (2&3, 4&5, 6&7) each having a data and a status port address, and 2 parallel ports (8 and 9.) Centronics drivers on the 8.5 MDOS Systems Diskette will not work with Bitstreamer II.

2-17 Remove section 2.3.7. (This is because the only way now to cause a return of control to the Extended Systems Monitor Executive is to press the RESET button on the computer chassis.)

3-3 Change section 3.7 to explain: Depress RESET on the computer chassis to return control to the Monitor Executive. Control-Q, ESC, and control-X will not work.

3-4 Change the reference to "control-Q" to "RESET button."

Change the title of section 3.1Ø to "ENTERING MDOS AND M.BASIC COMMANDS." Change the contents of the section to read "All operator entries to the MDOS and M.BASIC Executives can be edited with the BACK SPACE, DEL, underscore, or control-H keystrokes. Terminate every line by depressing the RETURN key. If desired, press control-T at almost any time to reverse the video image to black on white, or back again. Some other special keys, such as the arrow keys to move the cursor, may affect the screen image, but do not use them while in the MDOS or M.BASIC Executives because these keys may confuse the Executives. (Note that other Executives, such as the Extended Systems Monitor Executive and the Word Management System do allow use of some of these special keys.)"

4-1 Replace "ASSM" with "ZSM."

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appendices

E-1 Add remark: RES.I/O has been altered for the re-arranged board addressing. Hence, if you need it, list it using LINEEDIT, or assemble it using ZSM from the 8.5 MDOS System Diskette.

H-1 The instructions in this appendix only apply to the Bitstreamer I board.

I-1 Change CØØØ to EØØØ.

J-1 Change FLASH7 to FLASH8.

K-1 and K-2 The standard location is from F8ØØ-FBFF. A single jumper at W4 is the standard.

O-1 If the system has a Bitstreamer II board controlling a printer, use Bitstreamer base address of Ø for serial ports at 2 and 3, and use base address 4 for ports 6 and 7 (to control the printer.) (Do not worry about control of a serial terminal, if used. This is handled by the Extended Systems Monitor.)

If controlling a printer out of a Bitstreamer II parallel port, then do not use the standard drivers.

P-2 Add the following: Ports 8 and 9 are Bitstreamer II parallel ports. 4Ø is 64K and 16K bank select. 1Ø-14 are used by the Vector Graphic Precision Analog Board. The Tarbell Disk uses FC as well as its other port addresses.

Q-1 and Q-2 Change "48K" to "56K." To use the T command, enter T ØØØØ DFFF. MAP uses scratch pad FCØØ to FDFF in all systems now. Add explanation of WORM, taken from the explanation above in this errata.

I GENERAL INFORMATION

1.0 GENERAL DESCRIPTION OF SYSTEM AND SUBSYSTEMS

Your system is a general purpose microprocessor based computer. It is delivered by Vector Graphic completely assembled and fully tested, including both hardware and operating system software, and including two quad density mini-floppy disk drives.

1.0.1 STANDARD HARDWARE AND SOFTWARE

1) Chassis with power supply and 18 slot fully shielded S-100 motherboard;

2) 4 MHz Z-80 CPU board;

3) Two quad density Micropolis mini floppy disk drives, allowing 1232 256-byte sectors per diskette.

4) Disk controller board;

5) Bitstreamer I/O board;

6) 48K Dynamic RAM board;

7) PROM/RAM III board, with space for 12K of EPROM and the ability to program EPROM's (see the PROM/RAM III board manual).

8) The Vector Graphic Extended Systems Monitor, on PROM;

9) Two copies of the MDOS System Diskette, each containing:

   a) The Vector Graphic-enhanced Micropolis Disk Operating System - MDOS - a complete floppy diskette operating system, including a Z-80 Assembler, an editor, a debugger, and several other utilities (see Ch.4);

   b) Micropolis BASIC (see Ch. 5);

   c) A number of games and video displays (see Appendix J.)

1.0.2 OPTIONAL COMPONENTS AND SOFTWARE

Your MZ can be configured with various optional peripherals. Section 2.2 of this manual lists the configurations of printers and consoles considered "standard" for the MZ, and gives the components such as interface boards and cables needed for each configuration. In addition to the configurations discussed in Section 2.2, the following components can optionally be added to an MZ:

1) Additional Bitstreamer I/O board(s), such as the Bitstreamer II having three serial ports, two parallel ports, real-time

clock, and Z-80 interrupts.

2) Additional memory board(s);

3) Other S-100 compatible boards from Vector Graphic or other sources.

4) 2 additional Micropolis mini-floppy disk drives;

5) Other operating system and language software.

Contact your dealer for more information on adding components to the system.

1.1 MICROPOLIS FLOPPY DISKETTE SUBSYSTEM SPECIFICATIONS

1.1.1 PERFORMANCE

Capacity per drive: 315K bytes, formatted
Transfer rate: 250K bits/second
Average rotational latency time: 100 milliseconds
Access time - track-to-track : 30 milliseconds
settling time: 10 milliseconds
Head load time: 75 milliseconds
Head positioner: stepper motor with lead-screw drive
Drive motor start time: 1 second
Rotational speed: 300 RPM
Recording density 5248 bits per inch (BPI)
Recording mode: MFM
Track density: 100 tracks per inch (TPI)
Surfaces used per diskette: 1

1.1.2 DRIVE RELIABILITY

MTBF	8000 hrs.
MTTR	0.5 hrs.
Media life	3 X 10 EXP 6 passes on single track
Head life	10 EXP 4 hrs.
Soft error rate	1 in 10 EXP 9
Hard error rate	1 in 10 EXP 12
Seek error rate	1 in 10 EXP 6

1.2 HEXADECIMAL NOTATION

In this manual as in most microcomputer literature, the base 16 number system is used for all references to memory locations, instruction codes, character codes, and so on. If you are not familiar with it, you will soon find that the hexadecimal system is the most natural way to express these numbers when dealing with a computer that stores data as groups of 8 binary digits (bits) and memory addresses as groups of 16 bits. Hex numbers will be indicated by an upper case H following the digits. Remembering a few key values will make things a great deal easier:

HEX NUMBER	DECIMAL VALUE	JARGON	BINARY BITS
A	10		4
B	11		4
C	12		4
D	13		4
E	14		4
F	15		4
10	16		5
FF	255		8
100	256		9
3FF	1,023		10
400	1,024	1K	11
FFF	4,095		12
1000	4,096	4K	13
4000	16,384	16K	15
8000	32,768	32K	16
FFFF	65,535	64K-1	16

The familiar rules of arithmetic work just the same in hex as in decimal:

```
                          10       HEX (TRIVIAL)
                     40) 400
or
                          16       DECIMAL (MORE DIFFICULT)
                     64) 1024
                          64
                          384
                          384
                            0
```

1.3 OPERATING SYSTEM SOFTWARE

1.3.1 VECTOR GRAPHIC EXTENDED SYSTEMS MONITOR

The first program the user comes into contact with after turning on the system is the Vector Graphic Extended Systems Monitor. (Exception: this is not true for MEMORITE systems.) It is entirely stored on non-volatile PROM. Note that this use of the term "Monitor" has a meaning entirely different than the term "monitor", which refers to a piece of hardware, namely a stand-alone video display. (NOTE: in the MEMORITE system, the Extended Systems

Monitor is not encountered unless you press the RESET key; or touch the ESC key while the system is under control of MDOS or another NON-word processing operating system.)

The Monitor consists of two parts: first, the Extended Systems Monitor Executive, which allows the operator, through special commands, to manipulate and display memory data and to jump to some other program; second, a program used to control console I/O.

You know the Extended Systems Monitor Executive is in control of the system when the Monitor prompt (*) appears on the left edge of the screen. The operator is then expected to enter one of the commands available for manipulating or displaying memory or jumping to another program. Most often, the operator will use the command which calls up a full operating system and then transfers control to it, and out of the Monitor.

Regardless of whether executive is in control of the system at any given time, the Monitor console I/O routines, though invisible to the operator, are continually being called on to control the console. (Exception: when MEMORITE or the Word Management System are doing word processing, the Monitor is not used to control the console. Instead, the word processing software in these two systems handles this task.)

Some of the Monitor's features and commands are explained where relevent in this manual. A complete description is included as a separate manual with your system.

1.3.2 PROGRAM DEVELOPMENT SOFTWARE - "PDS"

The operating system found on the MDOS Systems Diskette included with the system is the Micropolis Diskette Operating System (MDOS). MDOS includes an assembly language program development package. Also found on the MDOS Systems Diskette is Micropolis Disk Extended BASIC (often called just M.BASIC). MDOS and M.BASIC together give all the functions a programmer may need for the development of either assembly language or BASIC programs.

1.3.3 ELEMENTS OF MDOS

MDOS consists of an executive program, a group of "shared" subroutines available to user programs as well as being used by MDOS, and various utilities which include assembly language program development tools.

The MDOS executive program allows the user to control computer system operations from the system console. It provides commands for memory management, file management, I/O control and program control.

The shared subroutines include those that provide for console and printer character I/O, buffered line I/O, text line parameter parsing, sequential and random file access, file management, physical diskette access, and 16 bit interger arithmetic. There are also a number of processor oriented utility subroutines.

The MDOS utilities are:

ZSM - a two pass, 8080/8085/Z80 disk to disk assembler program.

LINEEDIT - a line number oriented assembly language text editor with character-within-line editing and global search and change capabilities.

FILECOPY - a utility that copies disk files.

DISKCOPY - a utility that makes an exact copy of an entire diskette.

SYMSAVE - a utility that creates a source file of symbol equate statements from the symbol table left in memory immediately after an assembly by the ZSM assembler.

DEBUG - a utility that facilitates checkout and debugging of 8080/8085 machine language programs. It cannot be used if Z80 code which is not part of the 8080 set is used.

1.3.4 ELEMENTS OF M.BASIC

M.BASIC is a complete, self-contained software package that provides total support for BASIC programming. When M.BASIC is loaded you have at hand a powerful set of tools for developing, testing, executing and maintaining BASIC programs.

Program lines may be as long as 250 characters in length and may include multiple statements. The maximum line number is 65529.

M.BASIC has 12 immediate mode commands, including: SAVE a file, LOAD a file, DISPLAY the file directory, SCRATCH a file, LIST a program, DELETE lines from a program, RUN a program, CNTL/C to interrupt a running program, CONT to continue an interrupted program, CNTL/U to cancel an input line, and FLOW and NOFLOW to enable and disable the flow trace debugging aid.

M.BASIC supports 6 distinct data types, including integers, integer arrays, floating point numbers in the range 1E-61 to 1E62-1, string arrays, floating point arrays, and character strings up to 250 characters long. Integer and floating point arrays may have up to 4 dimensions. String arrays may have up to 3 dimensions plus a length parameter.

A unique SIZES statement enables you to select the precision of numeric variables up to 60 digits for simple arithmetic and 20 digits for transcendental functions. The system defaults to 8 digits for real numbers and 6 for integers.

M.BASIC supports numeric operators for addition, subtraction, multiplication, division, integer division, and exponentiation.

There are relational operators to compare numbers or strings and the logical operators AND, OR, and NOT. String concatenation is also available.

Numeric functions include ABS, ATN, COS, EXP, FIX, FRAC, INT, LN, LOG, MAX, MIN, MOD, RND, SGN, SQR, and TAN.

String functions include ASC, CHAR$, FMT, INDEX, LEFT$, LEN, MID$, MAX, MIN, REPEAT$, RIGHT$, STR$, VAL, VERIFY.

The unique FMT (X,Y$) function is the key to a powerful formatted output capability. It returns a string which is the value of X formatted per the image defined by format string Y$.

The DEF FN statement is provided to allow construction of user defined functions. An assembly language function may be accessed by using the DEF FA construction.

Standard statements in BASIC include CHAIN, DATA, DEF, DIM, EDIT, END, EXEC, FOR-NEXT-STEP, GOSUB, GOTO, IF-THEN, INPUT, LET, MEMEND, MERGE, NOFLOW, FLOW, ON-GOTO, ON-GOSUB, OUT, PLOADG, POKE, PRINT, READ, REM, RENUM, RESTORE, RETURN, SIZES, STOP, and STRING.

The CHAIN is a true chain that passes variables from the current program segment to next one loaded from disk.

EXEC is a unique statement that allows a string variable or constant to be executed as if it were a predefined program line.

Data file programming in M.BASIC is simple. Files can be opened simultaneously for both sequential and direct (random) access in both read and write modes. Up to 10 files can be open at one time. A CLEAR option allows a file to be opened for rewrite instead of append. An END option provides an on-endfile-goto capability. An ERROR option provides an on-error-goto capability.

Data is written to and read from files using GET and PUT statements with variable lists that allow a mixture of numeric and string variables.

The file I/O structure also extends to printer and console output files to afford a high degree of device independence. Additional options on the OPEN statement facilitate the pagination of output reports.

Also provided is a BASIC Utility program that provides for initializing diskettes, saving M.BASIC on a BASIC-only diskette, and examining and changing RAM memory. In addition, there is a utility called FEATURES which allows you to shorten M.BASIC by eliminating some of the features needed only for program development, but not for running production programs.

1.3.5 OTHER OPERATING SYSTEMS

Other operating systems and higher level languages are available from Vector Graphic. These will not be discussed here. (See the literature accompanying this manual.) MDOS and M. BASIC meet the needs of the large majority of users.

1.3.6 RESIDENT PROGRAMS

MDOS and M.BASIC share the Extended Systems Monitor. They also share a common program module called RES. This module contains among other routines, the printer and diskette I/O routines, and some of the console I/O routines.

Also shared is the ROM resident Disk Bootstrap program, (which is what the Monitor uses in order to call up MDOS), and the Disk Controller, (which is simply memory space needed to handle the diskette drives.)

These routines are always resident in the computer memory when either MDOS or M.BASIC is running. For interested users, listings will be found in Appendix E for the I/O portion of RES, Appendix F for the Disk Bootstrap program, and the Extended Systems Monitor manual for the Monitor.

In contrast, MDOS and M.BASIC overlay each other; that is, they are assigned the same area of memory; only one can be in memory at any given time. Commands are provided for leaving one and calling up the other.

Fig. 1.1 illustrates the relationships between the various system programs. Programs which are always in memory when MDOS or M.BASIC is used are in the center.

Fig. 1.2 gives the addresses of the various programs and important memory locations in your system. No particular operating system is shown.

Fig. 1.3 gives addresses for MDOS and M. BASIC. Note that this operating system software fits into the unassigned memory area in Fig. 1.2.

FIGURE 1.1 MZ SOFTWARE STRUCTURE USING MDOS

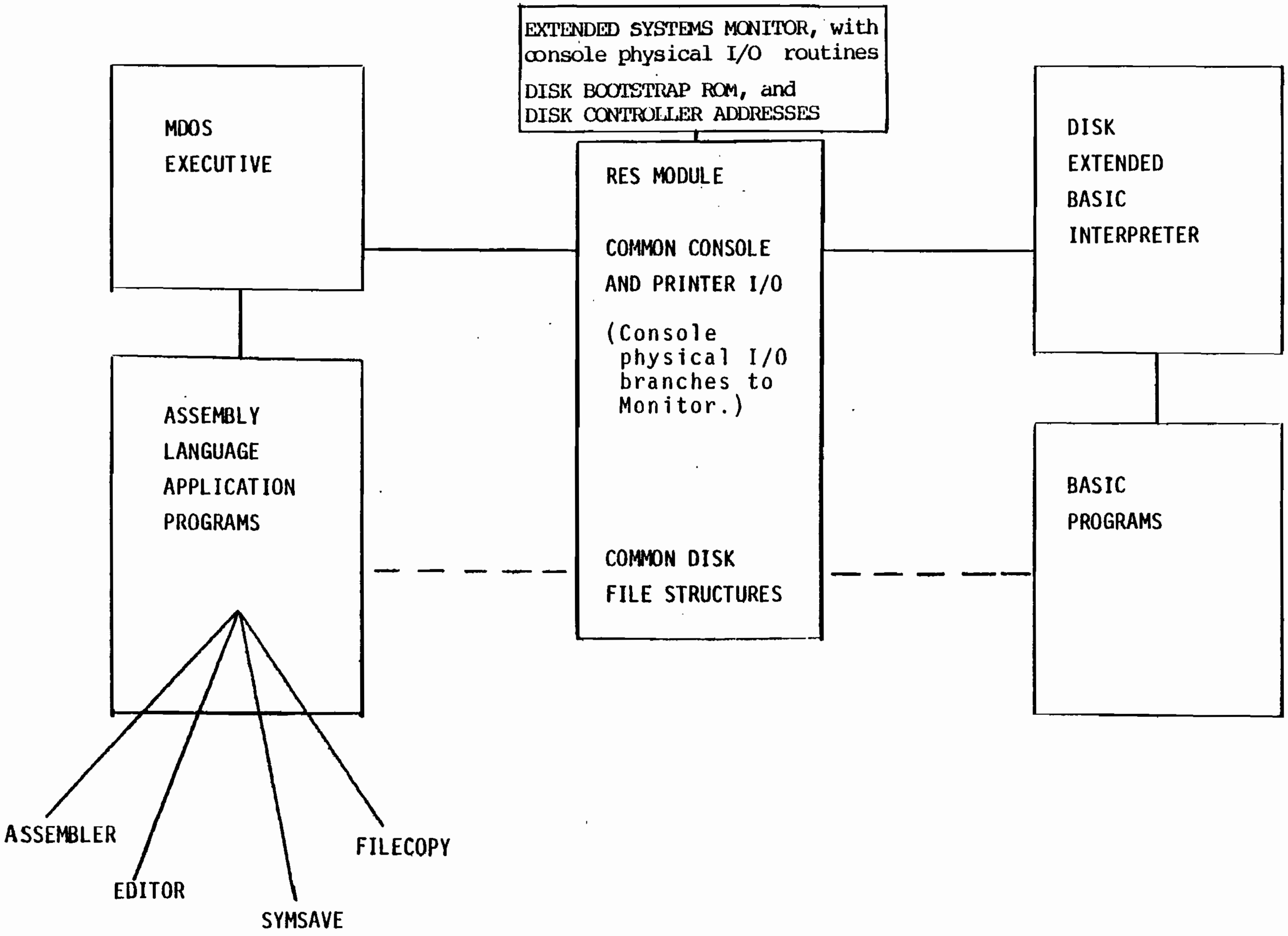
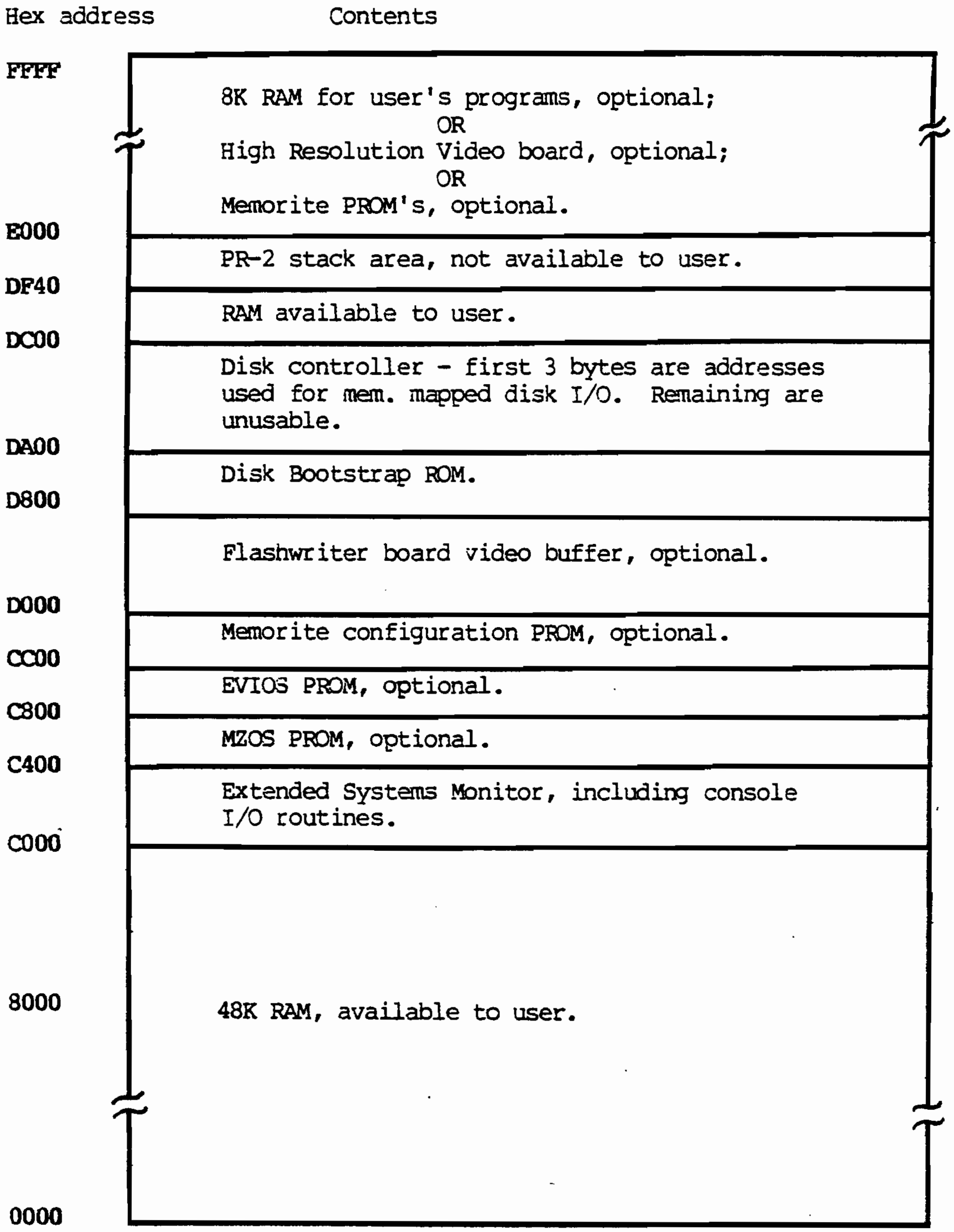

EXTENDED SYSTEMS MONITOR, with console physical I/O routines
DISK BOOTSTRAP ROM, and DISK CONTROLLER ADDRESSES
MDOS EXECUTIVE
RES MODULE
COMMON CONSOLE AND PRINTER I/O
(Console physical I/O branches to Monitor.)
COMMON DISK FILE STRUCTURES
DISK EXTENDED BASIC INTERPRETER
ASSEMBLY LANGUAGE APPLICATION PROGRAMS
BASIC PROGRAMS
ASSEMBLER
EDITOR
SYMSAVE
FILECOPY

FIG 1.2 MEMORY MAP FOR VECTOR GRAPHIC SYSTEMS



Hex address

Contents

FFFF

8K RAM for user's programs, optional;
OR
High Resolution Video board, optional;
OR
Memorite PROM's, optional.

E000

PR-2 stack area, not available to user.

DF40

RAM available to user.

DC00

Disk controller - first 3 bytes are addresses used for mem. mapped disk I/O. Remaining are unusable.

DA00

Disk Bootstrap ROM.

D800

Flashwriter board video buffer, optional.

D000

Memorite configuration PROM, optional.

CC00

EVIOS PROM, optional.

C800

MZOS PROM, optional.

C400

Extended Systems Monitor, including console I/O routines.

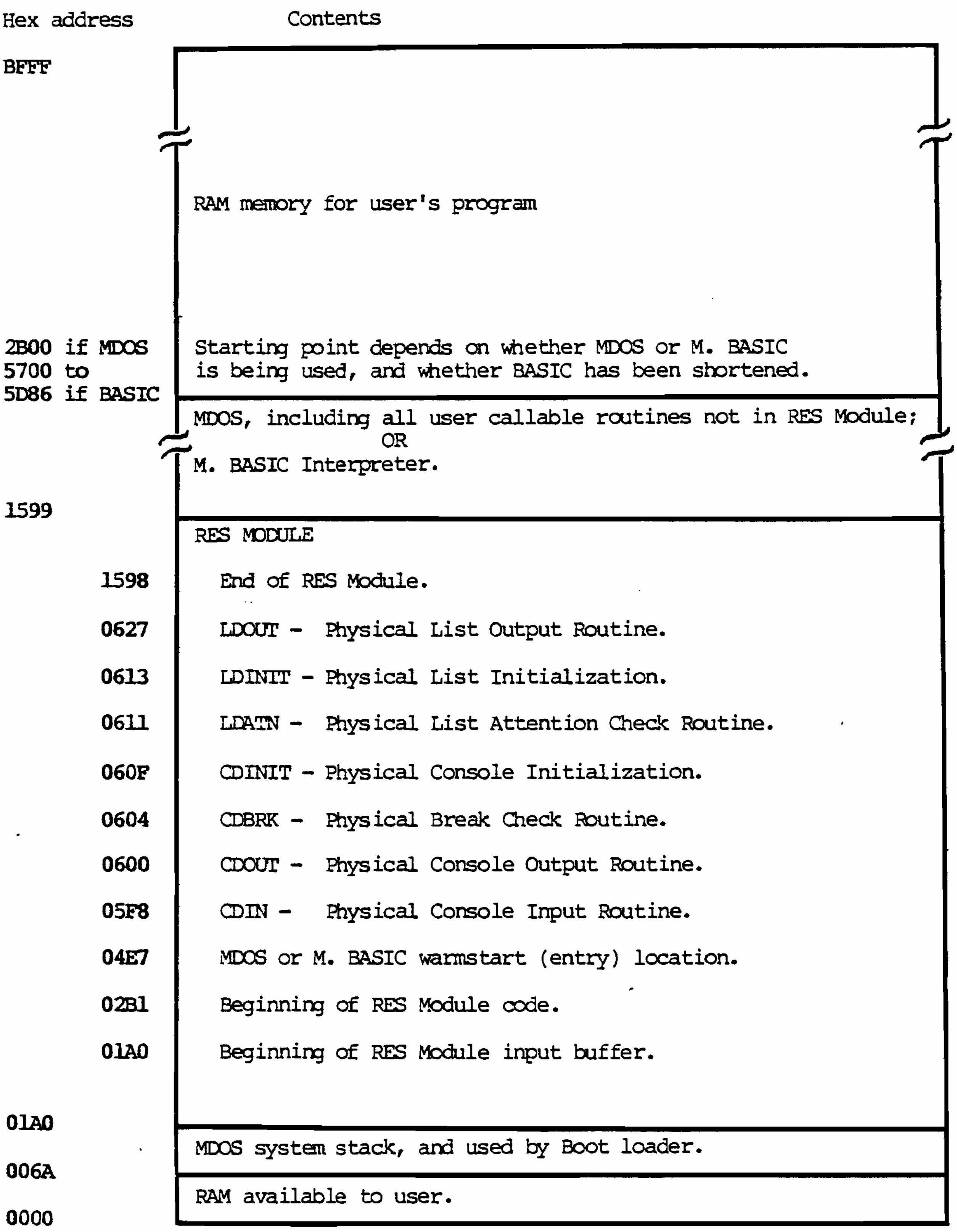
C000

8000

48K RAM, available to user.

0000

FIG 1.3 MEMORY MAP FOR MDOS AND M. BASIC



Hex address Contents

BFFF

RAM memory for user's program

2B00 if MDOS
5700 to
5D86 if BASIC

Starting point depends on whether MDOS or M. BASIC is being used, and whether BASIC has been shortened.

MDOS, including all user callable routines not in RES Module;
OR
M. BASIC Interpreter.

1599

RES MODULE

1598 End of RES Module.

0627 LDOUT - Physical List Output Routine.

0613 LDINIT - Physical List Initialization.

0611 LDATN - Physical List Attention Check Routine.

060F CDINIT - Physical Console Initialization.

0604 CDBRK - Physical Break Check Routine.

0600 CDOUT - Physical Console Output Routine.

05F8 CDIN - Physical Console Input Routine.

04E7 MDOS or M. BASIC warmstart (entry) location.

02B1 Beginning of RES Module code.

01A0 Beginning of RES Module input buffer.

01A0

MDOS system stack, and used by Boot loader.

006A

RAM available to user.

0000

1.4 MDOS SYSTEM DISKETTE

This revision of the User's Guide to Vector Graphics Systems Using MDOS corresponds to MDOS System Diskette 8.4, (and minor revisions of it labeled 8.4.1, 8.4.2, etc.) Following is a list of the files on this diskette:

(Under TYPE, "EC" means the file is stored in executable machine language code and it will be executed immediately if you type its name after the MDOS prompt. "AL" means the file is stored in assembly language source code. You must first assemble it using ZSM before it can be executed by the computer. "B" means the file is stored in the M.BASIC language. It will be executed by using the M.BASIC interpreter explained in chapter 5.)

NAME	DESCRIPTION	TYPE
DIR	The disk directory.	
RES	Machine language routines used by both MDOS and M.BASIC Do not delete it unless you are modifying it.	
MDOS	MDOS executive and disk I/O routines. Do not delete this. See Appendix B to create a BASIC-only diskette.	
BASIC	M.BASIC interpreter and disk I/O. See Chapter 5.	EC
LINEEDIT	Line editor for writing assembly language. programs. See Section 4.4.	EC
ZSM	Assembler of Z-80 code prepared in extended 8080 mnemonics. See Section 4.5.	EC
SYMSAVE	Utility which creates a source file of equate statements using the symbol table resulting from an assembly. See Section 4.6. Used occasionally by assembly language programmers.	EC
FILECOPY	Utility for copying a file from one drive to another. See Secton 4.7. Used often.	EC
DISKCOPY	Utility for copying a disk from one drive to another. See Section 4.8. Used often.	EC
COPYFILE	Utility for copying a file from one disk to another, using the SAME drive, for systems having only one drive. See Section 4.10.	EC
DEBUG-GEN	Utility used to generate the DEBUG utility residing in a particular portion of memory. See Section 4.11.	EC
FEATURES	Utility used to shorten BASIC. See Appendix G.	EC

NAME	DESCRIPTION	TYPE
SYSQ1, and SYSQ2	Assembly language source code containing the names of all MDOS shared subroutines, equated to their addresses. Used in assembly language programs calling those routines. See Section 4.3. Used from time to time by assembly language programmers.	AL
UTILITY	A utility used to initialize diskettes, create BASIC-only diskettes, and examine memory. See Appendix B.	B
RES.I/O	The source code file of the I/O routines in RES. Used to rewrite the I/O routines if using non-standard peripherals. See Appendices M, N, and O.	AL
DIAB	Routine for interfacing to Diablo-protocol printers if the Bitstreamer board is addressed for ports 0 - 3. Overlays directly over RES in memory. See Section 2.2.2. Not needed after RES is saved on diskette.	EC
DIAB4	Same as DIAB, but Bitstreamer is at 4 - 7.	EC
CENT	Same as DIAB, but for Centronics printers.	EC
CENT4	Same as CENT, but Bitstreamer is at 4 - 7.	EC
DECW	Same as DIAB, but for teletype-protocol printers.	EC
DECW4	Same as DECW, but Bitstreamer is at 4 - 7.	EC
SAVERES	Utility used to save on disk the machine language version of the I/O portion of the RES Module. See Section 2.2.0. Not needed after the RES Module is finalized.	EC
NOESCAPE	Utility which stops the ESC key from causing control to be passed to the Systems Monitor. See Section 2.3.7. Not needed after used once.	EC
MDIAG	Utility used to check the computer's memory. See Appendix Q. Do not delete this.	EC
MAP	Utility which tells what kind of memory (RAM, ROM or nothing) is in the system at each address. See Appendix Q. Useful when servicing a system.	EC
FLASH7	Demonstration of the graphics capability of the Flashwriter II board. See Appendix J. Dealers use often.	EC
PROM	Utility used with the PROM/RAM III board to program EPROM's. See PROM/RAM III manual.	EC
STARTREKG	The Star Trek game. See Appendix J. Dealers use often. Others if they like it.	B
CIVILWAR	Another game. See Appendix J.	B
LUNAR	Another game. See Appendix J.	B
FINANCE	Day-to-day financial calculations. See Appendix J. Used often if you need it.	B

To obtain a list of the files on your diskette, to see what is actually there, turn the machine on, mount the system diskette in drive 0 (right-hand drive), type B after the Monitor prompt (*), type FILES after the MDOS prompt (>), and then press the RETURN key. The interaction looks like this on the screen:

```
*B
Vector MZ MDOS X.XX
>FILES
DIR          03  0000
RES          03  0014
        .
        .
        .
```

The left-hand number refers to the file type, explained in Section 4.2.3. The right-hand number gives the length of the file in sectors. Both numbers are in hexadecimal (base 16).

The list is long and will roll past the edge of the screen. To stop it at any point, depress control-S (CTRL key and S at the same time.) To start it up again, depress the spacebar.

If you have a printer which is up and running with your system, you can print the directory by typing ASSIGN 2,3 (return), before you type FILES. After the directory is printed, type ASSIGN 2,2 (return) to turn the printer off again. "(return)" means press the RETURN key.

II INSTALLATION, CONFIGURING PERIPHERALS, AND USE OF DISKETTES

2.1 INSTALLATION

For turn-key systems (that is, all internal wiring and software modifications have been done prior to delivery), just plug in external cables to the sockets on the rear panel of the mainframe. End users: if sockets are not labeled and choice is not obvious, ask your dealer.

For non-turn-key systems, refer to Section 2.2 for directions on setting up peripherals, interface boards, cables, and interface software. For systems with which a printer will be used, it may be desirable to first set the system up as if there were no printer, test it as explained below, then complete the setting up procedures for the printer. Section 2.2 separates the 2 stages.

When ready to test the system, do as follows:

1. Turn the power key on the front panel and then turn on peripherals. The Monitor prompt * should appear on the screen. (Exception: in MEMORITE systems, depress RESET on the front panel after turning the power on. The Monitor prompt should then appear.)

2. Enter N on the keyboard. This is a memory test which also functions as a test of the console. After a few seconds a hexadecimal number should appear. It indicates the first memory address where no memory hardware is located. In normal systems with 48K of RAM, the number should be C000.

3. Insert and mount the MDOS Personalized System Diskette in drive 0. Drive 0 is the right-hand drive. The left-hand drive is drive 1. Refer to Section 2.4 for how to insert, mount, and in general handle diskettes.

4. Enter B. This causes MDOS to be loaded and take control. This will be indicated by the MDOS sign on message and the MDOS prompt: >.

5. To test a separate printer, if any, first make sure there is paper in the printer. Then, enter ASSIGN 2,3 (return), followed by FILES (return). (The expression (return) always means "press the RETURN key."). A list of the files on the System Diskette will be printed.

When the system is working properly, refer to Chapter 3 for a complete description of normal operating procedures, and to Section 2.4 for instructions on the handling and maintenance of diskettes. Do not neglect either Section 2.4 or Chapter 3 as they contain information which is not effectively acquired by trial and error alone. Section 2.3 describes various modifications which can be made to the hardware.

alone. Section 2.3 describes various modifications which can be made to the hardware and systems software.

2.2 CONFIGURING THE MZ - THIS SECTION FOR NON-TURN-KEY SYSTEMS ONLY

2.2.0 MODIFYING THE RES MODULE

At various points in this chapter (or in related appendices) you will be instructed to carry out procedures which modify the RES Module. The most common of such procedures are the Software Implementation Procedures found in section 2.2.1 under each of the standard configurations. (These Software Implementation Procedures are used only if a printer is implemented.)

To carry out any procedure which modifies the RES Module, turn the system and all peripherals on. In MEMORITE systems, depress the RESET button next. Then insert and mount the Personalized MDOS System Diskette in drive 0. Do not use the Master MDOS System Diskette. This diskette should never be altered and only used for emergency back-up. After the Monitor prompts with *, enter B. This "boots up" MDOS, as indicated by the MDOS sign-on message and MDOS prompt: >. Now proceed with the given procedure.

Note that in all software procedures, "(return)" means "press the RETURN key."

The user may be instructed to enter a command, such as DIAB4 (return). Whenever such a command is entered, the system will respond by displaying the MDOS sign-on message again, or at least the MDOS prompt >.

A step will be found which commands "Save the RES Module on Personalized System Diskette." This is accomplished as follows: Make sure the Personalized MDOS System Diskette is inserted and mounted in drive 0. Then under MDOS type SAVERES (return). The drive should write on the diskette. The RES Module is now saved on the Personalized MDOS System Diskette.

Important: You may want to do several different procedures, each of which terminates with saving the RES Module. You are definitely free to do any group of them at one sitting, and then save the RES Module as described above ONCE at the end of the session, in order to save trouble. Alternately, you may of course save the RES Module after each such procedure, if desired.

Note: SAVERES is a utility which saves on diskette the I/O portion of the RES Module, in machine language form. The block of code which is saved corresponds to the code found in the source listing called RES.I/O, plus a few bytes before and after. In the rare case you have modified the RES Module outside of the I/O portion, then you must use the following alternate steps to save the RES Module: Under MDOS, enter TYPE "RES" Ø (return) SCRATCH "RES" (return) SAVE "RES" 2B1 1598 3 (return).

2.2.1 STANDARD CONFIGURATIONS

At this time, Vector Graphic supplies the interface hardware and software to support several different configurations of main peripheral devices, that is, printers, keyboards, video displays, and terminals. This section is concerned with identifying these standard configurations, and explaining how they are implemented.

If the peripheral device desired is not found among the standard configurations, refer to Section 2.2.3.

The information is collected in the following pages. Each section is concerned with one configuration. Each configuration is a selected group of peripherals. Peripherals are listed as generic types, (upper case lettering). Specific makes are given as examples, (lower case lettering). The user is not limited to these examples, but can use any model that falls within the given generic description.

To use these charts, find the configuration desired. When ordering an MZ or other Vector Graphic computer, order it with the components listed as well as the peripherals desired if supplied by Vector Graphic. (Since all systems are always delivered with one Bitstreamer board and an I/O cable, do not explicity order these items.)

If no printer is being used, find the desired configuration ignoring the type of printer listed. For this purpose, refer only to those configurations whose headings are NOT preceded by asterisks(*). Then, only order the parts and carry out the steps shown WITHOUT asterisks.

If a printer is being added to an existing system, find the desired configuration, then only order the parts and carry out the steps shown WITH an asterisk (*). To obtain a useful summary of the issues involved with printers, see seciton 2.2.2

Some systems may already be partially configured at the factory or by intermediaries, so that you need order and set up only the components not already included. For example, **"System B"** is an MZ with the Vector Graphic Mindless Terminal and Flashwriter II board. All you have to add is a printer. Your choices would be the configurations in Sections 2.2.1.4 and 2.2.1.6 for Centronics or Diablo-type printers respectively. MEMORITE is even simpler than a System B. Just do the Software Implementation procedure in Section 2.2.1.6, using the DIAB4 command.

Flashwriter Board: The charts refer to a "Flashwriter Board." Order a Flashwriter I for 16 x 64 display and Flashwriter II for 80 X 24 display. When ordering an Extended Systems Monitor for use with one of these boards, always state which it is for.

When your system and/or components are delivered, refer again to the chart. Perform the implementation procedures listed in order to implement the desired configuration.

* 2.2.1.1 Printer: PARALLEL, CENTRONICS 700 SERIES PROTOCOL. Console: SERIAL VIDEO TERMINAL.

Example: Parallel Centronics matrix printer (700 Series), and Hazeltine terminal.

Interface Components Required

1. Option C Extended Systems Monitor, on PROM.
* 2. Centronics interfacing kit
3. Bitstreamer board and I/O cable (no need to order; included in system automatically.)

Hardware Implementation Procedures

* 1. Install the Centronics interfacing kit as instructed in Appendix H. Make sure there is an I/O cable connected at one end to J3 on the Bitstreamer board and at the other end installed in one of the cutouts at the rear of the mainframe.

2. Plug the external terminal cable into the socket on the rear of the mainframe which is wired to the 6 pin molex connector on the Bitstreamer board.

* 3. Plug the printer cable into the socket which is wired to J3 on the Bitstreamer board.

Software Implementation Procedures

* 1. Under MDOS, enter CENT (return).

* 2. Save RES Module on Personalized System Diskette.

2.2.1.2 Printer: SERIAL, DIABLO 1610 OR TELETYPE PROTOCOL. Console: SERIAL VIDEO TERMINAL.

Example: Printer: if Diablo protocol - Diablo 1610 or 1620, Qume Sprint 5, or NEC Spinwriter; if Teletype protocol - Decwriter, Teletype, or TI 810 or 820.
Console: Hazeltine terminal.

Interface Components Required

1. Option C Extended Systems Monitor, on PROM
2. Bitstreamer board and I/O cable (no need to order; included in system automaticelly.)
* 3. A second Bitstreamer board
* 4. A second I/O cable

Hardware Implementation Procedures

* 1. Jumper one of the Bitstreamer boards so that it is readdressed for ports 4 - 7 rather than the original 0 - 1. Instructions will be found in the Bitstreamer User's

Manual. This board will be used to control the printer.

* 2. Make sure that the printer is set for its highest speed, (1200 baud for Diablo 1610 protocol), and that its parity setting is MARK parity. Check the printer manual if necessary. Some printers such as the Diablo require a jumper on internal circuitry to increase from 300 baud to 1200 baud.

* 3. Make sure that the Bitstreamer board is set for the same speed as the printer. This is set on a dipswitch on the upper left-hand corner of the board. Press the appropriate switch in and upward and make sure all other switches are pressed downward.

4. Connect one of the I/O cables to J3 on one of the Bitstreamer boards. Install the 25 pin socket on the other end of the cable in a cutout at the rear of the mainframe.

* 5. Do step 4 for the second Bitstreamer and I/O cable.

* 6. Plug the printer cable into the socket connected to the <u>readdressed</u> Bitstreamer.

7. Plug the terminal cable into the socket connected to the normal Bitstreamer. IMPORTANT: Some terminals will not operate if they are connected to all 25 pins, because some of the pins of J3 on the Bitstreamer have functions other than serial communications. If your terminal does not operate after connecting it to all pins, then connect only the essential ones. Example: the Hazeltine 1400 will function only if a 3-line cable is used, connecting pins 2,3, and 7. A 25 pin ribbon connector will not work. Other terminals may require additional pins, but again not all 25. Refer to the Bitstreamer board manual if necessary for definitions of each of the pins on the backpanel connector.

Software Implementation Procedures

* 1. Under MDOS, if printer uses Diablo protocol, enter <u>DIAB4 (return)</u>; if printer uses Teletype protocol, enter <u>DECW4 (return)</u>.

* 2. Save RES Module on Personalized System Diskette.

* 2.2.1.3 Printer: PARALLEL, CENTRONICS 700 SERIES PROTOCOL Console: PARALLEL ASCII KEYBOARD, SEPARATE VIDEO MONITOR.

Example: Printer: Parallel Centronics matrix printer (Series 700)
Console: Vector Graphic stand-alone parallel keyboard and Hitachi video monitor.

Interface Components Required

1. Option EV Extended Systems Monitor on PROM
2. Flashwriter board
3. I/O cable
4. Video cable, for Flashwriter to rear panel
5. Video monitor to mainframe cable
* 6. Centronics interface kit
* 7. Bitstreamer board with I/O cable (no need to order; included in system automatically.)

Hardware Implementation Procedures

* 1. Jumper the Bitstreamer board so that it is readdressed for ports 4 - 7 rather than the original 0 - 1. Instructions will be found in the Bitstreamer User's Manual.

* 2. Install the Centronics interfacing kit as instructed in Appendix H. However, do not install the 6 pin molex connector or the serial I/O cable which come in the Centronics interface kit. They are not needed and can be set aside. Make sure that there is a regular I/O cable connected to J3 on the Bitstreamer board and installed at the other end in a cutout at the rear of the mainframe. This socket will be used for the printer cable.

3. Connect the 2 pin socket at one end of the video cable to the 2 left-most pins which will be found rising vertically from the left-hand corner of the Flashwriter board. The socket should be positioned so that the inside wire is connected to pin 1, and the outside "shield" wire is connected to pin 2 (ground). Install the circular socket at the other end of the cable into one of the circular cutouts at the rear of the mainframe.

4. Connect the 24 pin dip plug at one end of the second I/O cable to J1 on the Flashwriter board. Install the 25 pin socket at the other end in one of the cutouts at the rear of the mainframe. This socket will be for the keyboard cable.

* 5. Plug the printer cable into the appropriate sockets on the rear of the mainframe.

6. Plug the external keyboard and monitor cables into the appropriate sockets on the rear of the mainframe.

Software Installation Procedures

* 1. Under MDOS, enter CENT4 (return).

* 2. Save RES module on Personalized System Diskette.

* 2.2.1.4 Printer: PARALLEL, CENTRONICS SERIES 700 PROTOCOL. Console: VECTOR GRAPHIC MINDLESS TERMINAL.

Example: Parallel Centronics matrix printer (Series 700) and Vector Graphic Mindless Terminal.

Interface Components Required

1. Option EV Extended Systems Monitor on PROM
2. Flashwriter board
3. Mindless Terminal 3-part I/O cable
4. External Mindless Terminal cable (or equivalent)

* 5. Centronics interface kit

* 6. Bitstreamer board with I/O cable (no need to order; included in system automatically.)

Hardware Implementation Procedures

* 1. Jumper the Bitstreamer board so that it is readdressed for ports 4 - 7 rather than the original 0 - 1. Instructions will be found in the Bitstreamer User's Manual.

* 2. Install the Centronics interfacing kit as instructed in Appendix H. However, do not install the 6 pin molex connector or the serial (3 wire) I/O cable which come in the Centronics interface kit. They are not needed and can be set aside. Make sure that there is a regular I/O cable connected to J3 on the Bitstreamer board and installed at the other end in a cutout at the rear of the mainframe. This socket will be used for the printer cable.

3. If not already done at the factory, install the Mindless Terminal 3-part I/O cable as instructed in the terminal's documentation. The 3 parts are connected to the power supply, the Flashwriter board video output pins, and the Flashwriter board keyboard input socket (J1). At the other end, the DB25 socket is installed in one of the cutouts at the rear of the mainframe.

* 4. Plug the printer external cable into the respective socket at the rear of the mainframe.

5. Plug the terminal external cable into the respective socket at the rear of the mainframe.

Software Installation Procedures

* 1. Under MDOS, enter CENT4 (return).

* 2. Save RES module on Personalized System Diskette.

2.2.1.5 Printer: SERIAL, DIABLO 1610 or TELETYPE PROTOCOL Console: PARALLEL ASCII KEYBOARD, SEPARATE VIDEO MONITOR.

Example: Printer: if Diablo protocol - Diablo 1610 or 1620, Qume Sprint 5, or NEC Spinwriter; if Teletype protocol - Decwriter, Teletype, or TI 810 or 820.

Console: a Vector Graphic stand-alone parallel keyboard and Hitachi video monitor.

Interface Components Required

1. Option EV Extended Systems Monitor on PROM
2. Flashwriter board
3. I/O cable
4. Video cable, Flashwriter to rear panel
5. Video monitor to mainframe cable
6. * Bitstreamer board with I/O cable (no need to order; included in system automatically.)

Hardware Implementation Procedures

1. If no printer is being used, remove the Bitstreamer from the mainframe, and do not put it back in. It cannot be in the system (unless readdressed as explained below.)

* 2. Jumper the Bitstreamer board so that it is readdressed for ports 4 - 7 rather than the original 0 - 1. Instructions will be found in the Bitstreamer User's Manual.

* 3. Make sure that the printer is set for its highest speed, (1200 baud for Diablo 1610 protocol), and that its parity setting is MARK parity. Check the printer manual if necessary. Some printers such as the Diablo require a jumper on internal circuitry to increase from 300 baud to 1200 baud.

* 4. Make sure that the Bitstreamer board is set for the same speed as the printer. This is set on a dipswitch on the upper left-hand corner of the board. Press the appropriate switch in and upward and make sure all other switches are pressed downward.

* 5. Make sure that there is a regular I/O cable connected to J3 on the Bitstreamer board and installed at the other end in a cutout at the rear of the mainframe. This socket will be used for the printer cable.

6. Connect the 2 pin socket at one end of the video cable to the 2 left-most pins which will be found rising vertically from the left-hand corner of the Flashwriter board. Install the circular socket at the other end of the cable

into one of the circular cutouts at the rear of the mainframe.

7. Connect the 24 pin dip plug at one end of the second I/O cable to J1 on the Flashwriter board. Install the 25 pin socket at the other end in one of the cutouts at the rear of the mainframe. This socket will be for the keyboard cable.

* 8. Plug the printer external cable into the appropriate socket on the rear of the mainframe.

9. Plug the keyboard and monitor external cables in the appropriate sockets on the rear of the mainframe.

Software Installation Procedures

* 1. Under MDOS, if printer uses Diablo protocol, enter DIAB4 (return); if printer uses Teletype protocol, enter DECW4 (return).

* 2. Save RES module on Personalized System Diskette

2.2.1.6 Printer: SERIAL, DIABLO 1610 or TELETYPE PROTOCOL. Console: VECTOR GRAPHIC MINDLESS TERMINAL.

Example: Printer: if Diablo protocol - Diablo 1610 or 1620, Qume Sprint 5, or NEC Sprinwriter; if Teletype protocol - Decwriter, Teletype, or TI 810 or 820.
Console: Vector Graphic Mindless Terminal.

Interface Components Required

1. Option EV Extended Systems Monitor on PROM
2. Flashwriter board
3. Mindless Terminal 3-part I/O cable
4. External Mindless Terminal cable (or equivalent)

* 5. Bitstreamer board with I/O cable (no need to order; included in system automatically.)

Hardware Implementation Procedures

1. If no printer is being used, remove the Bitstreamer from the mainframe. Do not put it back in. It cannot be in the system.

* 2. Jumper the Bitstreamer board so that it is readdressed for ports 4 - 7 rather than the original 0 - 1. Instructions will be found in the Bitstreamer User's Manual.

* 2. Make sure that the printer is set for its highest speed, (1200 baud for Diablo 1610 protocol), and that its parity setting is MARK parity. Check the printer manual if

necessary. Some printers such as the Diablo require a jumper on internal circuitry to increase from 300 baud to 1200 baud.

* 4. Make sure that the Bitstreamer board is set for the same speed as the printer. This is set on a dipswitch on the upper left-hand corner of the board. Press the appropriate switch in and upward and make sure all other switches are pressed downward.

* 5. Make sure that there is a regular I/O cable connected to J3 on the Bitstreamer board and installed at the other end in a cutout at the rear of the mainframe. This socket will be used for the printer cable.

6. If not already done at the factory, install the Mindless Terminal 3-part I/O cable as instructed in the terminal's documentation. The 3 parts are connected to the power supply, the Flashwriter board video output pins, and the Flashwriter board keyboard input socket (J1). At the other end, the DB25 socket is installed in one of the cutouts at the rear of the mainframe.

* 7. Plug the printer external cable into the respective socket at the rear of the mainframe.

8. Plug the terminal external cable into its socket at the rear of the mainframe.

Software Installation Procedures

* 1. Under MDOS, if printer uses Diablo protocol, enter <u>DIAB4 (return)</u>; if printer uses Teletype protocol, enter <u>DECW4 (return)</u>.

* 2. Save RES module on Personalized System Diskette.

* 2.2.1.7 SERIAL PRINTING TERMINAL (HAS A KEYBOARD), DIABLO 1610 OR TELETYPE PROTOCOL AND A VIDEO MONITOR

Example: Printing terminal: if Diablo protocol - Diablo 1620, Qume Sprint 5 with keyboard, or NEC Sprinwriter with keyboard; if Teletype protocol - Decwriter, Teletype, or TI 810 or 820, with keyboards;
Video monitor: Hitachi.

Interface Components Required

1. Option CV Extended Systems Monitor on PROM
2. Flashwriter board
3. Video cable, Flashwriter to rear panel
4. Video Monitor to Mainframe cable

* 5. Bitstreamer board with I/O cable (no need to order; included in system automatically.)

Hardware Implementation Procedures

* 1. Make sure that the printer is set for its highest speed, (1200 baud for Diablo 1610 protocol), and that its parity setting is MARK parity. Check the printer manual if necessary. Some printers such as the Diablo require a jumper on internal circuitry to increase from 300 baud to 1200 baud.

* 2. Make sure that the Bitstreamer board is set for the same speed as the printer. This is set on a dipswitch on the upper left-hand corner of the board. Press the appropriate switch in and upward and make sure all other switches are pressed downward.

* 3. Make sure that there is a regular I/O cable connected to J3 on the Bitstreamer board and installed at the other end in a cutout at the rear of the mainframe. This socket will be used for the printer cable.

* 4. Disable the parallel port on the Flashwriter board. To do this, simply remove chip U52 from the board, using a small screw driver to pry it out of its socket. If U52 cannot be easily located, refer to the Flashwriter User's Manual.

5. Connect the 2 pin socket at one end of the video cable to the 2 left-most pins which will be found rising vertically from the left-hand corner of the Flashwriter board. The socket should be positioned so that the inside wire is connected to pin 1, and the outside "shield" wire is connected to pin 2 (ground). Install the circular socket at the other end of the cable into one of the circular cutouts at the rear of the mainframe.

* 6. Plug the printer external cable into the socket on the rear of the mainframe.

7. Plug the monitor external cable into the appropriate socket on the rear of the mainframe.

Software Installation Procedures

* 1. Under MDOS, if printer uses Diablo protocol, enter DIAB (return); if printer used Teletype protocol, enter DECW (return).

* 2. Save RES module on Personalized Diskette.

* 2.2.1.8 SERIAL PRINTING TERMINAL (HAS KEYBOARD), DIABLO 1610 OR TELETYPE PROTOCOL NO VIDEO.

Example: Printing terminal: if Diablo protocol - Diablo 1620, Qume Sprint 5 with keyboard, or NEC Sprinwriter with keyboard; if Teletype protocol - Decwriter, Teletype, or TI 810 or 820, with keyboards;

Interface Components Required

1. Option C Extended Systems Monitor on PROM

* 2. Bitstreamer board with I/O cable (no need to order; included in system automatically.)

Hardware Implementation Procedures

* 1. Make sure that the printer is set for its highest speed, (1200 baud for Diablo 1610 protocol), and that its parity setting is MARK parity. Check the printer manual if necessary. Some printers such as the Diablo require a jumper on internal circuitry to increase from 300 baud to 1200 baud.

* 2. Make sure that the Bitstreamer board is set for the same speed as the printer. This is set on a dipswitch on the upper left-hand corner of the board. Press the appropriate switch in and upward and make sure all other switches are pressed downward.

* 3. Make sure that there is a regular I/O cable connected to J3 on the Bitstreamer board and installed at the other end in a cutout at the rear of the mainframe. This socket will be used for the printer cable.

* 4. Plug the printer cable into the socket at the rear of the mainframe.

Software Implementation Procedures

* 1. Under MDOS, if printer uses Diablo protocol, enter DIAB (return); if printer uses Teletype protocol, enter DECW (return).

* 2. Save RES Module on Personalized System Diskette.

* 3. If printer uses Diablo protocol, then before each session at the computer, as the first step after loading MDOS, enter:

ASSIGN 2,3 (return)
ASSIGN 1,0 (return)

(Do not be concerned that while entering the second line, the printer prints every character twice.)

NOTE: Using the serial Diablo protocol printing terminals at 1200 baud with no video display is limited by the fact that no Extended Systems Monitor commands which cause outputing more than about 40 characters can be used. (This is because serial output from the Extended Systems Monitor does not use the Diablo protocol technique of checking whether the printer can accept the next character. More than 40 characters at 1200 baud will usually cause the printer's buffer to overflow.) MDOS and M.BASIC commands do not cause the same problem, so long as the above mentioned ASSIGN commands are used prior to each session.

One way to solve this problem is to run the printer at 300 baud (Bitstreamer at 300 baud too) and to use the DECW command rather than the DIAB command before saving the RES module on the Personalized System Diskette. In this case, the ASSIGN commands are not needed. The drawback is slower printing.

2.2.2 ADDING A STANDARD PRINTER TO AN EXISTING SYSTEM

The information in this section concerns adding a printer to an existing system, one which already has some kind of video display and keyboard functioning. The logic behind this information is the same as that used in section 2.2.1, except that here it is presented in summary form.

The printers presently considered standard for Vector Graphic systems are:

Centronics Series 700 parallel matrix printers,
Diablo 1610 protocol serial printers, such as Diablo 1610, Qume Sprint 5, or NEC Sprinwriter, and
Teletype protocol printers, such as Decwriter, Teletype, or TI 810 and 820.

There are many makes and models with protocols similar or identical to the above. Some differences between makes of printers will not make them incompatible with the Vector Graphic computers necessarily, but it is recommended that the user try out with his system any printer not listed above, before purchasing.

Adding a printer involves 3 steps:

1) obtain the interface components, as well as the printer,
2) do hardware implementation procedures required, and
3) do software implementation procedures required.

INTERFACE COMPONENTS REQUIRED

1) Bitstreamer board and I/O cable. Generally, use the one which came with your system. If it is being used to control a serial terminal now, it can be used in addition to control a parallel printer such as a Centronics printer. However, if the present

terminal is serial, and a SERIAL printer such as Diablo, Qume, or Teletype is desired, a second Bitstreamer and I/O cable must be ordered.

2) If a parallel Centronics protocol printer is to be implemented, order a CENTRONICS INTERFACE KIT from Vector Graphic or an authorized dealer.

HARDWARE IMPLEMENTATION

1) If the keyboard and video are controlled by a Flashwriter board, or if both the printer and the video console are serial, then there will be 2 interface boards in the system. When this is the case, the Bitstreamer controlling the printer must be jumpered to respond to port addresses 4 - 7 rather than 0 - 1. Instructions will be found in the Bitstreamer User's Manual.

2) If the printer is a parallel printer using Centronics protocol, make the modifications to the Bitstreamer board and install the Centronics Interface Kit, both as described in Appendix H. Do all the procedures in Appendix H if the keyboard and video are a serial terminal such as Hazeltine. However, if the keyboard and video are controlled by a Flashwriter board, then do not bother to install the 6-pin plug or the serial I/O cable.

3) If printer is serial, make sure it is set at its highest speed (1200 baud if it is Diablo 1610 protocol.) Then make sure the dipswitch on the upper left-hand corner of the Bitstreamer is set at the same rate (chosen switch up, all others down.) Printer must be set for MARK parity.

4) Make sure the the 24 pin dip plug on the I/O cable is inserted in J3 on the Bitstreamer board and that the socket on the other end is installed in one of the cutouts on the mainframe back panel. Then plug the printer cable into that same socket on the back panel.

SOFTWARE IMPLEMENTATION

The RES Module on the MDOS System Diskettes is not configured for any particular printer. However, a large number of versions of the I/O portion of the RES Module are present on the diskettes. The user need only overlay the desired version onto the RES Module stored in memory, and then save the new RES Module onto the Personalized System Diskette. The versions available as of this release are:

CENT and CENT4	for parallel Centronics protocol printers
DIAB and DIAB4	for serial Diablo protocol printers
DECW and DECW4	for serial Teletype protocol printers

In each case, the version with a "4" attached must be used if the Bitstreamer has been readdressed for ports 4 - 7. Otherwise use the version without a "4".

To accomplish the overlay, simply enter the name of the file in upper case letters following the MDOS prompt >. After the overlay is done, indicated by another MDOS sign-on message appearing on the screen, save the RES Module by entering the following commands under MDOS:

```
TYPE "RES" 0 (return)
SCRATCH "RES" (return)
SAVE "RES" 2B8 146B 3 (return)
```

If the printer is not one of the above types, then a custom interface routine must be written. See Appendix N.

2.2.3 NON-STANDARD CONFIGURATIONS

Any configuration of peripherals which includes a printer, video unit, keyboard, or terminal different than those used in the standard configurations, is a non-standard configuration.

Hardware: In order to order and implement the interface hardware, use the standard configuration procedures as models as far as is possible.

Software: In many non-standard configurations, it will be necessary to custom write a printer and/or console physical I/O routine. refer to Appendix M for rewriting console I/O and to Appendix N for rewriting printer I/O.

2.3 MODIFYING THE SYSTEM HARDWARE

2.3.1 CHANGING TO 2 MHZ CLOCK RATE

Some non-Vector Graphic S-100 boards operate only at 2 MHz, the rate of the original 8080 clock. Since the Z-80 can operate at both rates, you may desire to run the system at 2 MHz in order to include such boards. Instructions will be found in Appendix L.

2.3.2 CONNECTING ADDTIONAL DISK DRIVES

2 Micropolis disk drives are standard equipment. Additional drives may be added because the Micropolis software can addresss up to 4 drives. Contact your dealer or Vector Graphic in order to order.

2.4 DISKETTE MEDIA

2.4.1 DESCRIPTION

The recording medium used with the MZ Micropolis diskette subsystem is an industry standard 5 1/4-inch diskette (Fig 2.1) in its hard-sectored version with 16 sectors, each defined by a sector hole. Thus, it has one index hole and 16 sector holes. Diskettes of this type are available from computer stores or from other computer supply sources. DO NOT USE DISKETTES WITH OTHER THAN 16 HARD SECTORS, OR THOSE WHICH ARE SOFT-SECTORED (NO SECTOR HOLES). THEY WILL NOT WORK.

2.4.2 HANDLING

1) The Micropolis flexible disk drive subsystem was designed to take every reasonable precaution to protect your diskettes and the data recorded on them. Examples of this care are the door interlock which prevents mounting of the diskette until it is properly inserted, and the automatic 5 second deselect feature which relieves the head load pressure from the recording surface when the drive is not in use.

Once the diskette is removed from the drive, it is your responsibility to exercise the same care in handling and storing the diskette to ensure its long service life. The following precautions are guidelines for proper handling:

a) The exposed recording surface is easily contaminated - do not touch or attempt to clean the surface. Do not smoke, eat or drink while handling the diskette. Whenever the diskette is removed from the drive, return it to its protective envelope.

b) The diskette is a thin oxide-coated plastic sheet which may be damaged if handled carelessly. Do not place heavy objects on the diskette; do not expose the diskette to excessive heat or sunlight; do not use rubber bands or paper clips on the diskette; do not bend or fold the diskette.

c) Do not write on the diskette labels with an erasable pencil: graphite particles may contaminate the diskette or it may be damaged by the force exerted in writing. A fiber-tip type of pen is recommended. Return the diskette to its envelope before writing on labels.

d) Information is recorded on the diskette as magnetized "spots". Exposure of the diskette to magnetic fields or ferromagnetic objects which may become magnetized may result in the loss of information.

If a diskette is damaged or contaminated it should be replaced. If a contaminated diskette is placed in the drive, the receiver and read/write head may become contaminated and ruin other diskettes.

2) The auto-deselect will ensure reasonable diskette life. But, as

a rule you should unmount the diskette whenever it is not going to be accessed for long periods of time. This will give added diskette life and prolong the life of the drive motor.

2.4.3 LOADING AND UNLOADING

There are two stages of loading a diskette. First, insert the diskette with label side upward for horizontal drives, or leftward for vertical drives, and with the edge nearest to the read/write head access hole going in first. Insert the diskette all the way, until it clicks into place. At this point the diskette is said to be "inserted" but not yet "mounted". The diskette may be left like this for any length of time without decreasing its life. Power may be turned on or off with the diskette in this condition. It is recommended however that if a diskette will not be used for any length of time it be returned to its envelope or other storage file.

Second, the diskette is "mounted" by depressing the manual load actuater on the disk drive slowly but firmly until it stays in the mounted position. The drive will begin to turn and rotate the diskette inside its jacket. If the load actuator cannot be fully depressed, this indicates that the diskette was not inserted completely or properly.

Power should NOT be turned on or off when a diskette is in the mounted position. The consequence is from time to time the loss of data on the diskette.

Once the diskette is mounted, it is accessible by software for writing or reading. When a read or write operation is initiated, you will hear an audible click from the drive unit and the red light on the unit will glow, indicating that unit has been selected. After the operation is complete, the unit will remain selected for 5 seconds. At the end of 5 seconds, the unit will be automatically deselected: the red light will go out, and there will be another click as the head load pad is raised off the surface of the diskette. This automatic deselect feature is important in lengthening the life-span of diskettes.

To dismount the diskette, press the load actuator down as far as it will go, then release pressure. It will then open to the unmounted position. This discontinues rotation of the diskette within its jacket. In order to do your part as user in prolonging the life of the diskette, observe the following rule: UNLOAD THE DISKETTE DURING PERIODS IN WHICH IT IS NOT IN USE. This reduces wear of the diskette against its jacket. Note that the diskette may be left inserted, so long as it is unmounted, without shortening its life.

To remove the diskette, press the load activator upward (or leftward in vertical drives). The diskette will be popped out (de-inserted) and can now be removed.

2.4.4 REPLACEMENT AND BACK-UP OF DISKETTES

The nature of floppy diskette drives is that the read-write head is in contact with the diskette surface whenever the unit is selected, resulting in gradual deterioration of the surface. Continual loading of the head on a single track will naturally result in its deterioration before the rest of the diskette. The rotation of the diskette within its jacket is an additional source of wear.

Backup: The BEST defense against loss of diskette-based data is maintaining a back-up diskette for each diskette you use. In the business world, this is considered dogma. Data is most often lost due to damage to diskettes from accidental mis-handling; normal wear is much less often a problem. The standard rule of thumb is as follows: copy a front-line diskette on to its back-up whenever you cannot afford to lose the information stored since you last backed it up. This goes for programs as well as data. If you are operating business programs such as inventory or accounts receivable, maintain a regular back-up schedule, once a week or once bi-weekly. In addition, your programs if possible should be written so that an internal file of entries is maintained, and a printout of entries made each day is produced. Then, if data is lost before it can be copied on to the back-up, it is fairly easy to re-enter it, using the back-up diskette as the starting point. In business particularly, back-up diskettes and printouts of daily entries should be stored in a safe place.

Replacement: In addition to being backed up, frequently used diskettes must be replaced from time to time. The intervals are entirely dependent on the kind of usage. There are no accurate predictions for diskette life-span, but 2000 to 3000 hours of rotation is a reasonable estimate. A good suggestion therefore is to replace such diskettes every 6 months. Data diskettes used infrequently may never require replacement.

Failure of a diskette will be indicated by the inability of the system to read a file which it normally has been able to read. MDOS will report "PERM I/O ERROR". With proper care, this should not occur.

Replacing a diskette simply means copying it onto a new previously unused diskette. The old diskette can be used for temporary storage, or disposed of.

To copy diskettes use the Diskcopy Utility, see Section 4.3.

2.4 DISKETTE MEDIA

2.4.1 DESCRIPTION

Use an industry standard 5 1/4-inch diskette (Fig 2.1) with 16 "hard" sectors. There will be 16 sector holes and 1 additional index hole around the edge of the center hole. Get them from computer stores or from other computer supply sources. DO NOT USE DISKETTES WITH OTHER THAN 16 HARD SECTORS, OR THOSE WHICH ARE SOFT-SECTORED (NO SECTOR HOLES). THEY WILL NOT WORK.

Without relation to price, some brands of diskettes do not work well in the Micropolis high-density drives. Use one of the following brands: Scotch, Dysan, or Maxell. Other brands will not be reliable.

Individual diskettes may sometimes not work. Besides manufacturing defects, we have occasionally found batches of diskettes with the wrong number or sectors, and sometimes diskettes are manufactured with 2 diskettes inside the jacket. Diskettes which do not work or do not work reliably should be replaced immediately.

2.4.2 IF YOU HAVE PROBLEMS WITH DISK ERRORS

By a disk error, we are referring to errors reported on the screen as "PERM I/O ERROR", indicating something wrong with the diskette or drive. (The message is different in different operating systems. Another uses "CRC ERROR".) If your system generates such errors often with different diskettes, take the following measures in the order given:

a) Make sure the ocver to the mainfram is on. It is a shield.

b) Switch to another of the suggested brands of diskettes.

c) If the errors persist, contact your dealer or service representative.

2.4.3 HANDLING

Diskettes are easily damaged and contaminated. Please obey the following rules without exception:

a) Do not touch or attempt to clean the inner surface.

b) Do not smoke, eat, or drink while handling the diskette.

c) Do not place heavy objects on the diskette.

d) Do not expose the diskette to excessive heat or sunlight.

e) Do not use rubber bands or paper clips on the diskette.

f) Do not bend or fold the diskette.

g) Do not write on a diskette with a pencil. A fiber-tipped pen is recommended. Return the diskette to its envelope before writing on it.

h) Do not expose the diskette to magnetic fields.

i) After use, always return a diskette to its protective envelope or other protective system such as plastic notebook pages designed for diskettes.

j) Store diskettes in a vertical position, thus reducing rubbing.

k) If a diskette is damaged or contaminated, replace it. If a contaminated diskette is placed in the drive, the receiver and read/write head may become contaminated and ruin other diskettes.

l) Unmount the diskette if it will not be accessed for a half hour or more. If the interval is very long, remove it from the drive and return it to its storage envelope.

2.4.4 LOADING AND UNLOADING

There are two stages of loading a diskette. First, insert the diskette with label side leftward, with the edge nearest the exposed area pointing inward. Insert the diskette until it clicks into place. You should not have to push so hard that the diskette bends. The diskette is now "inserted" but not yet "mounted". Although not good practice for long periods, you may leave the diskette like this any length of time, and even turn power on or off.

Second, to "mount" the diskette, push the door of the drive until you feel increased resistence about half-way closed, then SLOW DOWN, and push SLOWLY but surely until it stays in the mounted position. The drive will begin to turn and rotate the diskette inside its jacket. If you cannot fully close the door, the diskette is not inserted properly.

Do NOT turn power on or off while a diskette is in the mounted position. This will sometimes damage the diskette. However, if you accidently do this, go ahead and use the diskette because it is probably undamaged.

Once the diskette is mounted, it is accessible by software for writing or reading. When the computer accesses the diskette, you will hear a click from the drive and its red light will glow. After the operation is complete, the drive will remain on for 5 seconds. You can be entering new material at the keyboard during this time. At the end of 5 seconds, the red light will go out, and there will be another click as the head load pad is raised off the surface of the diskette. This automatic deselect feature is imporant in lengthening the life-span of diskettes.

To dismount the diskette, press the door further open as far as it will go, then let it close. It will then release to the unmounted position. This stops the rotation of the diskette. UNMOUNT THE DISKETTE DURING PERIODS IN WHICH IT IS NOT IN USE. This reduces wear of the diskette against its jacket. You may leave it inserted withough shortening lifespan.

To remove a diskette, press the door lefward. The diskette will pop out.

2.4.5 RECOVERY TECHNIQUES

If you repatedly get PERM I/O erros using one particular diskette, then it is probably defective. This will sometimes happen with a new diskette when you are initializing it or copying another diskette to it. After several attempts, discard it or return it if possible. Whenever you repeat a disk operation after an error, always unload and reload the diskette, because it may be seated incorrectly.

If an old diskette repeatedly gives errors, first repeat the operation several times, unloading and reloading the diskette each time. If there is still a problem, check the center hole. If it is wrinkled, straighten it out with your fingers and then try again. If you still get errors, try copying the diskette to another diskette using the DISKCOPY utility in MDOS. If the error still occurs, try switching source and destination drives. Some combination of drives and repositioning of diskettes within drives will almost always result in a successful copy. If you cannot copy a diskette at all, then copy it file by file to another initialized diskette using the MDOS COPYFILE utility. There will probably be one file which does not copy, but if you are lucky, they will all be good.

2.4.6 REPLACEMENT AND BACK-UP OF DISKETTES

As with any magnetic storage medium, the recording gradually deterioreates over time. Even if a diskette is not damaged, it will begin producing errors after sufficient use.

Backup: The BEST defense against loss of diskette-based data is maintaining a back-up diskette for each diskette you use. In the business world, this is considered dogma. Copy a diskette on to its back-up whenever you cannot afford to lose the information stored since you last backed it up. This goes for programs as well as data. If you are operating business programs such as inventory or accounts receivable, maintain a regular back-up schedule, once a week or once bi-weekly. In addition, a transaction journal - that is a printed copy of entries made each day into the system - is an excellent idea to build into business software as a last resort back-up.

Replacement: In addition to being backed up, replace frequently used diskettes by copying to a fresh diskette every 6 months. A good suggestion is to use the back-up diskette, which is fairly fresh, as the new front-line diskette, and to create a fresh back-up. Do not wait until a frequently used diskette fails, before you replace it with the back-up.

To copy diskettes, use the DISKCOPY utility. See Section 4.3

2.4.7 INITIALIZING DISKETTES

Previously unused diskettes must be initialized (also called "formatted") before use. There are two routines in the Micropolis software that can do this. Use either the INIT command in MDOS (see 4.1.5.22) or the F command in the BASIC UTILITY program operating under M.BASIC. (see Appendix B). Their results are identical. DO NOT INITIALIZE THE MDOS SYSTEM DISKETTES PROVIDED WITH THE SYSTEM, OR ANY OTHER DISKETTE CONTAINING DESIRED INFORMATION. THIS DESTROYS THEIR CONTENTS.

2.4.8 WRITE PROTECT FOR DISKETTES

Write protect tabs come in boxes of new diskettes. If you attach a tab over the write protect cutout on a diskette as shown in Fig. 2.2 the disk drive will not allow you to erase or change any information on the diskette. The tab may be removed later.

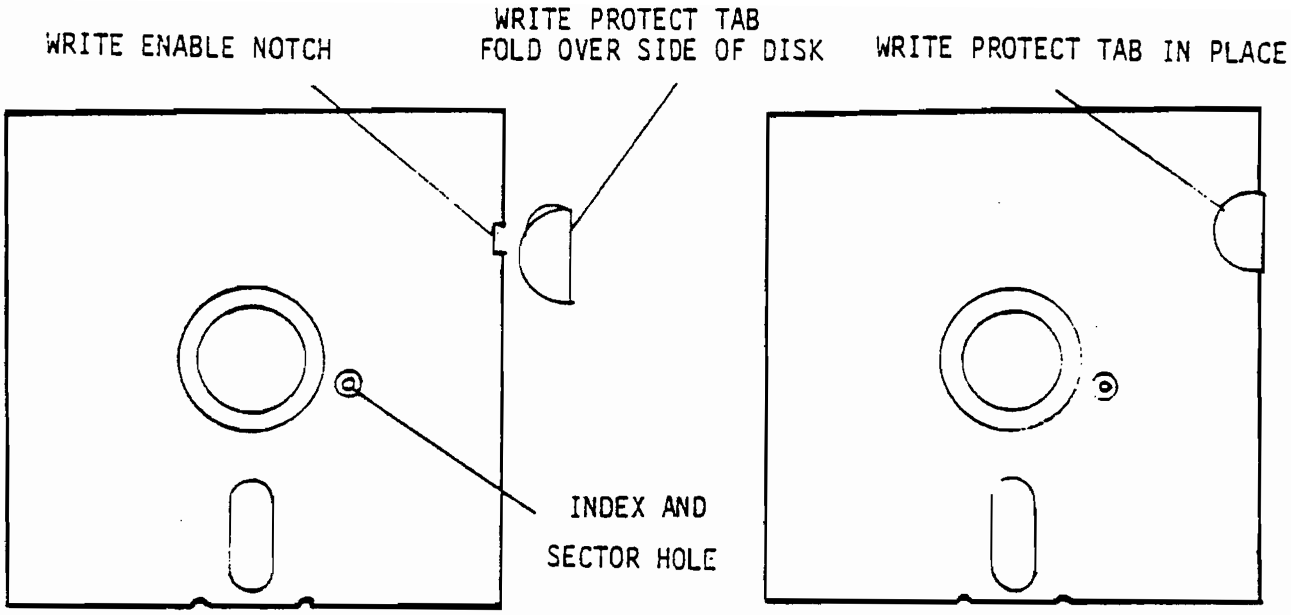


Figure 2.2 How To Mount Write Protect Tab

III DAY TO DAY OPERATIONS FOR MDOS AND M.BASIC

3.0 SUMMARY OF NORMAL START UP PROCEDURE

1) Power-on the mainframe, then the peripherals.
2) If yours is a MEMORITE system, depress RESET key.
3) Insert and mount MDOS System diskette in drive 0.
4) Enter B on keyboard. MDOS comes on.
5) Enter BASIC (return) on keyboard. M.BASIC comes on.

(return) means press the RETURN key.

Please read the rest of this chapter thoroughly. The above does not give all the information you need.

3.1 SUMMARY OF PROMPTS

When one of these prompts appears, it indicates the corresponding system is loaded and its executive routine is waiting for operator input.

1)	*	Monitor
2)	>	MDOS
3)	READY	M.BASIC

3.2 POWER-ON

1) No diskette may be in mounted position, (i.e. rotating) but it may be inserted in drive.

2) Turn the power key on the mainframe. The RESET button will light up.

3) If yours is a MEMORITE system, depress the RESET button.

4) Switch on all desired peripherals.

5) Depress RESET on printer, if printer will be used and if printer has one.

6) An asterisk and cursor will appear on the console indicating the Extended Systems Monitor executive is available for commands. A few Monitor commands are covered in this chapter. The remaining will be found in the Extended Systems Monitor manual. Look it over. Some may be useful. Monitor commands can be entered at this time or at any other time that the Monitor executive is called back into control, indicated by the Monitor prompt (*).

3.3 LOAD MDOS

1) Insert, if not done already, and mount an MDOS System diskette in drive 0. In place of the MDOS System diskette, you may substitute an M.BASIC-only diskette.

2) Enter B. MDOS will be loaded into memory and control will be transferred to the MDOS executive. The screen will look like this:

```
*B
Vector MZ MDOS X.XX
>
```

You may now enter MDOS commands (Chapter 4).

If MDOS should come up but does not, refer to Appendix I for troubleshooting.

If a M.BASIC-only diskette was in drive 0, the screen will look like this:

```
*B
MICROPOLIS BASIC VS. X.X.-COPYRIGHT 19XX
READY
```

In this case, you may begin entering M.BASIC commands immediately (chapter 5) and skip Section 3.4. Section 2.3.6 discusses BASIC-only diskettes.

3.4 LOAD M.BASIC FROM MDOS

You may work in MDOS for some time and then transfer control to M.BASIC, or you may desire to go immediately to M.BASIC as your first MDOS command. In either case, enter BASIC (return). The screen will appear like this:

```
>BASIC
MICROPOLIS BASIC VS. X.X.-COPYRIGHT 19XX
READY
```

You may now enter M.BASIC commands. (Chapter 5).

3.5 OTHER OPERATING SYSTEMS AND LANGUAGES

This manual deals primarily with the MDOS operating system, as it is normally delivered. For commands in other operating systems, including how to load their associated BASIC's or other languages, refer to the manuals for those systems, included if and when they are ordered.

3.6 RETURNING TO MDOS FROM M.BASIC

1) Make sure there is a System diskette with MDOS mounted in drive 0.

2) Enter LINK "MDOS" (return). (See Section 5.21.2.7 for how LINK works and for other uses of LINK command).

3) Screen will look like this:

```
READY
LINK "MDOS"
Vector MZ MDOS X.XX
>
```

You may now enter MDOS commands.

To return to M.BASIC, enter BASIC (return) as usual (see Section 3.4.)

3.7 RETURNING TO MONITOR FROM ANYPLACE

1) Depress control-Q (hold CTRL key down while depressing Q); or press the RESET key on the mainframe front panel. Control-Q is preferred.

2) You may now enter Extended System Monitor commands.

NOTE: For systems without the version 3.1 Systems Monitor, control-Q will not work when you try it. If you find this to be the case, then either the ESC key or control-X WILL work instead. To find out which will work in your system, get MDOS running and try them. Control-X and the ESC key each have a special function in the MDOS and M.BASIC editors. If one of these causes a return to the Monitor, then obviously, you cannot use that function in the MDOS and M.BASIC editors. Make a mental note of this when reading the MDOS and M.BASIC editor instructions. If ESC or control-X causes a return to the Monitor instead of control-Q then substitute it wherever control-Q appears in this chapter.

Returning to the Monitor is useful when Monitor commands are needed for trouble-shooting MDOS or M.BASIC programs. It is also used if there is no other way to break out of an undesired loop or output sequence in any program. Always use control-Q rather than RESET if possible, because on extremely rare occasions, RESET may change some of the contents of memory.

Control-Q will not work when certain special purpose programs are operating. The most important of these are disk access routines, and the Word Management System and MEMORITE word processing software. RESET is necessary in these cases if you want to return to the Monitor.

Avoid using RESET to abort a disk write operation, if possible, because if at that moment the directory is being written, then all the data on the disk can be effectively lost. (The same holds true if you dismount the disk at that time.)

In addition, aborting a disk read or write operation may leave the file in an "open" state, which can cause an error message next time the drive is accessed. This can be cleared by executing the FILES command in MDOS. Enter FILES (return), then return to your program and access the disk.

The best advice is, in general, allow disk read and write operations to go to their natural conclusions. Only abort if the operation is looping indefinitely.

3.8 RETURNING TO MDOS (OR M.BASIC) FROM MONITOR IF MDOS (OR M.BASIC) IS ALREADY IN MEMORY

This is the MDOS (or M.BASIC) warm-start command.

Depress J after the Monitor prompts with *.

3.9 RETURNING TO MDOS OR M.BASIC EXECUTIVE FROM WITHIN A ROUTINE RUNNING UNDER THAT EXECUTIVE

Depress control-C. (Hold the CTRL key down while depressing C.

Response is MDOS prompt (>) if MDOS is the executive, or BASIC prompt (READY) if BASIC is the executive.

Control-C is used to leave a routine at other than the normal end point. Use it when the routine is waiting for any type of keyboard input. It is sometimes also effective for interrupting an overly long or unending stream of output.

If it does not work, then control-Q is the alternative. Since this returns control to the Monitor, depress J then to return to MDOS or M.BASIC.

3.10 VIDEO COMMANDS

This section is ONLY relevent to systems using memory mapped video, such as the Vector Graphic Mindless Terminal. If a serial terminal such as Hazeltine is used, then refer to the manual for that terminal to find how you can control the screen image from the keyboard.

These commands may also not work if another operating system, such as CP/M is in control of the system. They will definitely not work when word processing, using the Word Management System or MEMORITE, is in control.

Most of the time, when the system is waiting for keyboard input, operator may perform the following operations on the screen image. These commands are made possible by the Extended Systems Monitor. For more information of a technical nature, refer to the Extended Systems Monitor manual.

3.10.1 CLEAR SCREEN

Depress control-D.

3.10.2 SCROLL SCREEN UP ONE LINE

Depress control-J or LF key.

3.10.3 BACKSPACE CURSOR

Depress BACKSPACE key, underscore key, or control-H. Also, the DEL key will have this effect IF MDOS or M.BASIC is running.

These commands will always work when MDOS or M.BASIC executives are waiting for input, and when any M.BASIC program is waiting for input.

In other situations, for example, when an assembly language program is waiting for input, these commands may or may not work depending on how the program in control was written.

3.10.4 CONVERT THE SYSTEM TO REVERSE VIDEO

For variation, you can cause the screen to display characters black-on-white rather than white-on-black. Just depress control-T (hold down CTRL key while depressing T) If you depress this again, the video will return to white-on-black. Characters already entered will remain on the screen the way they were entered.

3.10.5 TAB CURSOR TO NEXT TAB LOCATION (EVERY 8 SPACES)

Depress TAB key or control-I

3.10.6 ELIMINATE CURSOR FROM THE SCREEN

Depress control-N

3.10.7 MOVE CURSOR TO TOP OF SCREEN

Depress control-B

3.10.8 MOVE CURSOR DOWN, UP, LEFT, OR RIGHT

Depress one of the keys with an arrow on it. If your keyboard has no arrow keys, then depress control-R, control-U, control-W, or control-Z to move cursor down, up, left, or right respectively. However, Control-U and the up-arrow key will not work under while in MDOS or M.BASIC, though it will work under certain machine language programs and when in the Extended Systems Monitor echo mode (Y command).

3.10.9 RETURN CURSOR TO LEFT EDGE OF SCREEN

Depress RETURN key or control-M.

3.11 POWER-DOWN

1. Make sure you have stored on diskette all the programs and data you wish to save.
2. Dismount all diskettes. They may be left inserted and clicked in, so long as they are not mounted (rotating).
3. Turn off all peripherals.
4. Turn the power key on the mainframe front panel.

IV MICROPOLIS DISKETTE OPERATING SYSTEM

4.Ø INTRODUCTION TO MDOS

Micropolis Program Development Software consists of two systems, Micropolis BASIC which is discussed in Chapter V and the Micropolis Diskette Operating System (MDOS). MDOS consists of an executive program, a group of shared subroutines available to user programs, and an assembly language program development package.

The MDOS executive program implements an interactive command language that allows the user to control computer system operations from the system console. It provides commands for memory management, file management, I/O control and program control.

MDOS contains a very large group of subroutines which can be called from a user's application program. These subroutines provide for console and printer character I/O, buffered line I/O, text line parameter parsing, sequential and random file access, file management, physical diskette access, and 16 bit integer arithmetic. There are also a number of processor oriented utility subroutines.

Six application programs make up the package that supports assembly language program development. LINEEDIT facilitates the creation of source files. ASSM is a two pass 8Ø8Ø/8Ø85 disk to disk assembler. SYMSAVE creates a source file of equate statements from a latent symbol table. FILECOPY is a utility for copying named files. DISKCOPY is a utility for making literal copies of an entire diskette. DEBUG provides facilities to locate and correct program bug's in machine language programs.

4.1 THE MDOS EXECUTIVE

The MDOS executive program implements an interactive command language that allows the operation of the microcomputer system to be controlled from the system console. When MDOS is loaded it signs on with the message

```
MICROPOLIS MDOS VS. X.X - COPYRIGHT 1978
>
```

It is then waiting for an executive statement to be entered.

4.1.1 ENTERING EXECUTIVE COMMANDS

Executive statements are entered by typing characters in sequence on the console keyboard. An executive statement is terminated by pressing the RETURN key. During the entry of a statement each character that is typed is echoed by the executive on the console display. Two control features may be used when entering a line.

1) when DEL or RUBOUT key is pressed the next previously typed character will be deleted from the line. A backarrow is echoed to the terminal display for each character deleted.

2) Holding down the control key and typing X (CNTL/X) will cause all of the current line to be cancelled. A carriage return line feed combination is echoed to the terminal display. The executive is positioned to accept entry of a new line.

4.1.2 EXECUTIVE STATEMENT FORMAT

An executive statement has the following form:

```
[unit:]NAME ["<ASCII>" "<ASCII>" ... "<ASCII>" <hex> <hex> ... <hex>]
```

The NAME in an executive statement may be the name of an explicit command or the name of a disk file. MDOS has 23 explicit commands which are discussed in this section. Explicit command names are uppercase only and must not be preceded by any spaces. In addition, executable assembly language programs can be loaded into memory and run by entering their file NAME. This provides an implicit command capability that can be used to extend the executives vocabulary. Implicit command filenames can be up to ten ASCII characters in the code range 21 hex to 7E hex. Imbeded spaces, double quotes, backarrows, and rubouts are not allowed in implicit command filenames.

When an executive statement is entered the executive program searches its table of explicit command names for a match with the NAME that was input. If the NAME is found in the table of command names the statement is executed immediately. If the NAME is not an explicit command name, then the NAME is treated as an implicit command filename which must be found on disk. Implicit command filenames may be prefixed by an optional unit number. This specifies the disk drive on which the NAMEd file is to be found. If no unit number is specified, unit Ø is assumed. If a unit number is specified it must be separated from the first character of the NAME by a colon (:). The executive processes the implicit command filename by searching the directory of the specified disk drive for the file. If the file is found on the disk (and the file type is correct) the executive loads the program file into memory and transfers control, along with any parameters in the executive statement, to the program. If the executive does not find the file on the specified drive an error message is output to the console stream: COMMAND NOT FOUND. If the file is found on the disk but it is not an executable file an error message is output to the console stream: WRONG FILE TYPE. See the section on file type definitions for a detailed discussion of file types.

Executive statements consist of a NAME followed by parameters, as necessary. Parameters can be ASCII or numeric. There can be up to four ASCII parameters and up to four numeric parameters. There must be at least one space between the NAME and any parameters. All parameters must be separated from each other by at least one space. Entry of an executive statement with too many parameters of either type, or without the required spaces between fields will result in a SYNTAX ERROR.

ASCII parameters consist of from Ø to 1Ø ASCII characters in the code range 2ØH to 7EH except for 22H which is the double quote and 5FH and 7FH which are interpreted as backspace requests by the logical console input routines. ASCII parameters must be enclosed in double quotation marks. Entry of an executive statement with unbalanced quotation marks or illegal characters in an ASCII parameter will result in a SYNTAX ERROR.

ASCII parameters in executive statements are generally used to specify disk filenames. In this usage a unit number may be prefixed to the ASCII filename within the quotation marks by typing the unit number followed by a colon (:) followed by the filename. This indicates the disk drive unit on which the file is to be found. If no unit is specified, unit Ø is assumed. The digit of the unit specification and the colon are not included in the 1Ø character length restriction for ASCII parameters. For example, "DATAFILE01" and "1:DATAFILE01" are both valid ASCII parameters in an executive statement.

Numeric parameters in executive statements are unsigned hexadecimal values from Ø to FFFF. They represent such elements as memory addresses, filetypes, and databytes. Entry of a numeric parameter with a value greater than FFFF or with illegal characters will result in a SYNTAX ERROR.

4.1.3 CANCELLING AN OPERATION

All MDOS explicit commands and all application programs supplied by Micropolis can be cancelled in progress by holding down the control key and typing a C (CNTL/C) on the console keyboard. The operation will be terminated as soon as the CNTL/C is recognized and the message CANCELLED will be output to the console. Control is returned to the MDOS executive.

4.1.4 DISPLAY CONTROL

All MDOS explicit commands and all application programs supplied by Micropolis can be temporarily stopped in progress by holding down the control key and typing an S (CNTL/S). The process will pause upon recognition of the CNTL/S. Typing any key other than CNTL/S or CNTL/C will cause the process to resume. This function is very useful in controlling commands and programs that output displays at high speed. For example, the output of a DISP command may be viewed at reading speed by stopping and resuming the output as necessary.

4.1.5 EXPLICIT EXECUTIVE COMMANDS

Command syntax for each of the MDOS explicit commands is illustrated in this section with the aid of the following notation:

[ ] Option brackets. Any parameters enclosed between brackets are optional.

< > Symbol brackets. This space should be replaced by the item described.

4.1.5.1 THE COMP COMMAND

COMP <start addr. block1> <end addr. block1> <start addr. block2>

The COMP command compares two blocks of memory and displays address locations that do not compare and the data at those locations. Example:

```
>COMP 5ØØØ 5ØØF 5Ø1Ø
5ØØ4 Ø1 Ø9 5Ø14
```

The block of memory from 5ØØØ to 5ØØF is compared with the block of memory from 5Ø1Ø to 5Ø1F. One location fails to compare. Location 5ØØ4 contains Ø1 while the corresponding location, 5Ø14, in the second block contains Ø9.

4.1.5.2 THE DUMP COMMAND

DUMP <start addr.>[<end addr.>]

The DUMP command outputs to the system console a formatted hex display of the contents of a block of memory. Sequential memory locations are shown 16 to a line with the memory address at the left margin. If the optional end address parameter is not entered, only one byte is displayed. Example:

```
>DUMP 5ØØØ 5Ø11
5ØØØ  5Ø CØ 27 77  4F 33 4F CD  7D 9E 98 ØØ  6A FD 82 9Ø
5Ø1Ø  77 2B
```

4.1.5.3 THE ENTR COMMAND

ENTR <start addr.>

The ENTR command allows data to be entered into memory directly from the console device. Example:

```
>ENTR 7ØØØ
>78 89
6F/
```

Three bytes were entered starting at location 7ØØØ hex. These were 78 at 7ØØØ, 89 at 7ØØ1, and 6F at location 7ØØ2.

Typing in an ENTR command places the executive in a special enter mode. While in the enter mode each line of values that is typed is entered into memory when the RETURN key is pressed. Until the RETURN key is pressed the standard backspacing and CNTL/X tools are available for line correction. The last value on the last line must be followed by a slash (/) to properly terminate the enter mode. Entry of a illegal hex value in any line will also cause termination of the enter mode with the message SYNTAX ERROR.

4.1.5.4 THE FILL COMMAND

```
FILL <start addr.> <end addr.> <byte>
```

The FILL command fills a block of memory with a specified byte. Example:

```
>FILL 7ØØØ 8ØØØ 9
```

Each byte of memory in the block from 7ØØØ to 8ØØØ is changed to a Ø9 by this command.

4.1.5.5 THE MOVE COMMAND

```
MOVE <source addr. start> <source addr. end> <dest. addr. start>
```

The MOVE command copies the source block of memory to the destination block. The source block is not changed. The destination block is changed to be an exact copy of the source block. Example:

```
>MOVE 3ØØØ 4ØØØ 7ØØØ
```

Each byte in the memory block from 3ØØØ to 4ØØØ is copied into the corresponding position in the memory block from 7ØØØ to 8ØØØ.

4.1.5.6 THE SEAR COMMAND

```
SEAR <start addr.> <end addr.> <byte>
```

The SEAR command searches a block of memory for all occurrences of the specified byte and displays all locations with a match. Example:

```
>SEAR 3ØØØ 3Ø2Ø 9F
3ØØ4 9F
3Ø18 9F
```

The block of memory from 3ØØØ to 3Ø2Ø is searched for all occurrences of a 9F. Location 3ØØ4 and location 3Ø18 both contain 9F. No other locations in the block contain 9F.

4.1.5.7 THE SEARN COMMAND

SEARN <start addr.> <end addr.> <byte>

The SEARN command searches a block of memory for all non-occurrences of a specified byte and displays all locations that do not match. Example:

```
>SEARN 3000 3010 67
3002 09 67
3006 76 67
```

The block of memory from 3000 to 3010 is searched for all non-matches with the mask 67. Location 3002 contained a 9 rather than a 67, and 3006 contained a 76 rather than a 67.

4.1.5.8 THE CREATE COMMAND

CREATE "[unit:]<filename>" [<file type>]

The CREATE command creates a new file in the directory of the diskette in the specified unit and allocates the initial track for the file. If no unit is specified, unit 0 is assumed. The second parameter optionally gives the file a TYPE designation. If no type is specified the type is defaulted to 0.

4.1.5.9 THE DISP COMMAND

DISP "[unit:]<filename>" [<record number>]

The DISP command outputs a formatted hex display of the data contents of a file to the system console. The unit number indicates the disk drive on which the file is to be found. If no unit is specified, unit 0 is assumed. The optional record number indicates on which record in the file the display is to begin. If no record number is specified, record 1 is assumed.

Each record is displayed with a header line that contains the record number, the address in memory where the record is to be loaded, and the number of data bytes in the record. Data lines follow the record header. Each data line has up to sixteen data bytes preceded by the index position in the record of the first data byte on that line.

```
>DISP "1:TEST" 29
0029  3C00 0022
00   12 2A BD 76  8F ED 54 41  89 00 00 82  BC CC 76 89
10   78 88 3B BB  88 54 58 56  90 88 32 31  30 0D 00 00
20   89 55
002A  3C80 0003
00   FF FF FF
002B  3F00 0009
00   45 43 4B 4C  31 37 38 0D 00
002C  2B00 0000
END-FILE
```

The first line of the display shows the record number 29, the load address 3C00, and the length of the record 22 bytes (all in hex). The header line is followed by three lines which display the data in record 29. Each data line starts with the index position of the first byte in the line. It is followed by two spaces and then the data.

The next header is for record 2A which has a load address of 3C80 and contains 03 bytes of data.

Record 2B has a load address 3F00 and contains 09 bytes of data.

The last header is for record 2C which has a load address of 2B00 and a record length of 0. If the file is an executable object file (like ASSM for example), the address in the zero length sector is the execution address of the file. LOADing stops when the zero length sector is read. If the file is a run type which is being implicitly loaded and run, program control is transferred to the execution address.

4.1.5.1Ø THE FILES COMMAND

FILES [<unit>]

The FILES command outputs a formatted display of the file information in a diskette directory to the system console. The unit number indicates which disk drive directory is to be displayed. If no unit is specified, unit Ø is assumed. Example:

```
>FILES 1
DIR            Ø3   ØØØØ
RES            Ø3   ØØ13
MDOS           ØF   ØØ1C
LINEEDIT       15   ØØØC
ASSM           15   ØØ1Ø
SYMSAVE        15   ØØØ3
FILECOPY       15   ØØØ3
DISKCOPY       ØF   ØØØ9
BASIC          ØF   ØØ4B
```

The files on drive one are displayed on the console. The left column contains the filename, the second column is the file type, and the third column contains the number of sectors the file uses. All numbers are in hex.

4.1.5.11 THE FREE COMMAND

FREE [<unit>]

The FREE command outputs to the system console the number of tracks left unallocated (free) on a diskette. The unit number indicates which disk drive. If no unit is specified, unit Ø is assumed. Example:

```
>FREE 1
ØØ3B
```

The diskette on drive one has 3B tracks available to be allocated.

4.1.5.12 THE SCRATCH COMMAND

SCRATCH "[unit:]<filename>"

The SCRATCH command removes a named file from the directory of a diskette and returns its allocated tracks to available status. Disk drive Ø is assumed if no unit is specified.

Note: Some files cannot be SCRATCHed without first changing the file TYPE (see 4.1.5.9 and 4.2.3).

4.1.5.13 THE LOAD COMMAND

The LOAD command loads (reads) a named file from a diskette into the computers memory and then returns control to the MDOS executive. If no unit number is specified, the file is expected to be found on unit Ø.

The LOAD command can be used in conjunction with two categories of files, OBJECT files and DATA files. The specific nature of the load that is performed depends on the category of the specified file to be loaded. The process of LOADing an OBJECT file is described in 4.1.5.13.1. The process of LOADing a DATA file is described in 4.1.5.13.2.

The LOAD command can NOT be used to load a file in the OVERLAY category. An OVERLAY file is defined as any file with a file type value in the range ØC - ØF hex (see Section 4.2.3). An attempt to LOAD an OVERLAY file results in the message WRONG FILE TYPE. OVERLAY files are not LOADable because they generally imply the replacement of the MDOS module and require immediate execution. Control cannot be returned to the MDOS executive and must be transferred immediately to the newly overlayed program module. If there is a necessity to LOAD an OVERLAY file into a memory area which does not conflict with MDOS, this can be done by changing the file type to an OBJECT type and then using an offset load per Section 4.1.5.13.1.

4.1.5.13.1 THE LOAD COMMAND FOR OBJECT FILES

An OBJECT file is defined as any file with a file type value in the range Ø8 - ØB hex or 14 - 1B hex. These ranges include ASSM object files, BASIC 'save memory' files, executable system files, and executable user files (see Section 4.2.3).

The format of the LOAD command for OBJECT files is:

```
LOAD "[unit:] <filename>" [<start addr.>]
```

OBJECT files are LOADed by using the address and length information in the header of each record of the file (see Section 4.2.4). This is called a 'scatter load' because it permits records in the file to be loaded into non-contiguous portions of memory depending on the associated addresses. The LOAD is terminated when the first Ø length record in the file is encountered.

If the optional start address is not specified in the LOAD command, then the load of an OBJECT file proceeds according to the following example.

The OBJECT file to be loaded is "TEST".

```
DISP "TEST"
ØØØØ  2BØØ ØØØ5
ØØ  31 32 33 34  35
ØØØ1  2CØØ ØØØ4
ØØ  54 45 53 54
ØØØ2  2BØØ ØØØØ
END-FILE
```

Typing LOAD "TEST" loads two text strings into memory. The string "12345" in record Ø is loaded starting at 2BØØ hex for five bytes. The test string "TEST" in record 1 is loaded starting at 2CØØ hex for four bytes. The last record contains a zero length sector which terminates the load of an OBJECT type file. For an executable file the zero length sector contains the run address which in this case is 2BØØ hex. This file, however, could not be a run file as it stands as there is no executable code.

If the load address of the first record is less than 2BØØ hex, the message LOAD ADDRESS ERROR is displayed because file may not be loaded beneath the MDOS application area.

If the optional start-address is specified in the LOAD command, then the first record of the file is loaded starting at the specified address. The load address in the record header of the first record is subtracted from the start-address to produce an offset. When the records following the first record of the file are loaded, the calculated offset is added to the load address in the record header and the record is loaded starting at the calculated address. This is called an 'offset scatter load'.

Using the file TEST in the example above, typing LOAD "TEST" 5ØØØ loads the string "12345" starting at memory location 5ØØØ hex for five bytes. The offset is calculated by subtracting the load address in the header of the first record from the start-address. 5ØØØ-2BØØ=25ØØ hex. The string "TEST" is loaded starting at 51ØØ hex for four bytes. The load address in the header of the second record, 2CØØ has the offset 25ØØ hex added to it and the result is the offset-load address.

If the optional start-address is less than 2BØØ the message LOAD ADDRESS ERROR is displayed.

4.1.5.13.2 THE LOAD COMMAND FOR DATA FILES

Any file which is not an OBJECT file and not an OVERLAY file is treated as a DATA file by the LOAD command. DATA files thereby include file type values in the ranges Ø-7, 1Ø-13 hex, and 1C-FF hex. These ranges cover MDOS and BASIC DATA files, ASSM and LINEEDIT source files, BASIC program files and all of the unassigned file types (see Section 4.2.3).

The format of the LOAD command for DATA files is:

```
LOAD "[unit:] <filename>" <start addr.>
```

The start address parameter is mandatory. If a start address is not specified a SYNTAX ERROR message will be displayed. If the start address is less than 2BØØ HEX a LOAD ADDRESS ERROR will result. This prevents accidental destruction of the operating system.

Data is loaded starting at the specified address and continuing until the number of records in the file as shown in the directory have been loaded. The data is loaded into memory sequentially and contiguously. Only the number of data bytes in each record are loaded. The LOAD command does not pad records of less than 256 bytes. If a file were loaded at location 3ØØØ and the first record had only 4 data bytes in it, then the first data byte from the next record would be loaded at location 3ØØ4. Records with zero length are skipped over. The load address in the sector header (see Section 4.2.4) has no meaning when doing a data LOAD.

4.1.4.14 THE SAVE COMMAND

```
SAVE "[unit:]<filename>" <start addr.> <end addr.> [<file type>]
[<exec. addr.>]
```

The SAVE command saves (writes) a new file to a diskette from a block of memory. The file is written sequentially from the memory start address through the memory end address into full sequential records. If no unit number is specified, the file is written to unit Ø. If a file type is not specified the file type will be zero. If an execution address is not specified, the execution address of the file will be set to the start address of the memory block. Note that the type and execution address parameters are position dependent such that if an execution address is specified then a file type must also be present. Example:

```
>SAVE "1:NEWFILE" 2BØØ 37ØØ Ø 3ØØØ
```

A file is created on the diskette in drive one with the name NEWFILE and the memory block from 2BØØ to 37ØØ is written to that file. The file is given a type of Ø and the execution address saved with the file is 3ØØØ. If no execution address had been specified then 2BØØ would be saved as the execution address.

4.1.5.15 THE RENAME COMMAND

```
RENAME "[unit:]<filename>" "<new name>"
```

The RENAME command changes the name of a diskette file to a specified new name. If no unit number is specified, the file to be renamed is expected to be found on unit Ø. Example:

```
>RENAME "1:OLDFILE" "NEWFILE"
```

The file named OLDFILE on the diskette in drive one is changed to NEWFILE on the diskette in drive one. The file type is unchanged by the renaming process.

4.1.5.16 THE TYPE COMMAND

```
TYPE "[unit:]<filename>" <type>
```

The TYPE command changes the type designation of a specified file. The type designation is a single hex byte. A definition of file types is given in Section 4.2. Example:

```
>TYPE "1:PROGRAMX" 15
```

The type of the file PROGRAMX one disk drive one is changed to a value of 15.

4.1.5.17 THE APP COMMAND

```
APP ["<ASCII>" "<ASCII>"..."<ASCII>"] [<hex> <hex>...<hex>]
```

The APP command transfers program control from the MDOS executive to the start of the MDOS applications area at 2BØØ hex. It expects a valid executable program to be in the applications area with its entry point at the beginning. Up to four ASCII parameters and four hex parameters can be passed to the program. For example, if you are doing several assemblies, the assembler need only be read into memory once from diskette as it does not change itself in the process of assembling a program. After it is once in memory the APP command can be used to communicate with the assembler. Example:

```
>APP "1:SOURCE" "OBJECT" "P"
```

If the assembler were already in memory, the above example would transfer control and the necessary parameters to the program and the assembler would assemble the source file called SOURCE from drive one; produce an object file on drive zero called OBJECT; and output a paginated listing on the print device.

The APP command functions like the EXEC command in that it PUSHes the address of the operating systems warm start entry point onto the system stack. Therefore if the program in the applications area does not provide its own stack, a RET would return control to the operating system.

4.1.5.18 THE ASSIGN COMMAND

```
ASSIGN <device #> <logical stream mask> [<width> <null count>]
```

The ASSIGN command is a dual purpose command which provides the ability to specify the connections of physical output print devices to logical output streams and the values for carriage width and nullcount of the referenced physical device. The physical device number must be 1 or 2. The logical stream mask must be a Ø,1,2, or 3. The device width and nullcount must be numeric values in the range 1 to FF hex. The width and nullcount parameters are optional. If width or nullcount are not included, the values corresponding to the referenced physical device are not changed. If only the device width is included, then the nullcount is left unchanged. However, if a nullcount is specified then the width must be present as a place holder even if it is the same. If the ASSIGN command contains only three parameters the third is always the width.

Logical output stream number one consists of all output generated by system messages, keyboard echoing and the output from any explicit executive command. Logical output stream number two consists of all output generated by LISTP and PRINTP commands in the line editor, and by all listings in the assembler. The logical stream mask can be set to a three to represent both logical output streams one and two, or to a zero indicating that the device is to receive no output.

Physical device number one represents the display element of the keyboard display device that is configured as the system console (see Section 2.2.4.1 on terminal configuration). Physical device number two represents the hard copy print device which is configured as the system printer (see Section 2.2.4.3).

The output of a logical stream is directed to all physical devices which are assigned to it. A physical device may be assigned to one, both, or no logical streams. The ASSIGN command cancels any previous assignment of the specified device.

In its initialized state the terminal is assigned to stream one only, and the printer is assigned to stream two only. This state can be restored by executing:

```
>ASSIGN 1 1
>ASSIGN 2 2
```

When the console and printer devices are configured, each device has a carriage width and nullcount parameter associated with it. These values may be changed by specifying optional third and fourth parameters in an appropriate ASSIGN command. The width parameter determines the maximum number of characters on each line for the given device. When a line is output that is longer than this value an autowrap feature is activated and a carriage return and line feed is inserted at the appropriate point so that the logical line is continued on the next device line. The width can be changed on a given device by repeating the current assignment with the new width parameter. For example, if the console were currently assigned to stream one with a width of 8Ø characters (decimal), it could be changed to a width of 72 characters (decimal) as follows:

```
>ASSIGN 1 1 48
```

72 decimal is 48 hex. This width assignment will stay in effect until the width is specifically reassigned, or until the system is rebooted.

The nullcount may have to be changed to accommodate unbuffered character serial devices which may lose characters while the carriage is being returned. The nullcount value is one greater than the actual number of output nulls (ie. 1 will output no nulls). For example, if the printer were currently assigned to stream two at 132 characters per line and no nulls (nullcount=1), the number of output nulls could be changed to five with the following command:

```
>ASSIGN 2 2 84 6
```

132 decimal is 84, and 6 will result in five nulls being output after a carriage return.

Because the MDOS executive language has been designed to be interactive it depends on the availability of a display device for system messages, keyboard echoing, and display of command results. Therefore an interlock is built into the system to ensure that stream one always has at least one device assigned to it. If an ASSIGN command violates this condition, then physical device one is automatically assigned to stream one as part of the assignment being processed. Additionally if the print device supports a printer attention condition (out of paper, motor off, etc.) the system will force the assignment to an initial state (ASSIGN 1 1, ASSIGN 2 2) if the printer signals that it needs attention. This ensures that the attention message will be output to the console.

4.1.5.19 THE EXEC COMMAND

EXEC <address>

The EXEC command transfers processor control directly to the specified memory address. It expects a valid program to begin at that address. The address of the operating systems warm start entry point is PUSHed onto the 8Ø8Ø's hardware stack by the EXEC command. Therefore, if the executed program does not set its own stack, a final RET in the program will return to the operating system. This feature allows subroutines to be exercised separate of the rest of a system under development.

4.1.5.20 THE MATH COMMAND

MATH <hex number> <hex number>

The MATH command performs 16 bit integer math functions on the two specified hex numbers. It displays the sum, difference, product, quotient, and modulus. Example:

```
>MATH 4 5
ØØØ9 FFFF ØØ14 ØØØØ ØØØ4
```

The results are displayed from left to right: 4+5=9 ; 4-5=FFFF ; 4*5=14 ; 4/5=0 (intiger division) and a remainder (modulus) of 4.

4.1.5.21 PROMPT "<ASCII>"

The PROMPT command sets the executive prompt string to the value of the ASCII string. The string can be up to ten characters long. Spaces are not allowed. The prompt is initially > when the system is configured. Example:

```
>PROMPT "**"
**
```

The prompt is changed from > to a **

4.1.5.22 THE INIT COMMAND

INIT <unit>

The INIT command initializes a diskette in the specified drive. The drive unit number must be specified. The INIT command formats the diskette by writing an empty block with the correct track and sector identification on every sector of the diskette and reading each sector to verify the media. It creates a blank directory and places a system loader on the diskette. The INIT command essentially cleans the diskette of any data previously on the diskette and prepares it for new use. Accidental use of the INIT command could destroy the entire content of a diskette. Therefore, the system provides an interlock on this command. After the command is entered, the system prompts ARE YOU SURE?. It waits for a 'Y' or 'N' response to indicate yes or no. An 'N' cancels the command without doing any damage. Example:

```
INIT 1
ARE YOU SURE?
```

The diskette on drive one will be initialized if a 'Y' is typed. All other replys will result in the command being canceled. Control returns to the executive.

4.2 MDOS DISK FILE I/O

MDOS implements a powerful and efficient method for storage and retrieval of files on diskettes compatible with Micropolis disk subsystems. Track Ø of each diskette contains a directory of the files on that diskette. Each directory entry holds the name, protection attributes, type, length and starting location for one file. Track Ø also contains a track map index that lists all unassigned tracks and all tracks assigned to each file in the order of assignment. Files are stored on the remaining tracks of the diskette using a track indexed architecture that allows files to grow or shrink dynamically. Files may be accessed sequentially by byte or record and directly (randomly) by record or byte within record.

4.2.1 TRACK INDEXED FILE STORAGE

The track indexed file storage scheme defines one track as the minimum disk space consumed by a file. The maximum storage assignable to one file is all tracks on the diskette (35 on MOD I subsystems and 77 on MOD II subsystems), except the directory track Ø. When MDOS creates a new file it assigns one track to that file. Additional file space is assigned to the file one track at a time as needed. Files are contiguous within a track but not necessarily from track to track. If a file is shortened, unused tracks are returned to available status. When a file is deleted (scratched), all of its assigned tracks are freed for reassignment.

Maintenance of the track map in the track indexed scheme operates as follows. Whenever a file is opened for access MDOS reads the track map from that files diskette into main memory. Any record in the file may then be accessed with only one disk seek by appropriate reference through the track map. File access operations that cause the file to be extended or shortened by one track also cause the track map to be immediately updated in memory and on disk. When the file is closed its directory entry is rewritten to reflect any changes in the files size or status.

4.2.2 FILE NAMES

File names consist of from Ø to 1Ø ASCII characters in the code range 2ØH to 7EH except for 22H which is the double quote and 5FH and 7FH which are interpreted as backspace requests by the logical console input routines.

A unit number may be prefixed to the filename by typing the unit number followed by a colon (:) followed by the filename. This indicates the disk drive unit on which the file is to be found. If no unit is specified, unit Ø is assumed. The digit of the unit specification and the colon are not included in the 1Ø character length restriction for ASCII parameters. For example, DATAFILEØ1 and 1:DATAFILEØ1 are both valid file names.

If the file name is to be an implicit command in an executive statement there are additional restrictions that apply. The file name may not start with a blank. It may have no imbeded blanks and it may not exist in the MDOS explicit command table.

Files that are to be shared with BASIC must have valid BASIC file names. BASIC file names can be up to 1Ø characters long and use the ASCII characters from 2D hex through 5A hex except the colon (3A hex). This should be kept in mind when creating file names for MDOS. The BASIC file names are a subset of the MDOS file names and some incompatibility can occur if care is not used.

4.2.3 FILE PROTECTION AND TYPE DEFINITION

MDOS provides two forms of file protection. A file can be write protected or a file can be delete protected. MDOS also allows files to be classified as to unique information content by assigning a type designation. A files' access codes and type designation are combined in one byte of the files' directory entry. The first two least significant bits of the file type byte are bit encoded and specify file access restrictions. The access codes are as follows:

BIT 1 Ø	
Ø Ø	A normal read/write file
Ø 1	A normal read only file
1 Ø	A permanent read/write file
1 1	A permanent read only file

A normal file can be read, written, and deleted from the diskette by using the SCRATCH command (Section 4.1.2.5). A read only file can be read or SCRATCHed but it cannot be written into. A permanent file can be read or written but it cannot be SCRATCHed. A permanent read only file can be read but it cannot be written into or SCRATCHed. Attempts to SCRATCH a permanent file will result in the message PERM FILE. Attempts to write into a read only file will result in the message READ ONLY FILE. The TYPE command may be used to change the access codes of a file if necessary.

Note that these access code safeguards are software features that will only protect a file as long as the operating system has not been damaged. Diskettes may be physically write protected by placing a write protect tab over the slot in the upper right hand edge of the diskette. This causes the write electronics in Micropolis disk subsystems to be disabled when that diskette is loaded in a disk drive.

The most significant six bits of the file type byte specify the type of file. This allows 64 different classifications of files each having four access codes.

The codes Ø through 7F hex are reserved for present and future system usage and should not be assigned other meanings by the user. The codes from 8Ø to FF hex are available to the user and are not used by the system.

The executive, the assembler, and the editor check file types when called upon to load, save, or resave a file. If the file type is not correct the function will not take place. A table of file types follows:

TYPE CODE IN HEX	DESCRIPTION
ØØ-Ø3	MDOS & BASIC DATA FILES
Ø4-Ø7	EDITOR/ASSEMBLER SOURCE FILES
Ø8-ØB	ASSEMBLER OBJECT & BASIC 'SAVE MEMORY' FILES
ØC-ØF	EXECUTABLE OVERLAY FILES
1Ø-13	BASIC PROGRAM FILES
14-17	EXECUTABLE SYSTEM FILES
18-1B	EXECUTABLE USER FILES
1C-7F	RESERVED FOR FUTURE EXPANSION
8Ø-FF	AVAILABLE FOR USER DEFINITION

The line editor produces type 4 files. It can load type 4,5,6, and 7 files. The assembler will only assemble type 4,5,6, and 7 files. It produces type 8 files.

Executable system files and user files may be loaded with the load command. Any attempt to load a file below the application program area will result in a LOAD ADDRESS ERROR. Executable overlay files may be loaded below the application program area by typing the file name as an implicit executive command. Any attempt to implicitly load a file that is not an overlay file will result in the message WRONG FILE TYPE.

It is not possible to load an overlay file without beginning its execution. However, the entry point of the overlay could contain a jump to the MDOS warmstart address. This would return control to MDOS immediately after the overlay file was loaded, provided that the file did not overlay any functional MDOS code.

4.2.4 FILE AND RECORD STRUCTURE

An MDOS file consists of a group of related records stored on a diskette. The group is given a filename and type designation as described above. These are stored in the file directory on track Ø of the diskette.

Each record of an MDOS file begins with a two byte memory address followed by a two byte length indicator. The remainder of the record consists of Ø to 256 data bytes. The memory address tells MDOS where in memory to load the data from that record. The length indicator tells MDOS how many valid data bytes are in the record. A record needs a minimum block of 4 bytes and a maximum block of 26Ø bytes to be properly stored.

The records of a MDOS file are stored on the sectors of a diskette, one for one. Micropolis disk subsystems write a physical sector that is 268 bytes long. The first 8 bytes of the sector are used for control purposes strictly by the operating system. The remaining 26Ø bytes are available for a record. Short records, including Ø length (empty) records are possible. If a particular record has less than 256 data bytes the remainder of the sector is not used. However, the record may be expanded at any time by rewriting the sector to make use of the unused bytes.

The object program file that corresponds to the following assembly language program serves to illustrate the MDOS file and record structure.

```
ADDR  B1 B2 B3  E  LINE#  LABEL        OPCODE          OPERAND

ØØØØ               1ØØØ  START        ORG             4ØØØH
4ØØØ  21 ØØ 7Ø     2ØØØ               LXI             H,7ØØØH
4ØØ3               3ØØØ  DATA         DS              1ØH
4Ø13  ØØ           4ØØØ  BYTE         DB              Ø
4Ø14               5ØØØ  DATA1        DS              1ØH
4Ø24  Ø1           6ØØØ  BYTE1        DB              1
4Ø25  C3 25 4Ø     7ØØØ  BEGIN        JMP             $
4Ø28               8ØØØ               END             BEGIN
```

The first record of the object file has 4ØØØ hex in the memory address bytes in Intel low/high format. The record length bytes contain ØØØ3, indicating that the record has only three bytes of data. The three data bytes are 21 ØØ 7Ø. This record is written on the disk as one sector. The second record of the object file has a memory address of 4Ø13 and a length of ØØØ1, one byte of data ØØ. This record is also stored on the disk as one sector. The third record has a memory address of 4Ø24 and a length of ØØØ4, four bytes of data Ø1 C3 25 4Ø. This record is stored on the disk as one sector. A fourth record is written that has a memory address 4Ø25 and a length of ØØØØ. This empty record marks the end of the object file and its memory address holds the execution address specified in the END statement.

The structure of this object file is standard for all MDOS executable or memory load files. The file is allocated one entire track on the disk. It contains eight data bytes spread across 3 sectors. The 4th and last sector contains no data. Its memory address field holds the file execution address. Given an executable file type, the records of this file could be loaded into memory at 4ØØØ, 4Ø13 and 4Ø24 by typing its name to the executive. Direct processor control would transfer to 4Ø25 to begin program execution. This type of file is called a scatter loadable file because it can be loaded non-contiguously into main memory.

Note: The number of records in each MDOS file is included in the directory entry for that file. This determines the end of file for data files. Data files do not require a zero length record to mark their end because there is no execution address for a data file. The special zero length record is used with files that load into a range of memory and may require an associated execution address. For these files the zero length record is included in the record count in the files' directory entry.

4.2.5 FILE ACCESS METHODS

MDOS contains shared subroutines that allow user application programs to access diskette files sequentially by byte or record and directly (randomly) by record and byte within record.

A file may be written sequentially by writing a byte at a time and incrementing the index position. The system buffers the bytes written until a full 256 byte record is constructed and then writes it to the next sector in the file. The file space is automatically extended as necessary. A file may also be written sequentially by repeatedly writing blocks of data up to 256 bytes in length as one record and then incrementing the record position to the next record. A file written in this manner may have records of varying length up to 256 bytes.

A file may be read sequentially by reading a byte at a time and incrementing the index position until the end of file is reached. If the file contains any short records the unused bytes at the end of the sectors of those records will be automatically skiped by this byte sequential access. A file may also be read sequentially a record at a time by starting at the first record, reading the record length and then reading that number of bytes as a block, incrementing the record position to the next record, and repeating the process until the end of file is reached.

A specific record in a file may be accessed by setting the index position directly to the start of that record. The record may then be read or written either a byte at a time or as a block of bytes. A specific byte in a directly accessed record may be read or written by first setting the index position directly to that byte in the record. These techniques facilitate the spot updating of a file.

4.2.6 COMPATIBILITY BETWEEN MDOS AND BASIC FILES

BASIC file names are a subset of MDOS file names. Therefore all BASIC files can be handled by the MDOS file name parsing logic, but not all MDOS file name can be handled by BASIC. Refer to the Section 4.2.2 on FILE NAMES for a complete discussion.

BASIC data files contain records of from zero to 25Ø bytes of data. The file and record structure is the same as that used by MDOS as discussed in Section 4.2.4. The two bytes at the start of the record which hold the length of the record can never be greater than 25Ø if the file is to be used by a BASIC program as a data file. BASIC will output an error message to the console stream and stop the program if the record length is greater than 25Ø. MDOS can create BASIC readable files as follows:

```
1ØØØ * GET DATA TO BE WRITTEN INTO A BASIC COMPATABLE FILE
2ØØØ            MVI     B,25Ø
3ØØØ GET        CALL    GETDATE
35ØØ            JC      EXIT            ;CLOSE FILE & EXIT
4ØØØ            CALL    @WTINXPOSI
5ØØØ            DCR     B
6ØØØ            JNZ     GET
7ØØØ            CALL    @INCRECPOS
8ØØØ            JMP     GET
```

This partial program illustrates a method for writing 25Ø byte records. For these records to be meaningfull to BASIC, the data must be seven bit ASCII with the proper BASIC string delimiters (refer to the STRING statement in the chapter on BASIC). The subroutine GETDATE is the users data acquisition routine which returns the carry flag set when the process is done. @WTINXPOSI and @INCRECPOS are MDOS subroutines which are documented in Section 4.3.3. The method shown corresponds to the process for writing a file sequentially by record as described in Section 4.2.5.

4.3 MDOS SHARED SUBROUTINES

MDOS provides the applications development programmer with many useful subroutines that can be accessed directly from an applications program. These subroutines provide for console and printer character I/O, buffered line I/O, text line parameter parsing, sequential and random file access, file management, physical diskette access, and 16 bit integer arithmetic There are also a number of processor oriented utility subroutines.

When you write an assembly language program, these subroutines can be referenced by name; e.g. CALL @HLADDA. The PDS MASTER diskette contains two files named SYSQ1 and SYSQ2. These are editor compatible source files that contain the names of all of the MDOS shared subroutines equated to their entry addresses. Application programs that reference these routines by name should include the SYSQ1 and SYSQ2 files in their assembly by using the assembler LINK pseudo-op, described in detail in Section 4.5.

The following sections specify what arguments each subroutines expects, what arguments each subroutine returns, and how it functions.

4.3.1 CONSOLE AND PRINTER INPUT/OUTPUT SUBROUTINES

Micropolis Program Development Software packages perform input and output through the following subroutines. These routines link the system with the device handlers described in Chapter II under configuring for supported devices.

The device handler routines start with a vector table whose address is @CIOTABLE for the console, and @LIOTABLE for the printer. The routines in this section enter the drivers by indirectly accessing these tables using @CONSOLEADDR, and @LISTADDR which are buffers that hold pointers to the actual location of @CIOTABLE and @LIOTABLE. By changing the two bytes at locations @CONSOLEADDR or @LISTADDR the user can have special purpose drivers in memory at the same time as the standard drivers.

4.3.1.1 @CIN - CONSOLE INPUT

The @CIN routine waits for input from the system console. It strips parity and changes ASCII codes 5F (backarrow) and 7F (rubout) into Ø8 (backspace). It returns the input character (7 bit ASCII) in the B register, with the carry flag clear (NC). It preserves the HL, DE, and C registers.

4.3.1.2 @COUT - CONSOLE OUTPUT

The @COUT routines waits until the console stream is ready and then outputs a character. It changes carriage returns into a carriage return followed by the number of nulls associated with the device attached to the console stream. It changes ASCII code Ø8 hex (backspace) into a 5F (backarrow). If the wrap logic for the device assigned to the console stream is enabled a line feed and a carriage return nulls sequence will be output when the number of characters on the line equals the width. Refer to the ASSIGN command in the MDOS executive. It expects the character (7 bit ASCII) in the B register. It returns the carry flag set (C) if a printer attention condition occurs, and sets the assignment to ASSIGN 1 1, and ASSIGN 2 2. Refer to the ASSIGN command in the MDOS executive. It preserves the HL, DE, and BC registers.

4.3.1.3 @CBRK - CONSOLE CHECK BREAK

The @CBRK routine checks the console device for the input of a cancel (control C), or a pause (control S). It returns the zero flag set (Z) and the CANCELED message code in the A register if a CONTROL C (Ø3) is input. It preserves the HL, DE, and C registers. On pause (control S) the routine loops, waiting for another character to be input. Entry of any character other than control S will terminate the pause and return to the caller.

4.3.1.4 @CDIN - CONSOLE DEVICE INPUT

The @CDIN routine waits for input from the console device. It returns the character (8 bits including parity) in the B register, with the carry flag clear (NC). It preserves the DE, HL, and C registers.

4.3.1.5 @CDOUT - CONSOLE DEVICE OUTPUT

The @CDOUT routine waits until the console device is ready to receive a byte and then outputs it. It expects the byte for output in the B register. It preserves the DE, HL, and BC registers. It returns the carry flag clear (NC).

4.3.1.6 @CDBRK - CONSOLE DEVICE BREAK CHECK

The @CDBRK routine checks the console input ready status. If an input is ready it gets the input. Otherwise it returns immediately. It returns the zero flag set (Z) and the input character (8 bits including parity) in the B register if there was an input. It preserves the DE, HL, and C registers. If there was no input the @CDBRK routine returns the zero flag clear (NZ), and the B register is unchanged.

4.3.1.7 @CDINIT - CONSOLE DEVICE INITIALIZATION

The @CDINIT routine initializes the console interface device. It preserves the HL, DE, and BC registers. It returns the carry flag clear (NC).

4.3.1.8 @LOUT - LIST OUTPUT

The @LOUT routine waits until the list stream is ready to receive and then outputs a character. It changes carriage returns into a carriage return followed by the number of nulls associated with the device attached to the list stream. It changes ASCII code Ø8 hex (backspace) into a 5F (backarrow). If the wrap logic for the device assigned to the list stream is enabled a line feed and a carriage return nulls sequence will be output when the number of characters on the line equals the width. Refer to the ASSIGN command in the MDOS executive. It expects the character (7 bit ASCII) in the B register. It returns the carry flag set (C) if a printer attention condition occurs, and sets the assignment to ASSIGN 1 1, and ASSIGN 2 2. Refer to the ASSIGN command in the MDOS executive. It preserves the HL, DE, and BC registers.

4.3.1.9 @LATN - LIST ATTENTION

The @LATN routine checks the list stream for a printer attention condition. It returns the carry flag set (C) if a printer attention condition occurs, and sets the assignment to ASSIGN 1 1, and ASSIGN 2 2. Refer to the ASSIGN command in the MDOS executive. It preserves the HL, DE, and BC registers.

4.3.1.10 @LDOUT - LIST DEVICE OUTPUT

The @LDOUT routine waits until the list device is ready to receive a byte and then outputs it. It expects the byte for output in the B register. It preserves the DE, HL, and BC registers. It returns the carry flag set (C) if a printer attention occurs.

4.3.1.11 @LDATN - LIST DEVICE ATTENTION

The @LDATN routine checks the list device for a printer attention condition. It returns the carry flag set (C) if a printer attention condition occurs. It preserves the HL, DE, and BC registers.

4.3.1.12 @LDINIT - LIST DEVICE INITIALIZATION

The @LDINIT routine initializes the list device. It preserves the HL, DE, and BC registers. It returns the carry flag clear (NC).

4.3.1.13 @CCRLF - CONSOLE LINE FEED CARRIAGE RETURN

The @CCRLF routine outputs a line feed carriage return and nulls to the console stream. It returns the carry flag set (C) if a printer attention condition occurs, and changes the assignment to ASSIGN 1 1, and ASSIGN 2 2. Refer to the ASSIGN command in the MDOS executive. It preserves the HL, DE, and BC registers.

4.3.1.14 @LCRLF - LIST LINE FEED CARRIAGE RETURN

The @LCRLF routine outputs a line feed carriage return and nulls to the list output stream. It returns the carry flag set (C) if a printer attention condition occurs, and changes the assignment to ASSIGN 1 1, and ASSIGN 2 2. Refer to the ASSIGN command in the MDOS executive. It preserves the HL, DE, and BC registers.

4.3.1.15 @ASSIGN - ASSIGN

The @ASSIGN routine assigns the physical device to specified logical stream(s) and sets the width and nullcount associated with the device. It expects the physical device number in the E register, the logical stream mask in the D register, the width in the C register, the nullcount (nulls+1) in the B register, and the number of parameters passed in the H register. No registers are preserved. (Refer to the ASSIGN command in the executive for a detailed discussion of physical device assignment to logical output streams).

4.3.1.16 @CILINE - CONSOLE INPUT LINE

The @CILINE routine outputs a specified prompt message to the console and then buffers up to 132 characters of input text from the console device. It provides the standard backspace (rubout) and line cancel (CNTL/X) controls during the line entry process. The text line input is terminated by a carriage return. (Note: The carriage return is not echoed to the console). It expects the address of a string of text to be output as a prompt in the HL registers. The message pointed to must be properly terminated with a byte code of Ø through 1F hex or the high order eight bit of the last byte set. It returns the input line in @INBUFF, and the number of input characters including the terminating carriage return in the B register. It preserves the HL, DE, and C registers. Any control characters input during the line entry process are echoed to the console stream but not entered into @INBUFF.

4.3.1.17 @HEXOUT - HEXADECIMAL OUTPUT

The @HEXOUT routine converts an unsigned 8 bit binary value in the A register to a hex number and outputs the number to the console. It returns the carry flag set (C) if a printer attention condition occurs, and changes the assignment to ASSIGN 1 1, and ASSIGN 2 2. Refer to the ASSIGN command in the MDOS executive. It preserves the HL, DE, and C registers.

4.3.1.18 @HEXADDOUT - HEXADECIMAL ADDRESS OUTPUT

The @HEXADDOUT routine converts an unsigned 16 bit binary value in the HL registers to a hex number and outputs the number to the console followed by one space character. It returns the carry flag set (C) if a printer attention condition occurs, and changes the assignment to ASSIGN 1 1, and ASSIGN 2 2. Refer to the ASSIGN command in the MDOS executive. It preserves the HL, DE, and C registers.

4.3.1.19 @HEXOUTSPC - HEXADECIMAL OUTPUT WITH SPACE

The @HEXOUTSPC routine converts an unsigned 8 bit binary value in the HL registers to a hex number and outputs the number to the console followed by one space character. It returns the carry flag set (C) if a printer attention condition occurs, and changes the assignment to ASSIGN 1 1, and ASSIGN 2 2. Refer to the ASSIGN command in the MDOS executive. It preserves the HL, DE, and C registers.

4.3.1.20 @SPACEOUT - SPACE OUTPUT

The @SPACEOUT routine outputs a space (2Ø hex) to the console stream. It returns the carry flag set (C) if a printer attention condition occurs, and changes the assignment to ASSIGN 1 1, and ASSIGN 2 2. Refer to the ASSIGN command in the MDOS executive. It preserves the HL, DE, and C registers.

4.3.1.21 @NLINEOUT - NEW LINE OUTPUT

The @NLINEOUT routine outputs a carriage return line feed and a line of text to the console stream. It expects the address of the beginning of the text line in the HL registers. The message pointed to must be properly terminated with a byte code in the range Ø through 1F hex or the high order eighth bit of the last byte set. It returns the carry flag clear (NC) in all cases. It preserves the HL, DE, and C registers.

4.3.1.22 @LINEOUT - LINE OUTPUT

The @LINEOUT routine outputs a line of text to the console stream. It expects the address of the beginning of the text line in the HL registers. The message pointed to must be properly terminated with a byte code in the range Ø through 1F hex or the high order eighth bit of the last byte set. It returns the carry flag clear (NC) in all cases. It preserves the HL, DE, and C registers.

4.3.2 TEXT LINE PARSING SUBROUTINES

The following routines are used by the system to parse input command lines for the MDOS executive. After the command has been entered into the input buffer using @CILINE, the @SCAN routine is used to locate the first space after the command, and @SKIPSPACE skips to the first non-space character. Then the @PARAM routine separates the command parameters into buffers according to their type. @PARAM makes use of @SCAN, @SKIPSPACE, and @AHEXTBIN to do its job. After the parameter types have been separated, the address of the beginning of the input buffer is placed into @MASKADDR and the @SEAR routine searches the MDOS command table for a match. If the command is valid, the @SEAR routine returns with the zero flag clear and @LHLI will get the function from the table, which in this case is an address. Control is passed to the command routine with a PCHL instruction. The command routine can retrieve the parameters from the appropriate buffers with LHLD instructions.

The user can use these routines to parse applications program input lines using similar logic.

4.3.2.1 @PARAM - PARAMETER

The @PARAM routine parses a text line. It separates parameters into ASCII, numeric and unit numbers. It counts the number of occurrences of each parameter type and places the count and each parameter in a separate buffer.

It expects the start address of the text to be parsed in the HL registers.

It returns ASCII parameters in @ASCBUFFØ through @ASCBUFF3.

It returns unit numbers in @DRIVENØ through @DRIVEN3.

It returns binary (numeric) parameters in @BBUFFØ through @BBUFF3.

It returns the number of ASCII parameters in @NASCPAR.

It returns the number of unit number parameters in @NDRVPAR.

It returns the number of binary parameters in @NBINPAR.

It returns the carry flag clear (NC) and the end of line address in the HL registers if there were no errors.

It preserves the DE and BC registers.

If a parameter is in error the carry flag is set (C), the SYNTAX ERROR code is in the A register, and the location where the error occurred is returned in the HL registers.

4.3.2.2 @SKIPSPACE - SKIP SPACES

The @SKIPSPACE routine skips spaces in a text line.

It expects the text line's start address in the HL register.

It returns the address in the HL registers of the first non-space character.

If the character is a control character the carry flag is set (C).

It preserves the DE and BC registers.

4.3.2.3 @SCAN - SCAN

The @SCAN routine scans a text line for the first occurrence of a specified character.

It expects the text line's starting address in the HL registers and the mask character in the C register.

It returns the address in the HL register where the match occurred and the number of characters passed over in the B register.

The carry flag is set (C) if the mask character was not found prior to a control character.

It preserves the DE and C registers.

4.3.2.4 @SEAR - SEARCH

The @SEAR routine searches a table of argument-function pairs and returns the address of the function associated with the argument. The last character of the argument has the most significant bit set high. For example, an ASCII A is 41 hex. If the most significant bit is set high it is a C1 hex.

The argument is immediately followed by its function. The arguments can be variable length but the functions must all be the same length. The end of the table is marked by a Ø following the last function.
It expects the table's start address in the HL register and the argument masks' starting address in @MASKADDR. The argument mask string must be terminated by a space or control character. It expects the A register to contain the size (number of bytes) of the functions in the table.

It returns the zero flag clear (NZ) and the address of the start of the argument's function in the HL register.

The zero flag is set (Z) if the argument was not in the table. In this case the HL registers contain the end of table address, ie. the address of the Ø after the last function.
It preserves the DE and BC registers.

4.3.2.5 @AHEXTBIN - ASCII HEX TO BINARY

The @AHEXTBIN routine converts a text string of unsigned hexadecimal digits represented in ASCII code into a binary number. The string can be one to four digits in length. It must end with a space or control character.

It expects the string's start address in the DE registers.

It returns a 16 bit binary number in the HL registers.

It returns the number of digits in the number in the B register.

It returns the DE registers pointing to the space or control character that ends the text string.

It preserves the C register.

If the number is greater than four digits long or not a hex value, the routine returns the carry flag clear (NC) and the illegal character's address in the DE registers.

4.3.3 THE FILE ACCESS ROUTINES

The file access subroutines implement the MDOS file access methods described in Section 4.2.5. They allow an open disk file to be accessed sequentially by byte or record and directly (randomly) by record and byte within record.

Before a file can be accessed it must be opened. To open a named file on a specified disk unit the file must be assigned a logical file number and a filebuffer. MDOS supports simultaneously open files numbered from Ø through 7. It makes available two resident filebuffers. Additional filebuffers must be allocated in the memory space of the application program. Each filebuffer requires 288 bytes of memory.

When a file is opened the first record of the file is read into its filebuffer. The record in the file buffer of a file at any given time is called the current record of that file. Associated with the current record of each open file is an update flag. Any access that modifies the content of the current record will cause the update flag to be set. If the update flag is set, any access that leads to the current record being replaced by a new record will first cause the current record with the modified content to be rewritten in place (updated) to the disk file. If the update flag is not set, no update takes place before a new record is read. Invoking a new record resets the update flag.

The current record of each open file has a record length which is written with the record as described in Section 4.2.4. Its value may vary from Ø to 256. A Ø length record indicates an empty record that still occupies one physical sector on the diskette. A 256 byte record is a full record that cannot be extended.

The index position of the current record is a logical pointer that marks the next byte in the record to be accessed. The value of the index position ranges from Ø to 255. However, the index position may never be greater than the length in a particular record. An index position of Ø indicates that the next byte to be accessed is the first byte in a record. An index position of 255 indicates that the next byte to be accessed is the last byte in a full record.

If the index position in the current record is less than the current record length, then it points to a valid byte position within the record. That byte may be read or rewritten. If the index position is equal to the current record length, then it points to the end of record (EOR) position which is the first non valid byte position in a non full record. The EOR position may be written but it may not be read.

Reading from the end of record position updates the current record to disk as necessary and the next record in the file becomes the current record. The index position is set to Ø and the data is read from this position. This allows files containing a mixture of non full records to be read sequentially by byte.

If the end of record position is written to, the length of the current record is increased by one and the position just written becomes a valid byte position. This allows data to be added to the end of a record extending it up to its maximum length of 256 bytes. Note, however, that incrementing the index position when it already has a value of 255 updates the current record to disk as necessary and the next record of the file becomes the current record. The index position will be set to Ø.

A new file may be written sequentially by byte by repeatedly writing to the index position and incrementing the index position. This will produce a file of full records with the possible exception of the last record. The system automatically extends the amount of disk space allocated to a file when enough new records are written to require another track.

The current record of each open file also has a record position number associated with it. The record position number specifies which record the current record is in the file. The record position number may be set or incremented. Setting the record position updates the current record to disk as necessary and the specified record from the file is read and becomes the current record. This provides a mechanism for direct (random) access to any record in a file. Incrementing the record position number updates the current record to disk as necessary and the next record in the file is read and becomes the current record. This function can be used to sequentially write a file of short/mixed length records.

When processing of a file is complete, the file must be closed. Closing a file updates the current record to disk as necessary and frees the logical file number and the filebuffer for subsequent reallocation.

4.3.3.1 @CREATE - CREATE

The @CREATE routine creates a file of a specified type on a specified disk unit. The created file has one track allocated to it and one empty (Ø length) record written to it. It is left open and ready for access with the index position set to Ø and the empty record as the current record.

It expects the file number in the B register and the disk unit number in the C register and the filename in @ASCIIBUFF.

It expects the file type in the D register and the start address of the file buffer in the HL registers.

If the routine detects an error it returns the carry flag set (C) and the error message code in the A register.

It preserves the HL, DE, and BC registers.

4.3.3.2 @GFILESTAT - GET FILE STATUS

The @GFILESTAT routine checks the open/closed status of a file.

It expects the file number in the B register.

If the file is closed it returns with the zero flag set (Z) and the "FILE NOT OPEN" message code in the A register.

It preserves the HL, DE, and BC registers.

If the routine detects an error it returns the carry flag set (C) and the error message code in the A register.

4.3.3.3 @DIRSEARCH - DIRECTORY SEARCH

The @DIRSEARCH routine reads the directory of a specified disk unit to determine if a specified file exists.

It expects the unit number in the C register and the file name in @ASCIIBUFF.

It returns the zero flag clear (NZ) and the "FILE NOT FOUND" message code in the A register if the file is not in the directory.

It preserves the HL, DE, and BC registers.

If the routine detects an error it returns the carry flag set (C) and the error message code in the A register.

4.3.3.4 @OPENFILE - OPEN A FILE

The @OPENFILE routine opens a file for processing. It assigns a specified logical file number and filebuffer to the file.

It expects the file name in @ASCIIBUFF, the file number in the B register, and the drive number in the C register.

It expects the address of the file buffer in the HL registers.

It preserves the HL, DE, and BC registers.

If the routine detects an error it returns the carry flag set (C) and the error message code in the A register.

4.3.3.5 @CLOSEFILE - CLOSE A FILE

The @CLOSEFILE routine updates the current record to disk as necessary and frees the logical file number and the filebuffer for subsequent reallocation.

It expects the file number in the B register.

It preserves the HL, DE, and BC registers.

If the routine detects an error it returns the carry flag set (C) and the error message code in the A register.

4.3.3.6 @RFILEINF - READ FILE INFORMATION

The @RFILEINF routine gets the disk unit number, the number of records in the file, the file type, and the record position number of the current record.

It expects the file number in the B register.

It returns the file type in the B register and the disk unit number in the C register.

It returns the number of records in the file in the DE registers.

It returns the record position number of the current record in the HL registers.

If the routine detects an error it returns the carry flag set (C) and the error message code in the A register.

4.3.3.7 @SINXTRS - SET INDEX POSITION TO RECORD START

The @SINXTRS routine updates the current record to disk as necessary and reads a specified record which becomes the current record. The index position is set to Ø.

It expects the file number in the B register and the record number in the HL registers.

It preserves the HL, DE, BC registers.

If the routine detects an error it returns the carry flag set (C) and the error message code in the A register.

4.3.3.8 @RRECORDLEN - READ RECORD LENGTH

The @RRECORDLEN routine gets the length of the current record in a file.

It expects the file number in the B register.

It returns the length of the record in the HL registers.

It preserves the DE and BC registers.

If the routine detects an error it returns the carry flag set (C) and the error message code in the A register.

4.3.3.9 @RINXPOS - READ INDEX POSITION

The @RINXPOS routine gets the index position of the current record of a file.

It expects the file number in the B register.

It returns the index position in the C register.

It preserves the HL, DE, B registers.

If the routine detects an error it returns the carry flag set (C) and the error message code in the A register.

4.3.3.1Ø @SINXPOS - SET INDEX POSITION

The @SINXPOS routine sets the index position within the current record in a file.

It expects the file number in the B register and the index position in the C register.

It preserves the HL, DE, BC registers.

If the routine detects an error it returns the carry flag set (C) and the error message code in the A register.

4.3.3.11 @INCINX - INCREMENT INDEX POSITION

The @INCINX routine increments the index position in the current record of a file. If the increment would result in a value greater than the current record length, then the current record is updated to disk as necessary and the next record of the file becomes the current record and the index position is set to Ø.

It expects the file number in the B register.

It returns the zero flag set (Z) if the index position is in the same record.

It returns the zero flag clear (NZ) if the index position is in a new record.

It preserves the HL, DE, BC registers.

If the routine detects an error it returns the carry flag set (C) and the error message code in the A register.

4.3.3.12 @RFINXPOS - READ FROM INDEX POSITION

The @RFINXPOS routine reads the data byte pointed to by the index position in the current record of a file. If the index position is at the EOR position the current record is updated to disk as necessary and the next record of the file becomes the current record. The index position is set to Ø and the data is read from this position.

It expects the file number in the B register.

It returns the data in the C register.

It returns the zero flag set (Z) if the data is from the same record.

It returns the zero flag clear (NZ) if the data is from a new record.

It preserves the HL, DE, B registers.

If the routine detects an error it returns the carry flag set (C) and the error message code in the A register.

4.3.3.13 @RFINXPOSI - READ FROM INDEX POSITION AND INCREMENT INDEX

The @RFINXPOSI reads the data byte pointed to by the index position in the current record of a file and then increments the index position. If the original index position is at the EOR position, the current record is updated to disk as necessary and the next record of the file becomes the current record. The index position is set to Ø and the data is read from that position. Then the increment takes place. If the increment would result in a value greater than the current record length, the current record is updated to disk as necessary and the next record from the file becomes the current record. The index position is set to Ø in that case.

It expects the file number in B.

It returns the data in the C register.

It returns the zero flag set (Z) if the data is from the same record.

It returns the zero flag clear (NZ) if the data is from a new record.

It preserves the HL, DE, BC registers.

If the routine detects an error it returns the carry flag set (C) and the error message code in the A register.

4.3.3.14 @WTINXPOS - WRITE TO INDEX POSITION

The @WTINXPOS routine writes to the index position in the current record of a file. If the index position is the EOR position the record length is extended by one.

It expects the data in the C register, and the filenumber in the B register.

It preserves the HL, DE, BC registers

If the routine detects an error it returns the carry flag set (C) and the error message code in the A register.

It returns the zero flag set (Z) if the data is from the same record.

It returns the zero flag clear (NZ) if the data is from a new record.

4.3.3.15 @WTINXPOSI - WRITE TO INDEX POSITION AND INCREMENT INDEX

The @WTINXPOSI routine writes to the index position in the current record and then increments the index position. If the index position is the EOR position the current record length is extended by one. If the increment would result in an index greater than 255, then the current record is updated to disk as necessary and the next record in the file becomes the current record. The index position is set to Ø in this case.

It expects the data in the C register, and the filenumber in the B register.

It preserves the HL, DE, BC registers.

If the routine detects an error it returns the carry flag set (C) and the error message code in the A register.

It returns the zero flag set (Z) if the data is from the same record.

It returns the zero flag clear (NZ) if the data is from a new record.

4.3.3.16 @LOADDATA - LOAD DATA

The @LOADDATA routine loads a block of data into memory starting from the index position in the current record and continuing from a specified number of bytes. It advances the index position like a repeated sequence of reads and increments.

It expects the file number in the B register.

It expects the start address of the memory block in the HL registers.

It expects the block size in the DE registers.

It returns the zero flag set (Z) if the last byte read is from the same record as the first byte.

It returns the zero flag clear (NZ) if the last byte read is from a new record.

It preserves the HL, DE, BC registers.

If the routine detects an error it returns the carry flag set (C) and the error message code in the A register.

After a call to @LOADDATA the buffer @MEMORYPNTR contains the address of the memory byte immediately after the last memory byte loaded. For example, if 5 bytes are loaded into 4ØØØH through 4ØØ4H, then @MEMORYPNTR contains the address 4ØØ5H in standard low-high format. This is useful in cases where the number of bytes loaded is less than the number of bytes requested because an end of file is encountered during the @LOADDATA.

4.3.3.17 @SAVEDATA - SAVE DATA

The @SAVEDATA routine writes a block of memory to a file starting at the index position of the current record and continuing for a specified number of bytes. It advances the index position like a repeated sequence of writes and increments.

It expects the file number in the B register.

It expects the start address of the memory block in the HL registers.

It expects the number of bytes in the memory block in the DE registers.

It preserves the HL, DE, BC registers.

If the routine detects an error it returns the carry flag set (C) and the error message code in the A register.

It returns the zero flag set (Z) if the last byte read is from the same record as the first byte.

It returns the zero flag clear (NZ) if the last byte read is from a new record.

After a call to @SAVEDATA the buffer @MEMORYPNTR contains the address of the memory byte immediately after the last memory byte saved. For example, if 5 bytes are saved from 4ØØØH to 4ØØ4H then @MEMORYPNTR contains 4ØØ5H in standard low-high format. This is useful in cases where a DISK FULL condition causes less bytes to saved than are requested in the call to @SAVEDATA.

4.3.3.18 @DFINXPOSTEOR - DELETE FROM INDEX POSITION TO END OF RECORD

The @DFINXPOSTEOR routine deletes from the index position to the end of the current record by making the record length equal to the value of the index position.

It expects the file number in the B register.

It preserves the HL, DE, BC registers.

If the routine detects an error it returns the carry flag set (C) and the error message code in the A register.

4.3.3.19 @DFINXPOS - DELETE FROM INDEX POSITION TO END OF FILE

The @DFINXPOS routine deletes from the index position to the end of the file by making the number of records in the file equal to the record position number of the current record and the current record length equal to the value of the index position. Any tracks no longer required by the file due to the deletion are freed for subsequent reallocation to other files.

It expects the file number in the B register.

It preserves the HL, DE, BC registers.

If the routine detects an error it returns the carry flag set (C) and the error message code in the A register.

4.3.3.2Ø @INCRECPOS - INCREMENT RECORD POSITION

The @INCRECPOS routine updates the current record to disk as necessary, reads in the next record which becomes the current record and sets the index position to Ø. If the current record is the last record in the file, the file is automatically extended by one record.

It expects the file number in the B register.

It preserves the HL, DE, BC registers.

If the routine detects an error it returns the carry flag set (C) and the error message code in the A register.

4.3.4 FILE MANAGEMENT SUBROUTINES

In addition to accessing named files on the disk it becomes necessary on occasion to perform housekeeping functions such as removing old files, changing file types and names, and determining the amount of space left on a disk for additional files. These functions are available as executive commands, and are also provided as subroutines that may be used directly by applications programs.

4.3.4.1 @FREE - FREE

The @FREE routine returns the number of tracks left on a diskette that are free and available for allocation to a file.

It expects the unit number in the C register.

It returns the number of free tracks in the HL registers.

If the routine detects an error it returns the carry flag set (C) and the error message code in the A register.

4.3.4.2 @RENAME - RENAME

The @RENAME routine renames a file on a diskette.

It expects the file number in the B register.

It expects the new name in @ASCIIBUFF.

It preserves the HL, DE, and BC registers.

If the routine detects an error it returns the carry flag set (C) and the error message code in the A register.

4.3.4.3 @TYPE - FILE TYPE

The @TYPE routine changes the type (attributes) of a file. See Section 4.2.3 for type definitions.

It expects the file number in the B register.

It expects the new file type in the C register.

It preserves the HL, DE, and BC registers.

If the routine detects an error it returns the carry flag set (C) and the error message code in the A register.

4.3.4.4 @SCRATCH - SCRATCH A FILE

The @SCRATCH routine deletes a specified file from a specified disk unit.

It expects the unit number in the C register.

It expects the file name in @ASCIIBUFF.

It preserves the HL, DE, and BC registers.

If the routine detects an error it returns the carry flag set (C) and the error message code in the A register.

4.3.5 PHYSICAL DISK ACCESS ROUTINES

The physical disk access subroutines are the most primitive level of access provided within the MDOS context. They allow a diskette to be treated as a collection of logical blocks independent of the MDOS file system and provide access to a specified logical block on a specified track of a diskette.

Micropolis MOD I disk subsystems write 35 tracks on one side of a diskette. The MOD II subsystems write 77 tracks on one side of a diskette. A track in either subsystem is divided into 16 sectors each of which contains 268 bytes. Tracks numbered Ø through 34 or 76 are written concentrically inward toward the center of the diskette. The physical sectors on a track are numbered from Ø through 15.

Diskettes initialized by and formatted for use with MDOS have the track number written in the first byte and the physical sector number written in the second byte of each sector of a track. These bytes are maintained exclusively by the operating system.

The remaining 266 bytes of a sector are accessible as a logical block by the MDOS physical disk access routines. In order to enhance access time to multiple blocks, MDOS maps logically sequential blocks onto the physical sectors of a track in a staggered pattern as shown.

LOGICAL BLOCKS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
PHYSICAL SECTORS	Ø	2	4	6	8	1Ø	12	14	1	3	5	7	9	11	13	15

The physical disk access routines automatically access the correct physical sector that corresponds to the logical block that is specified. If it is necessary to access the sectors of a track in true physically sequential order, the application program must use the table above to unmap the sectors. For example, to access sector Ø followed by sector 1 the program would have to specify logical block 1 followed by logical block 9.

Note that the record structure of MDOS files as detailed in Section 4.2.4 must be preserved if the physical disk access routines are used to operate on such records.

4.3.5.1 @GETASEC - GET A SECTOR

The @GETASEC routine gets (reads) a sector from a specified disk unit into a specified memory buffer given the track and logical block numbers.

It expects the unit number in the C register.

It expects the track number in the D register and the logical block number in the E register.

It expects the address in the HL register of the start of a 266 byte buffer.

If the routine detects an error it returns the carry flag set (C) and the error message code in the A register.

4.3.5.2 @PUTASEC - PUT A SECTOR

The @PUTASEC routine puts (writes) from a specified memory buffer to a sector on a specified disk unit given the track and logical block numbers. Before it writes the sector it reads the header information of the target sector-2 to verify that it will be writing on the correct sector. This is called a preread. It requires that the preread sector be readable.

It expects the unit number in the C register.

It expects the track number in the D register and the logical block number in the E register.

It expects the address in the HL register of the beginning of a 266 byte buffer.

If the routine detects an error it returns the carry flag set (C) and the error message code in the A register.

4.3.5.3 @WRITESECTOR - WRITE A SECTOR

The @WRITESECTOR routine writes from a specified memory buffer to a sector on a specified disk unit given the track number and logical block number. It does not do a preread before writing. This allows a sector to be written on an uninitialized track or a track on which the preread sector is unreadable.

It expects the unit number in the C register.

It expects the track number in the D register and the logical block number in the E register.

It expects the address in the HL registers of the beginning of a 266 byte buffer.

If the routine detects an error it returns the carry flag set (C) and the error message code in the A register.

4.3.5.4 @VERIFYSECTOR - VERIFY A SECTOR

The @VERIFYSECTOR routine verifies the validity of the header information and checksum of a sector on a specified disk unit.

It expects the unit number in the C register.

It expects the track number in the D register and the logical block number in the E register.

If the routine detects an error it returns the carry flag set (C) and the error message code in the A register.

4.3.5.5 @SEEKTRACK - SEEK TO A TRACK

The @SEEKTRACK routine moves the read/write head to a specified track on a specified disk unit.

It expects the unit number in the C register.

It expects the track number in the D register.

If the routine detects an error it returns the carry flag set (C) and the error message code in the A register.

4.3.5.6 @RESTOREDISK - RESTORE THE READ/WRITE HEAD

The @RESTOREDISK routine positions the read/write head to track zero of a specified disk unit.

It expects the unit number in the C register.

If the routine detects an error it returns the carry flag set (C) and the error message code in the A register.

4.3.6 PROCESSOR ORIENTED UTILITY ROUTINES

These subroutines effectively extend the instruction set of the 8Ø8Ø to provide for some commonly required operations.

When parentheses enclose an item in the following subsections, this indicates the contents of the memory location specified by the value within the parentheses. For example, HL=(HL) means that the HL register pair is replaced with the bytes at the address in HL and HL+1. If the HL registers contain the address 4ØØØ hex, and at location 4ØØØ there is a Ø1, and at location 4ØØ1 there is a Ø2, then the HL register would be replaced by Ø2Ø1 hex. The low byte goes into L and the high byte into H.

4.3.6.1 @HLADDA - ADD A TO HL

The @HLADDA routine adds the unsigned 8 bit value in the A register to the unsigned 16 bit value in the HL registers.

It expects a value in the HL, and the A registers.

It returns HL=HL+A.

It preserves the DE and BC registers.

4.3.6.2 @INXM - INCREMENT MEMORY

The @INXM routine increments a memory pair pointed to by the HL registers. It is similar to an INR M instruction but it operates on a byte pair (16 bits) in memory.

It expects the address of the memory pair in the HL registers.

It preserves the DE and BC registers and the PSW.

4.3.6.3 @LHLINDEXED - LOAD HL INDIRECT INDEXED

The @LHLINDEXED routine loads the HL registers indirect from the location pointed to by the HL registers indexed by the A register.

It expects the address in the HL registers, and the index in the A register.

It returns HL=(HL+2*A).

It preserves the DE and BC registers.

4.3.6.4 @LHLI - LOAD HL INDIRECT

The @LHLI routine loads the HL registers with the content of the byte pair pointed to by the HL registers.

It expects an address in the HL registers.

It returns HL = (HL).

It preserves the BC and DE registers.

4.3.6.5 @TRANSDHC - TRANSFER FROM DE TO HL FOR A COUNT OF C

The @TRANSDHC routine copies a memory block pointed to by the DE registers to a memory block pointed to by the HL registers for a length in the C register. It begins at the start of each block and working to the end.

It expects the start address of the source block in the DE registers and the start address of the destination block in the HL registers and the number of bytes to copy in the C register.

It returns (HL+Ø...+C) = (DE+Ø...+C).

It preserves the B register.

4.3.6.6 @TRANSDHBC - TRANSFER FROM DE TO HL FOR A COUNT OF BC

The @TRANSDHBC routine copies a memory block pointed to by the DE registers to a memory block pointed to by the HL registers for a length in the BC registers. It begins at the start of each block and works to the end.

It expects the start address of the source block in the DE registers and the start address of the destination block in the HL registers and the number of bytes to copy in the BC registers.

It returns (HL+Ø...+BC) = (DE+Ø...+BC).

4.3.6.7 @TRANSDHBCR - TRANSFER FROM DE TO HL FOR A COUNT OF BC REVERSE

The @TRANSDHBCR routine copies a memory block pointed to by the DE registers to a memory block pointed to by the HL registers for a length in the BC registers. It begins at the end of each block and working to the beginning.

It expects the start address of the source block in the DE registers and the start address of the destination block in the HL registers and the number of bytes to copy in the BC registers.

It returns (HL+BC....+Ø) = (DE+BC....+Ø).

4.3.6.8 @TRANSFILENAME - TRANSFER A FILENAME

The @TRANSFILENAME routine copies a filename from one of the ASCII buffers (@ASCBUFFØ through @ASCBUFF3) to the @ASCIIBUFF.

It expects the @ASCBUFF number (ie. Ø to 3) in the C register.

It preserves the HL, DE, and BC registers.

4.3.6.9 @FILLZER - FILL ZEROES

The @FILLZER routine fills a block of memory up to 256 bytes in length with zeros.

It expects the start address of the memory block in the HL registers and the number of bytes to fill in the B register.

It preserves the DE and C registers.

4.3.6.10@FILLSPC - FILL SPACES

The @FILLSPC routine fills a block of memory up to 256 bytes in length with spaces (hex 2Ø).

It expects the start address of the memory block in the HL registers and the number of bytes to fill in the B register.

It preserves the DE and C registers.

4.3.6.11 @FILLA - FILL FROM THE A REGISTER

The @FILLA routine fills a block of memory up to 256 bytes in length with the value specified in the A register.

It expects the start address of the memory block in the HL registers, the number of bytes to fill in the B register, and a fill value in the A register.

It preserves the DE and C registers.

4.3.6.12 @COMPARE - COMPARE HL TO DE

The @COMPARE routine compares the value in the HL registers to the value in the DE registers.

It expects a value in the DE register and the value to compare it to in the HL register. The forms are like an 8Ø8Ø CMP B instruction where DE is analogous to the A register and HL is analogous to the B register.

It returns the following sense:

DE = HL	zero flag set (Z),	carry flag clear (NC)
DE > HL	zero flag clear (NZ),	carry flag clear (NC)
DE < HL	zero flag clear (NZ),	carry flag set (C)
DE >=HL	zero flag any state,	carry flag clear (NC)

It preserves the HL, DE, and BC registers.

4.3.7 EXTENDED 8Ø8Ø INTEGER ARITHMETIC (16 BITS)

These routines extend the capability of the 8Ø8Ø to allow 16 bit unsigned integer addition, subtraction, multiplication, and division (quotient, and modulus).

The result of all of these routines is returned in the BC registers. The HL and DE registers are preserved. With the exception of @DEDIVHL and @DEMODHL (divide and modulus routines), the carry flag is returned set (C) if a carry or borrow occurred. The divide and modulus routines return the carry unchanged.

4.3.7.1 @DEADDHL - BC=DE+HL

The @DEADDHL routine performs 16 bit unsigned integer addition.

It expects the addend in the DE register and the augend in the HL registers.

It returns the sum in the BC registers and the carry clear (NC) unless a carry out of the high order bit occurs.

It preserves the HL and DE registers.

4.3.7.2 @DESUBHL - BC=DE-HL

The @DESUBHL routine performs 16 bit unsigned integer subtraction using twos compliment addition.

It expects the minuend in the DE registers the subtrahend in the HL registers.

It returns the difference in the BC registers as a twos compliment number and the carry clear (NC) unless a borrow into the high order bit occurs.

It preserves the HL and DE registers.

4.3.7.3 @DEMULHL - BC=DE*HL

The @DEMULHL routine performs 16 bit unsigned integer multiplication.

It expects the multiplicand in the DE registers and the multiplier in the HL registers.

It returns the product in the BC registers and the carry clear (NC) unless a carry out of the high order bit occurs.

It preserves the HL and DE registers.

4.3.7.4 @DEDIVHL - BC=DE/HL

The @DEDIVHL routine performs 16 bit unsigned integer division.

It expects the dividend in the DE registers and the divisor in the HL registers.

It returns the integer quotient in the BC registers.

It preserves the HL and DE registers.

4.3.7.5 @DEMODHL - BC=DE%HL

The @DEMODHL routine performs 16 bit unsigned integer division and returns the modulus (remainder) of the operation.

It expects the dividend in the DE registers and the divisor in the HL registers.

It returns the remainder of the division in the BC registers.

It preserves the HL and DE registers.

Example: 5/2=2 and a remainder of 1. The quotient is the result of @DEDIVHL and the modulus (or remainder) is the result of @DEMODHL.

4.3.8 MESSAGE OUTPUT SUBROUTINES

These routines provide a simple means for outputing standard messages. Some of the routines access the system messages while others allow the user to set up a table of applications messages. The system messages are described in Section 4.8.

4.3.8.1 @DISKERROR - DISK ERROR MESSAGES

The @DISKERROR routine outputs system error messages related to disk operation. The routine closes all open disk files, outputs the appropriate error message to the console stream, and returns control to the MDOS executive which resets the 8Ø8Ø stack to the MDOS system stack.

It will output the appropriate error messages as detected by FILE MANAGEMENT and PHYSICAL DISK ACCESS routines (Sections 4.3.3 and 4.3.4) when they return a carry set (C) condition and an error message code in the A register.

It expects the error message code in the A register.

It DOES NOT RETURN.

4.3.8.2 @CLOSEFILES - CLOSE ALL FILES

The @CLOSEFILES routine closes all open files using the standard system file close routines. Any errors that are encountered will be reported on the console device.
It always returns the carry flag clear (NC).

It preserves the HL, DE and BC registers.

4.3.8.3 @ERRORMES - ERROR MESSAGES

The @ERRORMES routine performs similarly to @DISKERROR except that it does not close all open files and it does return to the calling routine on exit.

It expects the error message code in the A register.

It preserves the C register.

4.3.8.4 @MESSAGEOUT - MESSAGE OUTPUT

The @MESSAGEOUT routine is a generalized message-table output routine. The user can provide his own applications message table and use this routine to output the messages to the console stream. The table may have variable length messages with imbedded blanks. Each message can be terminated with a control character or a character with the most significant bit set high. The control character will not be output. The character with the eighth bit high will be output after the bit is stripped. For example, an ASCII A is hex 41. C1 hex is an ASCII A with the most significant bit high.

It expects the message table's address in the HL registers.

It expects the message's code in the A register. The code corresponds to the message's location in the table. ie., Ø is the first message, 5 is the sixth etc.

It preserves the C register.

4.3.9 SYSTEM BUFFERS AND ENTRY POINTS

These are miscellaneous entry points and buffers already described in detail in conjunction with other subroutines.

@CONSOLEADDR - Contains the location of @CIOTABLE

@LISTADD - Contains the location of @LIOTABLE

@CIOTABLE - Start address of the console input/output vector table

@LIOTABLE - Start address of the list input/output vector table

@PCON - Start address of physical console driver routines

@PLIST - Start address of physical list driver routines

@WARMSTART - Warm start entry point; initializes console and list devices, and prints the MDOS signon message.

@MDOSEXECUTIVE - Entry point for MDOS executive. Outputs the current MDOS executive prompt and initializes the MDOS stack. This entry does not output the signon message.

@FILEBUFFERØ and @FILEBUFFER1 - @FILEBUFFERØ and @FILEBUFFER1 are 288 byte buffers used by the system for file access. They may be used as applications program file buffers. See the section on FILE ACCESS ROUTINES.

@APROGRAM - Address of the start of the applications area. The APP command transfers program control to this address. All file types except overlay (ØC-ØF hex) must have load addresses greater than or equal to @APROGRAM or a LOAD ADDRESS ERROR will occur when an attempt is made to load the file.

@MASKADDR - A two byte pointer used by the @SEAR routine. @MASKADDR points to the address of the mask string.

@PARAMLEN - A one byte parameter used by the @SEAR routine. It contains the length of the functions in the table to be searched.

@MDOSRETURN - Applications programs that have not changed the I/O initialization return to this entry point instead of @WARMSTART. @MDOSRETURN outputs the MDOS signon message and initializes the MDOS stack but does not reinitialize the I/O handlers.

The following buffers are used by the @PARAM routine and are discussed in detail there.

1) One byte buffers which holds the number of specified parameters.

   @NDRVPAR   @NASCPAR   @NBINPAR

2) Ten byte buffers which holds ASCII parameters.

   @ASCBUFFØ   @ASCBUFF1
   @ASCBUFF2   @ASCBUFF3

3) One byte buffers which holds disk unit number parameters.

   @DRIVENØ   @DRIVEN1
   @DRIVEN2   @DRIVEN3

4) Two byte buffers which holds binary parameters.

   @BBUFFØ   @BBUFF1
   @BBUFF2   @BBUFF3

@ASCIIBUFF - @ASCIIBUFF is a ten byte buffer which holds filenames for the @CREATE, @RENAME, @SCRATCH, and @TRANSFILENAME routines.

@INBUFF - @INBUFF is the system input buffer. It is 132 bytes long.

4.4 LINEEDIT - THE MDOS LINE EDITOR

LINEEDIT is an MDOS application program which provides assistance in creating and maintaining assembly language source program files that are compatible with the MDOS 8Ø8Ø/8Ø85 assembler. It may also be used as a limited general text editor.

LINEEDIT is invoked by typing LINEEDIT in response to an MDOS executive prompt or by typing the command LOAD "LINEEDIT" followed by the command APP. It signs on with the message MDOS LINE EDITOR VS. X.X.

The user interacts with LINEEDIT through the system console. Lines entered at the keyboard may be text lines which are stored in the edit buffer or commands for LINEEDIT to execute. The general editing process consists of three parts.

1) Placing a text file into the edit buffer by entering it a line at a time from the keyboard or by loading an existing file from disk.

2) Modifying the text file in the edit buffer by adding, changing, and deleting lines.

3) Storing the file in the edit buffer onto a disk.

How to use LINEEDIT to carry out this process is described in the following sections.

4.4.1 ENTERING LINES TO LINEEDIT

After signing on LINEEDIT waits for a line to be input. A line consists of not more than 132 characters typed in sequence. The entry of a line is terminated by pressing the RETURN key. During the entry of a line each character that is typed is echoed by LINEEDIT on the console display. If more than 132 characters are typed prior to the RETURN, LINEEDIT will stop echoing characters and only honor a valid control function such as the RETURN. Characters which may be entered into a text line are ASCII characters in the code range 2ØH to 7EH with the exception of the backarrow (5FH). LINEEDIT also uses the MDOS console output system to keep track of the character count as a line is typed and automatically output a carriage return/line feed combination when the count exceeds the width of the display device. This combination is not included in the line count.

Two control features may be used when entering a line.

1) When DEL or RUBOUT key is pressed the next previously typed character will be deleted from the line. A backarrow is echoed to the terminal display for each character deleted. Neither the deleted characters nor the backarrow are included in the line count.

2) Holding down the control key and typing X (CNTL/X) will cause all of the current line to be cancelled. A carriage return/line feed combination is echoed to the terminal display. LINEEDIT is positioned to accept entry of a new line.

4.4.2 KEYING IN A NEW TEXT FILE

LINEEDIT recognizes a line as a text file line by the presence of a leading line number. Each line number must be in the range Ø to 9999. A text file is entered one line at a time using the normal line entry procedure. As each line is entered LINEEDIT stores it in the edit buffer which it maintains in the computer system's main memory. Text lines are stored in the edit buffer in numeric order by line number. The lines in the buffer at any given time constitute the current text file.

To insert a new line in the current text file, type in the new line including the line number. LINEEDIT will automatically place the new line in the program buffer in proper sequence according to its line number.

To replace an existing line in the current text file enter the line number and the new text. The new line will automatically replace the old line that has the same line number in the current text file.

To delete one existing program line in the current text file type the line number and press the return key. The corresponding line will be eliminated from the current text file. Note that multiple lines may also be eliminated by using the DELT command as described in Section 4.4.18.

Consecutive text lines may be entered conveniently by using LINEEDIT's automatic line numbering feature. Prior to typing the first character of a new line, you can cause the 'next' line number to be generated for you by pressing the space bar one time. The 'next' line number will echo to the terminal display and LINEEDIT will then be waiting for the first text character of that line. See Section 4.4.7 on the AUTO command to specify the increment that determines the 'next' line number.

4.4.3 ENTERING LINEEDIT COMMANDS

Whenever a line is typed which does not begin with a line number, LINEEDIT attempts to interpret this line as a command. If the line is not recognizeable as a LINEEDIT command, the message COMMAND NOT FOUND will be displayed. LINEEDIT commands are single words or abbreviations followed by parameters if required. All LINEEDIT commands are uppercase only. If the command requires one or more parameters, there must be at least one space between the command word and the first parameter and between each parameter. Parameters may be ASCII or numeric. ASCII parameters must be enclosed in double quotation marks except for within the SEARCH and CHANGE command dialogues. Numeric parameters are entered in decimal. LINEEDIT offers commands to facilitate the management of the editing process.

4.4.4 THE CLEAR COMMAND

The edit buffer may be initialized to an empty state by using the CLEAR command. This command has no parameters. It is entered by typing CLEAR and pressing the return key.

Entering a CLEAR command may result in the message FILE ON DISK NOT UPDATED, PROCEED?. This is a warning that the contents of the current text file has not been stored on disk since it was last altered. When the message appears the current text file is not yet lost. To override this warning type Y and press the return key. The CLEAR command will be processed. Otherwise type N and press the return key. The message CANCELLED will be displayed and LINEEDIT will be waiting for an alternate command.

When the CLEAR command is processed, LINEEDIT will display the message FILE NOT NAMED followed by two hex numbers which indicate that the edit buffer is empty and unnamed.

4.4.5 THE NAME COMMAND

The current text file in the edit buffer may be named or renamed by using the NAME command. NAME "filename" is the general form of this command. The filename may be any valid MDOS filename. No disk drive unit number should be specified since this name is to be associated with the current text file in the edit buffer which is in the main system memory. When the NAME command is executed, LINEEDIT will display the new filename followed by two hex numbers which represent the beginning and ending addresses of the current text file in memory. A text file may be keyed into the edit buffer before it is named. However, it cannot be stored on disk without being named.

4.4.6 THE FILE COMMAND

The name of the current text file and its address limits in memory can be determined by using the FILE command. This command has no parameters. It is entered by typing FILE and pressing the return key. The name of the current text file will be displayed, followed by two hex numbers which are the starting and ending memory addresses of the current text file. If the current text file has not been named, the message FILE NOT NAMED will be displayed in place of the filename.

4.4.7 THE AUTO COMMAND

LINEEDIT's automatic line numbering facility adds a fixed increment to the last entered line number in order to compute the 'next' automatic line number. When LINEEDIT is started this increment value is set at a default of 1. This value may be changed by using the AUTO command. The general form of the command is AUTO number. The increment will be set to the decimal value of number.

4.4.8 THE PROMPT COMMAND

When LINEEDIT is started its prompt message is null. After processing an input line, it simply echoes a carriage return/line feed combination, and waits for a new input with the cursor at the left margin of the terminal display. A prompt character or message can be specified for LINEEDIT by using the PROMPT command. PROMPT "message" is the general form of this command. The message may be from 1 to 1Ø characters in length and include any characters valid in a text line. It must be enclosed in double quotes as shown. When the PROMPT command is executed, LINEEDIT will immediately display the new prompt at the left of the terminal display and be positioned waiting for a new input line. The LINEEDIT prompt may be restored to its initialized state by typing PROMPT and pressing the return key.

4.4.9 THE LOAD COMMAND

A text file may be loaded into the edit buffer from disk by using the LOAD command. LOAD "unit number:filename" is the general form of the command. The double quotes must be used as shown. The filename must be a valid MDOS filename. The unit number is optional. If it is supplied, it must consist of a single digit from Ø to 3 followed by a colon (:). It designates the disk unit on which the specified file is to be found. If no unit number is specified, unit Ø is assumed.

When a text file is successfully loaded, it replaces the contents of the edit buffer and all text from the previous text file in the buffer is lost. The name of the current text file becomes the name of the disk file that was loaded, not including the unit number.

Entering a LOAD command may result in the message FILE ON DISK NOT UPDATED, PROCEED?. This is a warning that the current text file has not been stored on disk since it was last altered. When the message appears, the current text file is not yet lost. To override this warning type Y and press the return key. The LOAD command will be processed. Otherwise, type N and press the return key. The message CANCELLED will be displayed and LINEEDIT will be waiting for an alternate command.

Entering a LOAD command may result in the message FILE BUFFER OVERFLOW. See Appendix D for an explanation of this condition.

4.4.10 THE APPEND COMMAND

A text file may be loaded from disk and appended to the end of the current text file in the edit buffer by using the APPEND command. APPEND "unit number:filename" is the general form of this command. The double quotes must be used as shown. The filename must be a valid MDOS filename. The unit number is optional. If it is supplied, it must consist of a single digit from Ø to 3 followed by a colon (:). It designates the disk unit on which the specified file is to be found. If no unit number is specified, unit Ø is assumed.

When an APPEND is executed, the text file from disk is concatenated onto the end of the text file which was already in the edit buffer. The text lines of the appended file are not merged into the existing file in order by line number. The appended file may contain line numbers which conflict with the existing file. For these reasons it is important to use the RENUM command immediately after a successful APPEND.

The name of the current text file in the edit buffer is not affected by an APPEND.

Entering an APPEND command may result in the message WRONG FILE TYPE. This is an indication that the requested file has an attribute type different than 4 through 7. These are the only valid source file types acceptable to LINEEDIT and the assembler.

Entering an APPEND command may result in the message FILE BUFFER OVERFLOW. This is an indication that the amount of system memory available for the edit buffer is not enough to hold the additional file which was requested. When this condition occurs, the requested file is not appended but the existing is retained without change.

4.4.11 THE SAVE COMMAND

The current text file in the edit buffer may be stored on disk as a new disk file by using the SAVE command. The general form of this command is SAVE unit number. The unit number is optional. If it is supplied, it must consist of a single digit from Ø to 3. It designates the disk unit on which the current text file is to be stored. If no unit number is specified, unit Ø is assumed.

The name of the current text file in the edit buffer is used to create an entry in the directory of the specified disk and the text file is stored on the disk under that name. If the name already exists on the specified disk a DUPLICATE NAME message will result, and nothing will be written to disk. The edit buffer is unchanged. The file may be SAVEd by first changing its NAME to one that doesn't conflict or by using the RESAVE command if appropriate.

A file created by the SAVE command is given the attribute type 4 which marks it as an editor/assembler source file.

4.4.12 THE RESAVE COMMAND

The current text file in the edit buffer may replace an existing file or disk by using the RESAVE command. The general form of this command is RESAVE unit number. The unit number is optional. If it is supplied, it must consist of a single digit from Ø to 3. It designates the disk unit on which the existing file to be replaced is found. If no unit number is specified, unit Ø is assumed.

The directory of the specified disk unit is searched for a filename which matches the name of the current text file in the edit buffer. The current text file is written over that file on the disk. If no match is found, the message FILE NOT FOUND will be displayed. The current text file can be saved as a new file by using the SAVE command. If the file matched on disk has a type other than 4 through 7, the message WRONG FILE TYPE will be displayed. Text source files must have a source file type.

4.4.13 THE LIST COMMAND

A formatted display of lines in the current text file can be output to the system console by using the LIST command. The forms of this command are LIST, LIST linenumber1, and LIST linenumber1 linenumber2. The display will begin with linenumber1 or the next highest and continue through linenumber2 or the next lowest. If linenumber1 and linenumber2 are the same, only one line will be displayed. If linenumber2 is less than linenumber1, nothing will be displayed. If linenumber2 is not supplied, the display will begin with linenumber1 or the next highest, and continue through the last line currently in the current text file. If no line numbers are supplied, the entire edit buffer will be displayed.

The LIST command produces a formatted display of the text lines that is oriented to 8Ø8Ø assembly language source text. The format is defined as four fields each beginning at a specific tab location. The first field begins at the left margin and displays the line number as a 4 digit number. The second field is the label field. It consists of all characters in the text line through the first space or colon (:) that occurs. The third field is the opcode and operands field. The opcode consists of all characters following the label field through the next occurrence of a space. The operand consists of all characters following the opcode through the next occurrence of a space. The fourth field is the comment field. It begins with a semicolon (;) following the space that terminates the operands and continues to the end of the text line.

Refer to the TAB command to change the tab settings which determine the placement of the fields for the LIST format. When using the LIST command with general text editing, it is advisable to set the tabs to 1 1 1. This effectively removes the tabulation effects which are designed for assembly language source text.

4.4.14 THE LISTP COMMAND

A formatted display of lines in the current text file can be output to the system printer by using the LISTP command. The forms of this command are LISTP, LISTP linenumber1, and LISTP linenumber1 linenumber2.

The LISTP command functions the same as the LIST command except that output is directed to the system printer instead of the system console.

4.4.15 THE PRINT COMMAND

A literal (unformatted) display of lines in the current text file can be output to the system console by using the PRINT command. The forms of this command are PRINT, PRINT linenumber1, and PRINT linenumber1 linenumber2. The linenumber specifications in the PRINT command function the same as in the LIST command.

The PRINT command displays text lines as they are stored in the edit buffer but without the line numbers so that general text may be displayed just as it was entered. If an unformatted display of assembly language source text is desired, it can be obtained by setting the tabs to 1 1 1 and using the LIST command.

4.4.16 THE PRINTP COMMAND

A literal (unformatted) display of lines in the current text file can be output to the system printer by using the PRINTP command. The forms of this command are PRINTP, PRINTP linenumber1, and PRINTP linenumber1 linenumber2.

The PRINTP command functions the same as the PRINT command except that output is directed to the system printer instead of the system console.

4.4.17 THE TAB COMMAND

The tab settings that determine the placement of the fields for the LIST and LISTP format may be changed by using the TAB command. TAB number1 number2 number3 is the form of this command. The first number is the column at which the opcode field begins. The second number is the column at which the operand field begins. The third number is the column at which the comment field begins.

The initial and default values of the TAB parameters are 15, 22, 36 decimal. The settings may be reset to these values by typing TAB without any parameters. Missing parameters are set to the default if possible or the value of the preceding parameter if that parameter is greater than the default value for that tab column. If TAB 17 were typed the tab setting would be 17, 22, 36. TAB 25 would set the tabs to 25, 25, 36.

4.4.18 THE DELT COMMAND

A group of consecutive lines may be deleted from the current text file by using the DELT command. The forms of this command are DELT linenumber1, and DELT linenumber1 linenumber2. Lines will be deleted from linenumber1 or the next highest that exists, through linenumber2 or the next lowest that exists. If linenumber2 is less than linenumber1 nothing will be deleted. If they are equal only that line will be deleted. If only linenumber1 is specified then only that line will be deleted. The edit buffer is automatically compressed whenever lines are deleted.

4.4.19 THE RENUM COMMAND

All or part of the lines in the current text file can be renumbered by using the RENUM command. The forms of this command are RENUM, RENUM startingnumber, RENUM startingnumber increment, and RENUM startingnumber increment first-line-to-change. RENUM takes the line number of the first line to change and sets it equal to the starting number. The line number of each line after the first line to change is then set to the value of the preceding new line number plus the increment value. If no first line to change is specified, the first line in the edit buffer is assumed. If no increment value is specified, the value 1Ø is used. If no starting number is specified, the value Ø is used. Typing RENUM alone will produce a text file numbered from Ø by 1Ø's.

Entering a RENUM command may result in the message LINE NUMBER OVERFLOW. This is an indication that the renumbering attempt lead to a line number greater than 9999. When this occurs the edit buffer is left in a partially renumbered state. Lines up to the overflow point have been renumbered but the ones after that point retain their old value. A RENUM with a smaller increment value should be executed immediately to correct this condition.

4.4.20 THE SEARCH COMMAND

Lines in the current text file that contain a specified string of text can be located and displayed by using the SEARCH command. The forms of this command are SEARCH, SEARCH linenumber1, or SEARCH linenumber1 linenumber2. SEARCH without a linenumber specified will search the whole buffer. SEARCH linenumber1 will search from the line number specified to the end of the buffer. SEARCH linenumber1 linenumber2 will search the buffer starting at the first line specified through the second line specified.

When the SEARCH command is entered, LINEEDIT will respond with the prompt SEARCH MASK ?. A string of up to 132 legal text line characters can be entered. The entry is terminated by pressing the return key. LINEEDIT searches through the lines in the current text file looking for the first occurrence within each line of a substring that matches the specified search mask. It examines every line except those lines that begin with an asterisk (*). Every examined line that contains a match is displayed on the system console. This display is a literal (unformatted) display including the line number. Lines with a leading asterisk (*) are considered comment lines in assembly language source text. Refer to the SEARCHALL command to operate on comment lines.

The SEARCH command also provides a universal match character capability. Each question mark (?) that is entered in the search mask string is treated as a match for any character in that position. For example, the search mask A?I will match all three character substrings that begin with A and end with I. Note that this capability means that question marks (?) included in the text cannot be explicitly searched for.

If no lines in the current text file contain a match to the specified search mask, the message STRING NOT FOUND will be displayed.

4.4.21 THE SEARCHALL COMMAND

All lines in the current text file that contain a specified string of text, including those lines that begin with an asterisk (*) can be located and displayed by using the SEARCHALL command.

The forms of this command are SEARCHALL, SEARCHALL linenumber1, or SEARCHALL linenumber1 linenumber2. SEARCHALL without a linenumber specified will search the whole buffer. SEARCHALL linenumber1 will search from the line number specified to the end of the buffer. SEARCHALL linenumber1 linenumber2 will search the buffer starting at the first line specified through the second line specified. The SEARCHALL command functions the same as the SEARCH command except that all text lines including those that begin with an asterisk (*) are included in the search.

4.4.22 THE CHANGE COMMAND

The first occurrences of a specified string in lines of the current text file can be replaced with a different string of same or different length by using the CHANGE command. The forms of this command are CHANGE, CHANGE linenumber1, or CHANGE linenumber1 linenumber2. CHANGE without a linenumber specified will change all lines in the buffer. CHANGE linenumber1 will change lines from the line number specified to the end of the buffer. CHANGE linenumber1 linenumber2 will change lines in the buffer starting at the first line specified through the second line specified.

CHANGE operates on all lines within the specified range except lines starting with an asterisk (*) or semicolon (;). These lines are considered comment lines in assembly language source text. Refer to the CHANGEALL command to operate on comment lines.

When the CHANGE command is entered, LINEEDIT will respond with the prompt SEARCH MASK ?. A string of up to 132 legal text line characters may be entered. The entry is terminated by pressing the return key. If no lines in the current text file contain a match to the specified search mask, the message STRING NOT FOUND will be displayed. Otherwise, LINEEDIT will then respond with the prompt CHANGE TO ?. Another string of up to 132 legal text string characters can be entered. The entry is terminated by pressing the return key. LINEEDIT searches through lines in the current text file looking for the first occurrence within each line of a substring that matches the specified search mask. It replaces such occurrences with the specified change-to string, adjusting line and buffer length accordingly. Each line as changed is displayed on the console without tabs expanded.

The CHANGE command also respects the universal match character capability as described under the SEARCH command. If the search mask contains one or more question marks (?) these characters positions will match any character in the search process, and the matched substring will then be replaced by the change-to string. Example:

```
LIST
1Ø S1@LABEL1A
2Ø S2@LABEL2A
3Ø @LABEL3
CHANGE
SEARCH MASK ? S?@
CHANGE TO   ? @
1Ø @LABEL1A
2Ø @LABEL2A
```

The change-to string may also contain question marks (?). This provides the ability to retain specified character positions in the search string while making changes on either or both sides of the retained character. Example:

```
LIST
1Ø TAGØ1A
2Ø TAGOFF
3Ø TAG22A
CHANGE
SEARCH MASK ? TAG??A
CHANGE TO   ? LABEL??B
1Ø LABELØ1B
3Ø LABEL22B
```

Lines 1Ø and 3Ø have been changed while line 2Ø is unchanged because it did not match the search string. The TAG at the beginning and the A at the end of lines 1Ø and 3Ø have been changed. The Ø1 in line 1Ø and the 22 in line 3Ø have been retained.

4.4.23 THE CHANGEALL COMMAND

The first occurrences of a specified string in all lines of the current text file, including those lines that begin with an asterisk (*), or semicolon (;) can be replaced with a different string of same or different length by using the CHANGEALL command. The forms of this command are CHANGEALL, CHANGEALL linenumber1, or CHANGEALL linenumber1 linenumber2. When the CHANGEALL command is entered it functions the same as the CHANGE command, except that all text lines including those that begin with an asterisk (*) are included in the search.

4.4.24 THE EDIT COMMAND

The text within a specified line in the current text file can be changed without retyping the entire line by using the EDIT command. EDIT linenumber is the form of this command. If the specified linenumber is not found in the current text file, the message LINE NOT FOUND is displayed. LINEEDIT processes an EDIT command by copying the specified line into a special editing buffer and displaying the line number at the left margin of the console. An invisible edit pointer is set to point to the first character in the text line after the space that terminates the line number. LINEEDIT is now in the EDIT command mode. A separate set of single key commands is available for editing a line in the special edit buffer.

4.4.24.1 ADVANCING THE EDIT POINTER - THE SPACE BAR

The invisible edit pointer in the special editing buffer may be advanced one position by pressing the space bar one time. The character to which the edit pointer is pointing will be displayed on the console. This indicates that the edit pointer has passed over the character. The edit pointer is then advanced so that it is now pointing at the next character in the text line immediately after the one that is displayed. The entire line can be displayed in this manner.

4.4.24.2 CHANGING THE NEXT CHARACTER - C

The character to which the edit pointer is pointing in the edit buffer can be changed by typing a c or C, followed by the new character. The new character is printed on the console and replaces the character in the edit buffer at that position. The edit pointer is advanced to point to the character immediately after the new displayed character.

4.4.24.3 DELETING THE NEXT CHARACTER - D

The character to which the edit pointer is pointing in the edit buffer can be deleted by typing a d or D. The deleted character is printed on the console enclosed in backslashes (/). The edit pointer is left pointing at the character immediately after the deleted character.

4.4.24.4 INSERTING CHARACTERS - I

Characters may be inserted into the line or at the end of the line by typing an i or I followed by the characters to be inserted. The insertion begins immediately before the character pointed to by the edit pointer. Characters are inserted in sequence as typed until the insert mode is terminated by depressing the ESC key. The edit pointer remains pointing to the same character that it pointed to when the insertion began. The insert mode may also be terminated by pressing the return key. This also terminates the EDIT command and replaces the line in the current text file with the newly edited version from the special editing buffer.

4.4.24.5 LISTING THE LINE IN THE SPECIAL EDITING BUFFER - L

The remainder of the line in the special edit buffer from the position of the edit pointer to the end of the line may be displayed by typing an l or L. The characters are displayed on the console followed by a carriage return-line feed. The line number is reprinted at the left margin of the console display and the edit pointer is reset to the beginning position. This command is useful to see what the line looks like before editing is completed. It may also be useful to use this command immediately after entering the original EDIT command. This would display the line about to be edited without exiting the editing mode.

4.4.24.6 SEARCHING TO A SPECIFIED CHARACTER - S

The edit pointer may be advanced in the special editing buffer to the first occurrence of a specified character by typing an s or S followed by the character to search for. The characters from the position of the edit pointer up to but not including the searched for character are printed on the console. The edit pointer is left pointing at the first occurrence of cne searched for character. If the search argument does not exist in the line then the entire line is printed and the edit pointer is positioned at the end of the line.

4.4.24.7 DELETING TO A SPECIFIED CHARACTER - K

Characters in the special editing buffer from the edit pointer position up to but not including a specified search character can be deleted by typing a k or K followed by the search character. The deleted characters are displayed on the console, enclosed in backslashes (/). If the search argument does not exist in the edit line, then all the characters from the edit pointer to the end of the line are deleted. The edit pointer is left pointing at the search character or at the end of the line.

4.4.24.8 QUITTING THE EDIT COMMAND MODE - Q

The EDIT command may be aborted without changing the line in the current text file by typing a q or Q. The partially edited line in the special editing buffer is abandoned. No changes are made to the line in the current text file. LINEEDIT is ready to accept a new command.

4.4.24.9 COMPLETING THE EDIT COMMAND - THE RETURN KEY

The line in the special editing buffer can replace the line in the current text file at any point by pressing the return key. This terminates the EDIT command in a normal manner.

4.4.25 THE DOS COMMAND - EXITING FROM LINEEDIT

Control of the computer system can be returned from LINEEDIT to the MDOS executive by using the DOS command. This command has no parameters. It is entered by typing DOS and pressing the return key. Control is returned to the MDOS executive which signs on with the message MICROPOLIS MDOS VS. X.X. LINEEDIT remains in the system application program area and the contents of the current text file are not disturbed unless some action taken from the executive destroys these areas. Entering an APP command to the executive would return control to LINEEDIT.

Entering the DOS command may result in the message FILE ON DISK NOT UPDATED, PROCEED?. This is a warning that the current text file has not been stored on disk since it was last altered. When the message appears the current text file is not yet lost. To override this warning type Y and press the return key. The DOS command will be processed. Otherwise type N and press the return key. The message CANCELLED will be displayed and LINEEDIT will be waiting for an alternate command.

4.4.26 LINEEDIT FILE STRUCTURE

The current text file in the LINEEDIT edit buffer has the following format. Each line begins with a byte that contains a count of the number of bytes in the line. The count includes the count byte and the carriage return at the end of the line. The count byte is followed by four bytes that hold the digits of the line number in ASCII. The line number can range from ØØØØ to 9999. At least one space (2Ø hex) follows the line number. The remainder of the line can contain from Ø to 125 characters followed by a carriage return. The shortest line contains 6 bytes. The longest line contains 132 bytes. The characters of the source program appear in the line exactly as they were typed during input. ASSM and LINEEDIT require only one space between elements of an assembly statement. Additional spaces are ignored. Therefore, there is no reason to type in more than the minimum number of spaces when entering a source program. After the carriage return that terminates the last line of the current text file there is a byte that contains a Ø1 to mark the end of the file.

The current text file is written to a disk file just as it appears in the edit buffer. All records in the disk file with the possible exception of the last one are full records. A text line may span two records. The following logic could be used in an MDOS application program designed to process an editor source file.

```
1ØØØ START        CALL         @RFINXPOSI
2ØØØ              DCR          C
3ØØØ              JZ           ENDOFFILE
4ØØØ              MVI          D,Ø
5ØØØ              MOV          E,C
6ØØØ              LXI          H,BUFFER
7ØØØ              CALL         @LOADDATA
8ØØØ *PROCESS THE LINE IN THE BUFFER
9ØØØ              JMP          START
```

The @RFINXPOS routine gets the line count byte into the C register. If the count is Ø1 the end of the file has been reached. Otherwise, all program lines have a line length of no less than 6. The line length is moved into the DE registers (D=Ø) and the buffer address is placed into the HL registers. The @LOADDATA routine starts at the index position and loads the next DE bytes into the buffer which leaves the index position pointing to the line count byte of the next text line. The program can then process the text line and loop back to get the next line.

4.5 ZSM - Z-80 ASSEMBLER

ZSM is an MDOS program to convert Z-80 assembly language source code into object code, which consists of a sequence of binary codes that can be loaded into the computer's memory and executed. ZSM takes the place of ASSM, the earlier 8080/8085 assembler for MDOS. Any references in this manual to ASSM should be understood as references to ZSM.

As input ZSM expects a type 4, 5, 6, or 7 text file, such as that produced by LINEEDIT. The output file produced will be a type 8 file. This type of file may be scatter loaded into memory, meaning that it need not be contiguous code; rather, it can be several groups of individual code.

Note that this is a disk assembler, so memory size is not a constraint on the size of file that may be assembled.

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4.5.1 HOW TO RUN ZSM

ZSM is invoked from the MDOS executive by typing its name, followed by the assembly parameters. The format is as follows:

```
>ZSM "<source filename>" "<object filename>" "<options>" [<offset>]
```

The <source filename> must be the assembly language source program as explained above. The <object filename> is the name of the output file. It must be included, but may be blank if the S or M option, below, is used.

The <options> are instructions to ZSM pertaining to how to assemble the program. The number of options specified varies with what is desired and may be blank, but the field must nevertheless be included. The options are as follows.

E Only lines containing assembly errors will be listed.

P The assembly listing will be paginated.

S The assembly listing will be produced, but no object code.

M The object code will be written into memory, not to a disk file.

L The line numbers from the source file will not appear on the listing.

T The symbol table created by ZSM will be printed following the listing.

"SM" is the only combination not allowable, since they are mutually exclusive. If they are both present, though, the S option will prevail.

The <offset> parameter indicates an offset to be added before the object code is placed into memory (via the M option). For example, it would be impossible to assemble a program into memory at 2B00, since that is where ZSM resides. Therefore, to put a program into memory that was designed to run at 2B00, you would have to specify an offset, for example 3000. This would result in code destined for 2B00 to be actually put into memory at 5A00 (2B00 + 3000).

Here are some examples of valid commands:

```
   1.  ZSM "SFILE" "OFILE" ""
   2.  ZSM "SFILE" "" "PTS"
   3.  ZSM "SFILE" "" "ML" 3000
   4.  ZSM "SFILE" "OFILE" "E"
```

Line 1 would assemble SFILE into the file OFILE, and produce a normal listing. Line 2 would assemble SFILE, producing a paginated listing including a symbol table, but not produce an object file. Line 3 would assemble SFILE, putting the object code into memory with an offset of 3000; it would produce no object file; and it would produce a normal listing, but without line numbers. Line 4 would assemble SFILE into the file OFILE, and only list those lines (if any) containing errors.

Assembling a file with the M option in such a way that the operating system or assembler would be overwritten will cause a 'Load address error'. Including the wrong number of parameters in the command line, or forgetting a quote symbol, will cause a 'Syntax error'. Specifying an object file which already exists will cause a 'Duplicate name' error, meaning there already exists a file with that name. Either SCRATCH that file, or select a new name for the object file.

4.5.2 LANGUAGE ELEMENTS

The source file has a general format as follows:

```
#### LABEL: OPCODE OPERANDS  ;comments
```

The #### represents the four digit line number assigned each line by the line editor. Although the line number itself is ignored, it ~must~ be present, and must be four characters long, followed by a space.

The LABEL is optional. If present, it will be entered into the symbol table. Whether or not it is present, its position must be followed by a space or colon. That is,

```
#### LABEL OPC  or  #### LABEL: OPC  or  ####  OPC
```

are valid, while

```
#### OPC
```

is not.

Labels may include any of the following characters:

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
a b c d e f g h i j k l m n o p q r s t u v w x y z
Ø 1 2 3 4 5 6 7 8 9 @ . [ ]{ } \ | ` ^ ~

To avoid ambiguity, however, the first character may not be . or Ø-9. In addition, a label may be of any length up to 47 characters. All characters are significant. In normal use, though, up to 12 characters should suffice; and over 14 characters will look a little strange on the listing.

The OPCODE must either be a Z-8Ø opcode or a pseudo-op. Both are explained later.

The OPERANDS vary. There can be any number of them, depending on whether they are operands for an opcode or a pseudo-op. There are also instances where there are no operands, and therefore this field can, in some cases, be omitted. If more operands are supplied that are needed, the extras are ignored.

The COMMENT field is totally ignored by the assembler, except for printing it on the listing. Comments are used only for documentation or clarity, and can be omitted altogether. If present, comments should be preceeded by a semicolon (;). The semicolon will cause a TAB to the third TAB setting, whereas its absence will result in the comment appearing immediately to the right of the operand field.

There is one exception to the above format, and that is the case of an all-comment line. If the first character of the line (after the line number and space) is either an asterisk (*) or semicolon, the entire line will be treated as a comment.

4.5.2.1 CONSTANTS

ZSM provides for constants of two varieties, numeric and ASCII.

ASCII constants are indicated by enclosing the appropriate character in single quotes ('). Any ASCII character can appear between the quotes, except for (1) control characters, having an ASCII code of under 2Ø hex; (2) the single quote character, ASCII code 27 hex; (3) the underscore character _, ASCII code 5F hex; and (4) the DEL character, 7F hex.

Numeric constants may be in any of four bases - 2, 8, 1Ø, and 16. A specific base is indicated as follows:

###H indicates hexadecimal (base 16) - for example 1C7H
###Q indicates octal (base 8) - for example 62Q
###B indicates binary (base 2) - for example 1Ø1Ø1B
###D or just ### indicates decimal (base 1Ø) - for example 193D or 193

Regardless of base, all numeric constants ~must~ begin with a digit, Ø-9. (This is to prevent ambiguity with labels.) Thus AØ7 hex would have to be written as ØAØ7H.

There is one special numeric constant, denoted by the symbol $. This constant is always equal to the address of the current line; that is, the memory location that the current line will be written into when it is loaded. Note that this reflects the address of the beginning of the current line, ~not~ the next line (as in some assemblers). As an example, consider that

```
ØØ1Ø        JMP   $
```

would cause an infinite loop, since it would jump to itself.

4.5.2.2 OPERATORS

ZSM recognizes 1Ø operators. They are as follows:

+	addition
-	subtraction, or negative (as in -1)
*	multiplication
/	division
%	modulo (remainder of division)
&	logical AND
!	logical OR
#	logical EXCLUSIVE-OR
>	rotate right (11Ø1Ø1B>3 yields 1Ø111ØB)
<	rotate left (111Ø11ØB<1 yields 11Ø11Ø1B)

All arithmetic operators treat their operands as unsigned 16-bit quantities, and answers are truncated to 16 bits. All logical operators perform their function on a bit-by-bit basis, and they also treat their operands as 16-bit values.

Operators combine with constants to form expressions. In an expression, all operators are evaluated in a strict left-to-right order, with no precedence of operators.

Thus consider the following situation:

TEST has been assigned the value 1ØØØH.
INC has been assigned the value 6.

The expression encountered is TEST*6+INC!7<8.

The procedure would be TEST*6 (6ØØØH) +INC (6ØØ6H) !7 (6ØØ7H) <8 (Ø76ØH). Thus the resulting value is 76ØH.

4.5.2.3 REGISTERS

The Z-8Ø has a number of registers, all of which have a specific symbolic reference. ZSM supports these references, as follows.

register	designation	
register B -	B	Also called BC for register-pair instructions
register C -	C	
register D -	D	Also called DE for register-pair instructions
register E -	E	
register H -	H	Also called HL for register-pair instructions
register L -	L	
accumulator-	A	
memory -	M	Also called (HL), but ZSM does not allow this.
A & flags -	PSW	Program Status Word, may also be called AF
Stack Ptr -	SP	
Index reg X-	IX	Also may be called X for brevity
Index reg Y-	IY	Also may be called Y for brevity

Of course, the Z-80 also has registers A', B', C', D', E', H', L', F', PC, I, and R, but these are never explicitly referred to in an instruction, so no special designation is needed.

4.5.2.4 PSEUDO-OPS

ZSM supports a large number of pseudo-ops. They will be explained now.

ORG Set origin

The ORG pseudo-op specifies where the object code is to be put. Assembled code and data is assembled starting at the address specified as the operand to the ORG psuedo-op, and proceeds upward, until the end of the program or another ORG. A program can contain as many ORGs as desired. Since ORG is handled in pass 1, any symbol appearing in the operand must already be defined.

LINK Link to a file

The LINK pseudo-op allows separate program files on the disk to be 'linked together' and assembled as one file. The LINK operand is a source file name, enclosed in single quotes. No drive specification is needed for the LINK file, as all units will be searched (starting with the unit the original source file is on) to locate the file. If the file is not found, a 'File not found' error will be issued, and the assembly aborted.
Linking to a file is like a subroutine; that is, when the linked-to file is exhausted, assembly of the original program will continue from where it was left off at. For example,

```
0010      LXI    H,4000H
0020      LINK   'TEST'
0030      MOV    A,M
```

will cause the entirety of the file TEST to be assembled between the LXI and the MOV.
Files that are linked to must not contain an END pseudo-op.

END   End of assembly

The END pseudo-op indicates to ZSM that the end of the program has been reached. As such, it may be omitted, since the physical end of a program has the same effect.
In addition, though, an operand may be included. This operand, if present, indicates the starting address of the program. This address is **not** where the program is loaded, but instead where execution will begin. This allows the program to begin execution at any point in memory, rather than the beginning of the program. If this is omitted, then the beginning of the program is used as the starting address.
In order for the starting address to be effective, the object file would be changed to an implicit command file under MDOS (type 0C-0F).

EQU   Equate

The EQU pseudo-op simply equates the label associated with it to the value of the operands.

```
0010 TEN       EQU   10
0020 TWENTY    EQU   2*10
```

The above code would cause the label TEN to have the value 10, and TWENTY to have the value 20.

REQ   Request value

The REQ pseudo-op is similar to the EQU pseudo-op, only instead of an explicit value being specified, the system console is prompted for the value. The prompt is specified as the operand. For example,

```
0010 TEST      REQ   'Input:'
```

Would cause the message

```
Input:
```

to be displayed on the console during pass 1 of the assembly. The operator must then type the value to be associated with the label. For example, if the operator had typed '56H' in response to the prompt, then TEST would have a value of 56 hex.

PRT   Print

The PRT pseudo-op allows information to be displayed on the console during pass 2. If operands are present, they are displayed, otherwise, just a carriage return/linefeed is printed. For example,

```
0010 TEST    EQU   7000H
0020         PRT   'This is a test ',TEST
```

would cause

```
This is a test 7000
```

to be printed on the console during pass 2.

TAB Tab settings

The TAB pseudo-op changes the tab settings for the assembly listing. Normally, they are at positions 15, 22, and 36. If it is desired to change them, then the TAB pseudo-op is used. It expects three operands, one for each tab setting. If a particular operand is zero, then that position is set to the default. The three settings represent the location of the opcode, operand, and comment fields respectively.

NLIST No list

The NLIST pseudo-op will cause code following it not to be listed. Note that this overrides any options which may have been specified in the command string; If the E option was used, nothing will be listed (errors or not) after a NLIST.

LIST List

The LIST pseudo-op cancels the effect of the NLIST pseudo-op. If there has been no NLIST, then this has no effect.

FORM Form feed

The FORM pseudo-op produces a formfeed in the listing when encountered.

IFF If false - conditional assembly

The block of code following the IFF pseudo-op will be assembled only if the operand evaluates to 0.

IFT If true - conditional assembly

The block of code following the IFT pseudo-op will be assembled only if the operand evaluates to anything other than 0.

ENDIF End of IF block

The ENDIF pseudo-op is used to mark the end of an IFT or IFF block.

DB   Define byte

The DB pseudo-op assigns its operands to successive memory locations. Either numeric or ASCII operands may be present, but either one must evaluate to only 8 bits. This means that only one ASCII character may be included per operand. For example,

```
ØØ1Ø LOCATION  DB    1,2ØH,11B,'D',TEST,14
```

would put each operand into a successive memory location.

'Z' is a special case of the DB pseudo-op, and it is equivalent to DB Ø. For example,

```
ØØ1Ø XXX      Z               and
ØØ1Ø XXX      DB    Ø
```

are equivalent.

DW   Define word

The DW pseudo-op is basically similar to DB, only it defines two bytes at a time, rather than 1. Also, the two bytes are in Intel standard low/high format.

DD   Define data

The DD pseudo-op is exactly like DW, only the two bytes are put in high/low format.

DT   Define text

The DT pseudo-op allows ASCII text to be put into memory. The desired text must be enclosed by single quotes. For example,

```
ØØ1Ø TEST    DT    'ABCDEF'
```

would produce the following object code: 41 42 43 44 45 46 (hex).

DTH   Define text terminated high

The DTH pseudo-op is like DT, only the last character is ORed with 8ØH before it is written out. In the above example, the last byte would be C6 hex.

DTZ   Define text terminated with zero

The DTZ pseudo-op is like DT also, only it causes a byte of ØØ to be appended to the text string. Thus the example would be 41 42 43 44 45 46 ØØ.

DS Define storage

The DS pseudo-op causes the assembler to skip over the number of bytes specified by the operand. Since the object file is scatter loaded, the area skipped over will remain undisturbed.

FILL fill storage

The FILL pseudo-op is similar to DS, only it fills the area with a constant, rather that skipping over it. The constant to fill with is specified with the second operand. For example,

```
ØØ1Ø          FILL   5,3
```

would produce the output

```
Ø3 Ø3 Ø3 Ø3 Ø3.
```

4.5.3 ASSEMBLY ERRORS

There are ten assembly errors. Note that an error doesn't necessarily cause the program to assemble wrong, particularly if the error is a syntax error in something like a TAB statement. Nevertheless, all errors should be avoided.

The errors are as follows.

A Argument error - This is caused by an invalid character in an operand field, or an ASCII constant which is out of range.

D Duplicate label error - This indicates that a symbolic name was used more than once as a label. The first value will be used.

J Jump error - This indicates a relative jump (JR, JRZ, JRNZ, JRC, JRNC, DJNZ) to a label which is out of range. The relative jump should be replaced with an absolute one.

L Label error - This is caused by a label which contains invalid characters.

M Missing label error - This indicates that an EQU or REQ pseudo-op was encountered, but there was no label on the line. Obviously, a label is necessary for either of these.

O Opcode error - This is caused by an illegal or missing opcode.

R Register error - This indicates that an illegal value was found where a register was expected.

S Syntax error - This is caused by missing operands or improper use of operators.

U Undefined symbol error - This indicates that a symbol was used, but that the symbol has not been defined.

V Value error - This indicates that the value computed is out of range for the operation being used, specifically a two-byte instruction, or a DB.

4.5.4 INSTRUCTION SET

ZSM supports the complete Z-8Ø instruction set, using the TDL-style mnemonics. These mnemonics represent the Z-8Ø instruction set as a logical superset of the 8Ø8Ø mnemonics. The reason that these 'superset' mnemonics were chosen over the Zilog mnemonics is for ease of use. All 8Ø8Ø programs will run unmodified on ZSM, but they wouldn't on a Zilog-mnemonic assembler. In addition, someone familiar with 8Ø8Ø mnemonics will find the superset easy to learn, since they are a logical extension of 8Ø8Ø mnemonics.

One thing that is important to grasp is how indexing is handled. Under Zilog mnemonics, an operand might appear as (IX+d) where d is the offset and IX is the index register. Under ZSM, it would be d(X). Thus instead of

```
ØØ1Ø          LD   HL,(IX+12)
```

the following notation is used:

```
ØØ1Ø          LXI   H,12(X)
```

The same is true of IY, only it would appear as (Y) instead of (X). In addition, an offset of zero may be omitted entirely. That is, (IX+Ø) needn't be written as Ø(X), it can simply be (X).

The next sections outline the instruction set. It is not meant as a tutorial on the Z-8Ø, but rather a guide to the specific mnemonics used. Following that is a test program. If you have a Mostek or Zilog Z-8Ø Programming Manual, notice that in the back is an alphabetic list of all possible instructions. That list is in Zilog mnemonics. The test program herein is an exact duplicate of that list, only in the superset mnemonics. You are not expected to enter and assemble this program, but to use it as reference for the mnemomics.

In the following section, certain general conventions are used. They are as follows:

n	an 8 bit value
nn	a 16 bit value
d	an 8 bit value, specifically a displacement
r	register, such as A, B, C, D, E, H, L, M, d(X), d(Y)
I	one of the index registers, IX or IY (abbreviated X or Y)
rp	register pair, such as B, D, H, SP, PSW, IX, IY

b   a bit, value Ø - 7

8 bit load group

Instruction	Zilog equivalent
MOV r,r	LD r,r
MOV r,M	LD r,(HL)
MOV r,d(I)	LD r,(I+d)
MOV M,r	LD (HL),r
MOV d(I),r	LD (I+d),r
MVI r,n	LD r,n
MVI M,n	LD (HL),n
MVI d(I),n	LD (I+d),n
LDA nn	LD A,(nn)
STA nn	LD (nn),A
LDAX rp	LD A,(rp)
STAX rp	LD (rp),A
LDAI	LD A,I
LDAR	LD A,R
LDIA	LD I,A
LDRA	LD R,A

16 bit load group

Instruction	Zilog equivalent
LXI rp,nn	LD rp,nn
LBCD nn	LD BC,(nn)
SBCD nn	LD (nn),BC
LDED nn	LD DE,(nn)
SDED nn	LD (nn),DE
LHLD nn	LD HL,(nn)
SHLD nn	LD (nn),HL
LSPD nn	LD SP,(nn)
SSPD nn	LD (nn),SP
LIXD nn	LD IX,(nn)
SIXD nn	LD (nn),IX
LIYD nn	LD IY,(nn)
SIYD nn	LD (nn),IY
SPHL	LD SP,HL
SPIX	LD SP,IX
SPIY	LD SP,IY
PUSH rp	PUSH rp
POP rp	POP rp

Exchange, block transfer, and search group

Instruction	Zilog equivalent
XCHG	EX DE,HL
EXAF	EX AF,AF'
EXX	EXX
XTHL	EX (SP),HL
XTIX	EX (SP),IX
XTIY	EX (SP),IY
LDI	LDI
LDIR	LDIR
LDD	LDD
LDDR	LDDR
CCI	CPI
CCIR	CPIR
CCD	CPD
CCDR	CPDR

Input / Output group

Instruction	Zilog equivalent
IN n	IN A,n
OUT n	OUT n,A
INP r	IN r,(C)
OUTP r	OUT (C),r
INI	INI
INIR	INIR
IND	IND
INDR	INDR
OUTI	OUTI
OUTIR	OTIR
OUTD	OUTD
OUTDR	OTDR

8 bit airthmetic/logical group

Instruction	Zilog equivalent
ADD r	ADD A,r
ADD M	ADD A,(HL)
ADD d(I)	ADD A,(I+d)
ADI n	ADD A,n
ADC r	ADC A,r
ACI n	ADC A,n
	(references to M and d(I) are like ADD)
SUB r	SUB A,r
SUI n	SUB A,n
SBB r	SBC A,r
SBI n	SBC A,n
ANA r	AND A,r
ANI n	AND A,n
ORA r	OR A,r
ORI n	OR A,n
XRA r	XOR A,r
XRI n	XOR A,n
CMP r	CP A,r
CPI n	CP A,n
INR r	INC r
DCR r	DEC r

16 bit arithmetic group

Instruction	Zilog equivalent
DAD rp	ADD HL,rp
DADC rp	ADC HL,rp
DSBC rp	SBC HL,rp
DADX rp	ADD IX,rp
DADY rp	ADD IY,rp
INX rp	INC rp
DCX rp	DEC rp

General purpose arithmetic and control group

Instruction	Zilog equivalent
DAA	DAA
CMA	CPL
NEG	NEG
CMC	CCF
STC	SCF
NOP	NOP
HLT	HALT
DI	DI
EI	EI
IM0	IM 0
IM1	IM 1
IM2	IM 2

Rotate and shift group

Instruction		Zilog equivalent	
RLC		RLCA	
RAL		RLA	
RRC		RRCA	
RAR		RRA	
RLCR	r	RLC	r
RLCR	M	RLC	(HL)
RLCR	d(I)	RLC	(I+d)
			(references to M and d(I) are like RLCR)
RALR	r	RL	r
RRCR	r	RRC	r
RARR	r	RR	r
SLAR	r	SLA	r
SRAR	r	SRA	r
SRLR	r	SRL	r
RLD		RLD	
RRD		RRD	

Bit manipulation group

Instruction		Zilog equivalent	
BIT	b,r	BIT	b,r
BIT	b,M	BIT	b,(HL)
BIT	b,d(I)	BIT	b,(I+d)
RES	b,r	RES	b,r
			(references to M and d(I) are like BIT)
SET	b,r	SET	b,r

Jump, call, and return group

Instruction			Zilog equivalent	
JMP	nn		JP	nn
JZ	nn		JP	Z,nn
JNZ	nn		JP	NZ,nn
JC	nn		JP	C,nn
JNC	nn		JP	NC,nn
JPO	nn	(or JNO)	JP	PO,nn
JPE	nn	(or JO)	JP	PE,nn
JM	nn		JP	M,nn
JP	nn		JP	P,nn
JR	nn	(or JMPR)	JR	d
JRZ	nn		JR	Z,d
JRNZ	nn		JR	NZ,d
JRC	nn		JR	C,d
JRNC	nn		JR	NC,d
DJNZ	nn		DJNZ	d
PCHL			JP	(HL)
PCIX			JP	(IX)
PCIY			JP	(IY)
CALL	nn		CALL	nn
CZ	nn		CALL	Z,nn
CNZ	nn		CALL	NZ,nn
CC	nn		CALL	C,nn
CNC	nn		CALL	NC,nn
CPO	nn	(or CNO)	CALL	PO,nn
CPE	nn	(or CO)	CALL	PE,nn
CM	nn		CALL	M,nn
CP	nn		CALL	P,nn
RET			RET	
RZ			RET	Z
RNZ			RET	NZ
RC			RET	C
RNC			RET	NC
RPO		(or RNO)	RET	PO
RPE		(or RO)	RET	PE
RM			RET	M
RP			RET	P
RETI			RETI	
RETN			RETN	
RST	n		RST	m (m = 8 * n)

Page 1

```
Addr B1 B2 B3 B4 E Line Label          Opcd    Operand

0000                0001 ;
0000                0002 ; Test file for ZSM
0000                0003 ; by Neale Brassell
0000                0004 ;
0000                0005 ; This uses all instructions
0000                0006 ;
0000 8E             0007 A.0000        ADC     M
0001 DD 8E 05       0008               ADC     IND(X)
0004 FD 8E 05       0009               ADC     IND(Y)
0007 8F             0010               ADC     A
0008 88             0011               ADC     B
0009 89             0012               ADC     C
000A 8A             0013               ADC     D
000B 8B             0014               ADC     E
000C 8C             0015               ADC     H
000D 8D             0016               ADC     L
000E CE 20          0017               ACI     N
0010 ED 4A          0018               DADC    B
0012 ED 5A          0019               DADC    D
0014 ED 6A          0020               DADC    H
0016 ED 7A          0021               DADC    SP
0018                0022 ;
0018 86             0023 A.0018        ADD     M
0019 DD 86 05       0024               ADD     IND(X)
001C FD 86 05       0025               ADD     IND(Y)
001F 87             0026               ADD     A
0020 80             0027               ADD     B
0021 81             0028               ADD     C
0022 82             0029               ADD     D
0023 83             0030               ADD     E
0024 84             0031               ADD     H
0025 85             0032               ADD     L
0026 C6 20          0033               ADI     N
0028 09             0034               DAD     B
0029 19             0035               DAD     D
002A 29             0036               DAD     H
002B 39             0037               DAD     SP
002C DD 09          0038               DADX    B
002E DD 19          0039               DADX    D
0030 DD 29          0040               DADX    X
0032 DD 39          0041               DADX    SP
0034 FD 09          0042               DADY    B
0036 FD 19          0043               DADY    D
0038 FD 29          0044               DADY    Y
003A FD 39          0045               DADY    SP
003C                0046 ;
003C A6             0047 A.003C        ANA     M
003D DD A6 05       0048               ANA     IND(X)
0040 FD A6 05       0049               ANA     IND(Y)
0043 A7             0050               ANA     A
0044 A0             0051               ANA     B
0045 A1             0052               ANA     C
0046 A2             0053               ANA     D
0047 A3             0054               ANA     E
0048 A4             0055               ANA     H
0049 A5             0056               ANA     L
```

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```
Addr B1 B2 B3 B4 E Line Label          Opcd    Operand

004A E6 20          0057               ANI     N
004C                0058 ;
004C CB 46          0059 A.004C        BIT     0,M
004E DD CB 05 46    0060               BIT     0,IND(X)
0052 FD CB 05 46    0061               BIT     0,IND(Y)
0056 CB 47          0062               BIT     0,A
0058 CB 40          0063               BIT     0,B
005A CB 41          0064               BIT     0,C
005C CB 42          0065               BIT     0,D
005E CB 43          0066               BIT     0,E
0060 CB 44          0067               BIT     0,H
0062 CB 45          0068               BIT     0,L
0064                0069 ;
0064 CB 4E          0070               BIT     1,M
0066 DD CB 05 4E    0071               BIT     1,IND(X)
006A FD CB 05 4E    0072               BIT     1,IND(Y)
006E CB 4F          0073               BIT     1,A
0070 CB 48          0074               BIT     1,B
0072 CB 49          0075               BIT     1,C
0074 CB 4A          0076               BIT     1,D
0076 CB 4B          0077               BIT     1,E
0078 CB 4C          0078               BIT     1,H
007A CB 4D          0079               BIT     1,L
007C                0080 ;
007C CB 56          0081               BIT     2,M
007E DD CB 05 56    0082               BIT     2,IND(X)
0082 FD CB 05 56    0083               BIT     2,IND(Y)
0086 CB 57          0084               BIT     2,A
0088 CB 50          0085               BIT     2,B
008A CB 51          0086               BIT     2,C
008C CB 52          0087               BIT     2,D
008E CB 53          0088               BIT     2,E
0090 CB 54          0089               BIT     2,H
0092 CB 55          0090               BIT     2,L
0094                0091 ;
0094 CB 5E          0092               BIT     3,M
0096 DD CB 05 5E    0093               BIT     3,IND(X)
009A FD CB 05 5E    0094               BIT     3,IND(Y)
009E CB 5F          0095               BIT     3,A
00A0 CB 58          0096               BIT     3,B
00A2 CB 59          0097               BIT     3,C
00A4 CB 5A          0098               BIT     3,D
00A6 CB 5B          0099               BIT     3,E
00A8 CB 5C          0100               BIT     3,H
00AA CB 5D          0101               BIT     3,L
00AC                0102 ;
00AC CB 66          0103               BIT     4,M
00AE DD CB 05 66    0104               BIT     4,IND(X)
00B2 FD CB 05 66    0105               BIT     4,IND(Y)
00B6 CB 67          0106               BIT     4,A
00B8 CB 60          0107               BIT     4,B
00BA CB 61          0108               BIT     4,C
00BC CB 62          0109               BIT     4,D
00BE CB 63          0110               BIT     4,E
00C0 CB 64          0111               BIT     4,H
00C2 CB 65          0112               BIT     4,L
```

```
                                                    Page 3
Addr B1 B2 B3 B4 E Line Label           Opcd    Operand

00C4               0113 ;
00C4 CB 6E         0114                 BIT     5,M
00C6 DD CB 05 6E   0115                 BIT     5,IND(X)
00CA FD CB 05 6E   0116                 BIT     5,IND(Y)
00CE CB 6F         0117                 BIT     5,A
00D0 CB 68         0118                 BIT     5,B
00D2 CB 69         0119                 BIT     5,C
00D4 CB 6A         0120                 BIT     5,D
00D6 CB 6B         0121                 BIT     5,E
00D8 CB 6C         0122                 BIT     5,H
00DA CB 6D         0123                 BIT     5,L
00DC               0124 ;
00DC CB 76         0125                 BIT     6,M
00DE DD CB 05 76   0126                 BIT     6,IND(X)
00E2 FD CB 05 76   0127                 BIT     6,IND(Y)
00E6 CB 77         0128                 BIT     6,A
00E8 CB 70         0129                 BIT     6,B
00EA CB 71         0130                 BIT     6,C
00EC CB 72         0131                 BIT     6,D
00EE CB 73         0132                 BIT     6,E
00F0 CB 74         0133                 BIT     6,H
00F2 CB 75         0134                 BIT     6,L
00F4               0135 ;
00F4 CB 7E         0136                 BIT     7,M
00F6 DD CB 05 7E   0137                 BIT     7,IND(X)
00FA FD CB 05 7E   0138                 BIT     7,IND(Y)
00FE CB 7F         0139                 BIT     7,A
0100 CB 78         0140                 BIT     7,B
0102 CB 79         0141                 BIT     7,C
0104 CB 7A         0142                 BIT     7,D
0106 CB 7B         0143                 BIT     7,E
0108 CB 7C         0144                 BIT     7,H
010A CB 7D         0145                 BIT     7,L
010C               0146 ;
010C DC 88 05      0147 A.010C          CC      NN
010F FC 88 05      0148                 CM      NN
0112 D4 88 05      0149                 CNC     NN
0115 CD 88 05      0150                 CALL    NN
0118 C4 88 05      0151                 CNZ     NN
011B F4 88 05      0152                 CP      NN
011E EC 88 05      0153                 CPE     NN
0121 E4 88 05      0154                 CPO     NN
0124 CC 88 05      0155                 CZ      NN
0127               0156 ;
0127 3F            0157 A.0127          CMC
0128               0158 ;
0128 BE            0159 A.0128          CMP     M
0129 DD BE 05      0160                 CMP     IND(X)
012C FD BE 05      0161                 CMP     IND(Y)
012F BF            0162                 CMP     A
0130 B8            0163                 CMP     B
0131 B9            0164                 CMP     C
0132 BA            0165                 CMP     D
0133 BB            0166                 CMP     E
   4 BC            0167                 CMP     H
   5 BD            0168                 CMP     L
```

```
                                                    Page 4
Addr B1 B2 E3 B4 E Line Label           Opcd    Operand

0136 FE 20         0169                 CPI     N
0138               0170 ;
0138 ED A9         0171 A.0138          CCD
013A ED B9         0172                 CCDR
013C ED A1         0173                 CCI
013E ED B1         0174                 CCIR
0140               0175 ;
0140 2F            0176 A.0140          CMA
0141               0177 ;
0141 27            0178 A.0141          DAA
0142               0179 ;
0142 35            0180 A.0142          DCR     M
0143 DD 35 05      0181                 DCR     IND(X)
0146 FD 35 05      0182                 DCR     IND(Y)
0149 3D            0183                 DCR     A
014A 05            0184                 DCR     B
014B 0B            0185                 DCX     B
014C 0D            0186                 DCR     C
014D 15            0187                 DCR     D
014E 1B            0188                 DCX     D
014F 1D            0189                 DCR     E
0150 25            0190                 DCR     H
0151 2B            0191                 DCX     H
0152 DD 2B         0192                 DCX     X
0154 FD 2B         0193                 DCX     Y
0156 2D            0194                 DCR     L
0157 3B            0195                 DCX     SP
0158               0196 ;
0158 F3            0197 A.0158          DI
0159               0198 ;
0159 10 2E         0199 A.0159          DJNZ    $+DIS
015B               0200 ;
015B FB            0201 A.015B          EI
015C               0202 ;
015C E3            0203 A.015C          XTHL
015D DD E3         0204                 XTIX
015F FD E3         0205                 XTIY
0161 08            0206                 EXAF
0162 EB            0207                 XCHG
0163 D9            0208                 EXX
0164               0209 ;
0164 76            0210 A.0164          HLT
0165               0211 ;
0165 ED 46         0212 A.0165          IM0
0167 ED 56         0213                 IM1
0169 ED 5E         0214                 IM2
016B               0215 ;
016B ED 78         0216 A.016B          INP     A
016D DB 20         0217                 IN      N
016F ED 40         0218                 INP     B
0171 ED 48         0219                 INP     C
0173 ED 50         0220                 INP     D
0175 ED 58         0221                 INP     E
0177 ED 60         0222                 INP     H
0179 ED 68         0223                 INP     L
 17B               0224 ;
```

```
Addr B1 B2 B3 B4 E Line Label          Opcd   Operand

017B 34            0225 A.017B         INR    M
017C DD 34 05      0226                INR    IND(X)
017F FD 34 05      0227                INR    IND(Y)
0182 3C            0228                INR    A
0183 04            0229                INR    B
0184 03            0230                INX    B
0185 0C            0231                INR    C
0186 14            0232                INR    D
0187 13            0233                INX    D
0188 1C            0234                INR    E
0189 24            0235                INR    H
018A 23            0236                INX    H
018B DD 23         0237                INX    X
018D FD 23         0238                INX    Y
018F 2C            0239                INR    L
0190 33            0240                INX    SP
0191               0241 ;
0191 ED AA         0242 A.0191         IND
0193 ED BA         0243                INDR
0195 ED A2         0244                INI
0197 ED B2         0245                INIR
0199               0246 ;
0199 E9            0247 A.0199         PCHL
019A DD E9         0248                PCIX
019C FD E9         0249                PCIY
019E DA 88 05      0250                JC     NN
01A1 FA 88 05      0251                JM     NN
01A4 D2 88 05      0252                JNC    NN
01A7 C3 88 05      0253                JMP    NN
01AA C2 88 05      0254                JNZ    NN
01AD F2 88 05      0255                JP     NN
01B0 EA 88 05      0256                JPE    NN
01B3 E2 88 05      0257                JPO    NN
01B6 CA 88 05      0258                JZ     NN
01B9               0259 ;
01B9 38 2E         0260 A.01B9         JRC    $+DIS
01BB 18 2E         0261                JR     $+DIS
01BD 30 2E         0262                JRNC   $+DIS
01BF 20 2E         0263                JRNZ   $+DIS
01C1 28 2E         0264                JRZ    $+DIS
01C3               0265 ;
01C3 02            0266 A.01C3         STAX   B
01C4 12            0267                STAX   D
01C5 77            0268                MOV    M,A
01C6 70            0269                MOV    M.B
01C7 71            0270                MOV    M,C
01C8 72            0271                MOV    M,D
01C9 73            0272                MOV    M,E
01CA 74            0273                MOV    M,H
01CB 75            0274                MOV    M,L
01CC 36 20         0275                MVI    M,N
01CE DD 77 05      0276                MOV    IND(X),A
01D1 DD 70 05      0277                MOV    IND(X),B
01D4 DD 71 05      0278                MOV    IND(X),C
01D7 DD 72 05      0279                MOV    IND(X),D
01DA DD 73 05      0280                MOV    IND(X),E
```

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Addr 31 B2 B3 B4 E Line Label          Opcd   Operand

01DD DD 74 05      0281                MOV    IND(X),H
01E0 DD 75 05      0282                MOV    IND(X),L
01E3 DD 36 05 20   0283                MVI    IND(X),N
01E7               0284 ;
01E7 FD 77 05      0285 A.01E7         MOV    IND(Y),A
01EA FD 70 05      0286                MOV    IND(Y),B
01ED FD 71 05      0287                MOV    IND(Y),C
01F0 FD 72 05      0288                MOV    IND(Y),D
01F3 FD 73 05      0289                MOV    IND(Y),E
01F6 FD 74 05      0290                MOV    IND(Y),H
01F9 FD 75 05      0291                MOV    IND(Y),L
01FC FD 36 05 20   0292                MVI    IND(Y),N
0200               0293 ;
0200 32 88 05      0294 A.0200         STA    NN
0203 ED 43 88 05   0295                SBCD   NN
0207 ED 53 88 05   0296                SDED   NN
020B 22 88 05      0297                SHLD   NN
020E DD 22 88 05   0298                SIXD   NN
0212 FD 22 88 05   0299                SIYD   NN
0216 ED 73 88 05   0300                SSPD   NN
021A               0301 ;
021A 0A            0302 A.021A         LDAX   B
021B 1A            0303                LDAX   D
021C 7E            0304                MOV    A,M
021D DD 7E 05      0305                MOV    A,IND(X)
0220 FD 7E 05      0306                MOV    A,IND(Y)
0223 3A 88 05      0307                LDA    NN
0226 7F            0308                MOV    A,A
0227 78            0309                MOV    A,B
0228 79            0310                MOV    A,C
0229 7A            0311                MOV    A,D
022A 7B            0312                MOV    A,E
022B 7C            0313                MOV    A,H
022C ED 57         0314                LDAI
022E 7D            0315                MOV    A,L
022F 3E 20         0316                MVI    A,N
0231 ED 5F         0317                LDAR
0233               0318 ;
0233 46            0319 A.0233         MOV    B,M
0234 DD 46 05      0320                MOV    B,IND(X)
0237 FD 46 05      0321                MOV    B,IND(Y)
023A 47            0322                MOV    B,A
023B 40            0323                MOV    B,B
023C 41            0324                MOV    B,C
023D 42            0325                MOV    B,D
023E 43            0326                MOV    B,E
023F 44            0327                MOV    B,H
0240 45            0328                MOV    B,L
0241 06 20         0329                MVI    B,N
0243               0330 ;
0243 ED 4B 88 05   0331 A.0243         LBCD   NN
0247 01 88 05      0332                LXI    B,NN
024A               0333 ;
024A 4E            0334 A.024A         MOV    C,M
024B DD 4E 05      0335                MOV    C,IND(X)
024E FD 4E 05      0336                MOV    C,IND(Y)
```

```
Addr B1 B2 B3 B4 E Line Label          Opcd  Operand

0251 4F            0337                MOV   C,A
0252 48            0338                MOV   C,B
0253 49            0339                MOV   C,C
0254 4A            0340                MOV   C,D
0255 4B            0341                MOV   C,E
0256 4C            0342                MOV   C,H
0257 4D            0343                MOV   C,L
0258 0E 20         0344                MVI   C N
025A               0345 ;
025A 56            0346 A.025A         MOV   D,M
025B DD 56 05      0347                MOV   D,IND(X)
025E FD 56 05      0348                MOV   D,IND(Y)
0261 57            0349                MOV   D,A
0262 50            0350                MOV   D,B
0263 51            0351                MOV   D,C
0264 52            0352                MOV   D,D
0265 53            0353                MOV   D,E
0266 54            0354                MOV   D,H
0267 55            0355                MOV   D,L
0268 16 20         0356                MVI   D,N
026A               0357 ;
026A ED 5B 88 05   0358 A.026A         LDED  NN
026E 11 88 05      0359                LXI   D,NN
0271               0360 ;
0271 5E            0361 A.0271         MOV   E,M
0272 DD 5E 05      0362                MOV   E,IND(X)
0275 FD 5E 05      0363                MOV   E,IND(Y)
0278 5F            0364                MOV   E,A
0279 58            0365                MOV   E,B
027A 59            0366                MOV   E,C
027B 5A            0367                MOV   E,D
027C 5B            0368                MOV   E,E
027D 5C            0369                MOV   E,H
027E 5D            0370                MOV   E,L
027F 1E 20         0371                MVI   E,N
0281               0372 ;
0281 66            0373 A.0281         MOV   H,M
0282 DD 66 05      0374                MOV   H,IND(X)
0285 FD 66 05      0375                MOV   H,IND(Y)
0288 67            0376                MOV   H,A
0289 60            0377                MOV   H,B
028A 61            0378                MOV   H,C
028B 62            0379                MOV   H,D
028C 63            0380                MOV   H,E
028D 64            0381                MOV   H,H
028E 65            0382                MOV   H,L
028F 26 20         0383                MVI   H,N
0291               0384 ;
0291 2A 88 05      0385 A.0291         LHLD  NN
0294 21 88 05      0386                LXI   H,NN
0297               0387 ;
0297 ED 47         0388 A.0297         LDIA
0299               0389 ;
0299 DD 2A 88 05   0390 A.0299         LIXD  NN
029D DD 21 88 05   0391                LXI   X,NN
                   0392 ;
```

```
Addr B1 B2 B3 B4 E Line Label          Opcd  Operand

02A1 FD 2A 88 05   0393 A.02A1         LIYD  NN
02A5 FD 21 88 05   0394                LXI   Y,NN
02A9               0395 ;
02A9 6E            0396 A.02A9         MOV   L,M
02AA DD 6E 05      0397                MOV   L,IND(X)
02AD FD 6E 05      0398                MOV   L,IND(Y)
02B0 6F            0399                MOV   L,A
02B1 68            0400                MOV   L,B
02B2 69            0401                MOV   L,C
02B3 6A            0402                MOV   L,D
02B4 6B            0403                MOV   L,E
02B5 6C            0404                MOV   L,H
02B6 6D            0405                MOV   L,L
02B7 2E 20         0406                MVI   L,N
02B9               0407 ;
02B9 ED 4F         0408 A.02B9         LDRA
02BB               0409 ;
02BB ED 7B 88 05   0410 A.02BB         LSPD  NN
02BF F9            0411                SPHL
02C0 DD F9         0412                SPIX
02C2 FD F9         0413                SPIY
02C4 31 88 05      0414                LXI   SP,NN
02C7               0415 ;
02C7 ED A8         0416 A.02C7         LDD
02C9 ED B8         0417                LDDR
02CB ED A0         0418                LDI
02CD ED B0         0419                LDIR
02CF               0420 ;
02CF ED 44         0421 A.02CF         NEG
02D1               0422 ;
02D1 00            0423 A.02D1         NOP
02D2               0424 ;
02D2 B6            0425 A.02D2         ORA   M
02D3 DD B6 05      0426                ORA   IND(X)
02D6 FD B6 05      0427                ORA   IND(Y)
02D9 B7            0428                ORA   A
02DA B0            0429                ORA   B
02DB B1            0430                ORA   C
02DC B2            0431                ORA   D
02DD B3            0432                ORA   E
02DE B4            0433                ORA   H
02DF B5            0434                OHA   L
02E0 F6 20         0435                ORI   N
02E2               0436 ;
02E2 ED BB         0437 A.02E2         OUTDR
02E4 ED B3         0438                OUTIR
02E6               0439 ;
02E6 ED 79         0440 A.02E6         OUTP  A
02E8 ED 41         0441                OUTP  B
02EA ED 49         0442                OUTP  C
02EC ED 51         0443                OUTP  D
02EE ED 59         0444                OUTP  E
02F0 ED 61         0445                OUTP  H
02F2 ED 69         0446                OUTP  L
02F4 D3 20         0447                OUT   N
02F6               0448 ;
```

```
Addr B1 B2 B3 B4 E Line Label         Opcd  Operand

02F6 ED AB          0449 A.02F6       OUTD
02F8 ED A3          0450              OUTI
02FA                0451 ;
02FA F1             0452 A.02FA       POP   PSW
02FB C1             0453              POP   B
02FC D1             0454              POP   D
02FD E1             0455              POP   H
02FE DD E1          0456              POP   X
0300 FD E1          0457              POP   Y
0302 F5             0458              PUSH  PSW
0303 C5             0459              PUSH  B
0304 D5             0460              PUSH  D
0305 E5             0461              PUSH  H
0306 DD E5          0462              PUSH  X
0308 FD E5          0463              PUSH  Y
030A                0464 ;
030A CB 86          0465 A.030A       RES   0,H
030C DD CB 05 86    0466              RES   0,IND(X)
0310 FD CB 05 86    0467              RES   0,IND(Y)
0314 CB 87          0468              RES   0,A
0316 CB 80          0469              RES   0,B
0318 CB 81          0470              RES   0,C
031A CB 82          0471              RES   0,D
031C CB 83          0472              RES   0,E
031E CB 84          0473              RES   0,H
0320 CB 85          0474              RES   0,L
0322                0475 ;
0322 CB 8E          0476              RES   1,M
0324 DD CB 05 8E    0477              RES   1,IND(X)
0328 FD CB 05 8E    0478              RES   1,IND(Y)
032C CB 8F          0479              RES   1,A
032E CB 88          0480              RES   1,B
0330 CB 89          0481              RES   1,C
0332 CB 8A          0482              RES   1,D
0334 CB 8B          0483              RES   1,E
0336 CB 8C          0484              RES   1,H
0338 CB 8D          0485              RES   1,L
033A                0486 ;
033A CB 96          0487              RES   2,M
033C DD CB 05 96    0488              RES   2,IND(X)
0340 FD CB 05 96    0489              RES   2,IND(Y)
0344 CB 97          0490              RES   2,A
0346 CB 90          0491              RES   2,B
0348 CB 91          0492              RES   2,C
034A CB 92          0493              RES   2,D
034C CB 93          0494              RES   2,E
034E CB 94          0495              RES   2,H
0350 CB 95          0496              RES   2,L
0352                0497 ;
0352 CB 9E          0498              RES   3,M
0354 DD CB 05 9E    0499              RES   3,IND(X)
0358 FD CB 05 9E    0500              RES   3,IND(Y)
035C CB 9F          0501              RES   3,A
035E CB 98          0502              RES   3,B
0360 CB 99          0503              RES   3,C
0362 CB 9A          0504              RES   3,D
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Addr B1 B2 B3 B4 E Line Label         Opcd  Operand

0364 CB 9B          0505              RES   3,E
0366 CB 9C          0506              RES   3,H
0368 CB 9D          0507              RES   3,L
036A                0508 ;
036A CB A6          0509              RES   4,M
036C DD CB 05 A6    0510              RES   4,IND(X)
0370 FD CB 05 A6    0511              RES   4,IND(Y)
0374 CB A7          0512              RES   4,A
0376 CB A0          0513              RES   4,B
0378 CB A1          0514              RES   4,C
037A CB A2          0515              RES   4,D
037C CB A3          0516              RES   4,E
037E CB A4          0517              RES   4,H
0380 CB A5          0518              RES   4,L
0382                0519 ;
0382 CB AE          0520              RES   5,M
0384 DD CB 05 AE    0521              RES   5,IND(X)
0388 FD CB 05 AE    0522              RES   5,IND(Y)
038C CB AF          0523              RES   5,A
038E CB A8          0524              RES   5,B
0390 CB A9          0525              RES   5,C
0392 CB AA          0526              RES   5,D
0394 CB AB          0527              RES   5,E
0396 CB AC          0528              RES   5,H
0398 CB AD          0529              RES   5,L
039A                0530 ;
039A CB B6          0531              RES   6,M
039C DD CB 05 B6    0532              RES   6,IND(X)
03A0 FD CB 05 B6    0533              RES   6,IND(Y)
03A4 CB B7          0534              RES   6,A
03A6 CB B0          0535              RES   6,B
03A8 CB B1          0536              RES   6,C
03AA CB B2          0537              RES   6,D
03AC CB B3          0538              RES   6,E
03AE CB B4          0539              RES   6,H
03B0 CB B5          0540              RES   6,L
03B2                0541 ;
03B2 CB BE          0542              RES   7,M
03B4 DD CB 05 BE    0543              RES   7,IND(X)
03B8 FD CB 05 BE    0544              RES   7,IND(Y)
03BC CB BF          0545              RES   7,A
03BE CB B8          0546              RES   7,B
03C0 CB B9          0547              RES   7,C
03C2 CB BA          0548              RES   7,D
03C4 CB BB          0549              RES   7,E
03C6 CB BC          0550              RES   7,H
03C8 CB BD          0551              RES   7,L
03CA                0552 ;
03CA C9             0553 A.03CA       RET
03CB D8             0554              RC
03CC F8             0555              RM
03CD D0             0556              RNC
03CE C0             0557              RNZ
03CF F0             0558              RP
03D0 E8             0559              RPE
03D1 E0             0560              RPO
```

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Addr B1 B2 B3 B4 E Line Label          Opcd    Operand

03D2 C8            0561               RZ
03D3               0562 ;
03D3 ED 4D         0563 A.03D3        RETI
03D5 ED 45         0564               RETN
03D7               0565 ;
03D7 CB 16         0566 A.03D7        RALR    M
03D9 DD CB 05 16   0567               RALR    IND(X)
03DD FD CB 05 16   0568               RALR    IND(Y)
03E1 CB 17         0569               RALR    A
03E3 CB 10         0570               RALR    B
03E5 CB 11         0571               RALR    C
03E7 CB 12         0572               RALR    D
03E9 CB 13         0573               RALR    E
03EB CB 14         0574               RALR    H
03ED CB 15         0575               RALR    L
03EF               0576 ;
03EF 17            0577 A.03EF        RAL
03F0               0578 ;
03F0 CB 06         0579 A.03F0        RLCR    M
03F2 DD CB 05 06   0580               RLCR    IND(X)
03F6 FD CB 05 06   0581               RLCR    IND(Y)
03FA CB 07         0582               RLCR    A
03FC CB 00         0583               RLCR    B
03FE CB 01         0584               RLCR    C
0400 CB 02         0585               RLCR    D
0402 CB 03         0586               RLCR    E
0404 CB 04         0587               RLCR    H
0406 CB 05         0588               RLCR    L
0408               0589 ;
0408 07            0590 A.0408        RLC
0409               0591 ;
0409 ED 6F         0592 A.0409        RLD
040B               0593 ;
040B CB 1E         0594 A.040B        RARR    M
040D DD CB 05 1E   0595               RARR    IND(X)
0411 FD CB 05 1E   0596               RARR    IND(Y)
0415 CB 1F         0597               RARR    A
0417 CB 18         0598               RARR    B
0419 CB 19         0599               RARR    C
041B CB 1A         0600               RARR    D
041D CB 1B         0601               RARR    E
041F CB 1C         0602               RARR    H
0421 CB 1D         0603               RARR    L
0423               0604 ;
0423 1F            0605 A.0423        RAR
0424               0606 ;
0424 CB 0E         0607 A.0424        RRCR    M
0426 DD CB 05 0E   0608               RRCR    IND(X)
042A FD CB 05 0E   0609               RRCR    IND(Y)
042E CB 0F         0610               RRCR    A
0430 CB 08         0611               RRCR    B
0432 CB 09         0612               RRCR    C
0434 CB 0A         0613               RRCR    D
0436 CB 0B         0614               RRCR    E
0438 CB 0C         0615               RRCR    H
043A CB 0D         0616               RRCR    L
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Addr B1 B2 B3 B4 E Line Label          Opcd    Operand

043C               0617 ;
043C 0F            0618 A.043C        RRC
043D               0619 ;
043D ED 67         0620 A.043D        RRD
043F               0621 ;
043F C7            0622 A.043F        RST     0
0440 CF            0623               RST     1
0441 D7            0624               RST     2
0442 DF            0625               RST     3
0443 E7            0626               RST     4
0444 EF            0627               RST     5
0445 F7            0628               RST     6
0446 FF            0629               RST     7
0447               0630 ;
0447 9E            0631 A.0447        SBB     M
0448 DD 9E 05      0632               SBB     IND(X)
044B FD 9E 05      0633               SBB     IND(Y)
044E 9F            0634               SBB     A
044F 98            0635               SBB     B
0450 99            0636               SBB     C
0451 9A            0637               SBB     D
0452 9B            0638               SBB     E
0453 9C            0639               SBB     H
0454 9D            0640               SBB     L
0455 DE 20         0641               SBI     N
0457               0642 ;
0457 ED 42         0643 A.0457        DSBC    B
0459 ED 52         0644               DSBC    D
045B ED 62         0645               DSBC    H
045D ED 72         0646               DSBC    SP
045F               0647 ;
045F 37            0648 A.045F        STC
0460               0649 ;
0460 CB C6         0650 A.0460        SET     0,M
0462 DD CB 05 C6   0651               SET     0,IND(X)
0466 FD CB 05 C6   0652               SET     0,IND(Y)
046A CB C7         0653               SET     0,A
046C CB C0         0654               SET     0,B
046E CB C1         0655               SET     0,C
0470 CB C2         0656               SET     0,D
0472 CB C3         0657               SET     0,E
0474 CB C4         0658               SET     0,H
0476 CB C5         0659               SET     0,L
0478               0660 ;
0478 CB CE         0661               SET     1,M
047A DD CB 05 CE   0662               SET     1,IND(X)
047E FD CB 05 CE   0663               SET     1,IND(Y)
0482 CB CF         0664               SET     1,A
0484 CB C8         0665               SET     1,B
0486 CB C9         0666               SET     1,C
0488 CB CA         0667               SET     1,D
048A CB CB         0668               SET     1,E
048C CB CC         0669               SET     1,H
048E CB CD         0670               SET     1,L
0490               0671 ;
0490 CB D6         0672               SET     2,M
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Addr B1 B2 B3 B4 E Line Label        Opcd   Operand

0492 DD CB 05 D6    0673             SET    2,IND(X)
0496 FD CB 05 D6    0674             SET    2,IND(Y)
049A CB D7          0675             SET    2,A
049C CB D0          0676             SET    2,B
049E CB D1          0677             SET    2,C
04A0 CB D2          0678             SET    2,D
04A2 CB D3          0679             SET    2,E
04A4 CB D4          0680             SET    2,H
04A6 CB D5          0681             SET    2,L
04A8                0682 ;
04A8 CB DE          0683             SET    3,M
04AA DD CB 05 DE    0684             SET    3,IND(X)
04AE FD CB 05 DE    0685             SET    3,IND(Y)
04B2 CB DF          0686             SET    3,A
04B4 CB D8          0687             SET    3,B
04B6 CB D9          0688             SET    3,C
04B8 CB DA          0689             SET    3,D
04BA CB DB          0690             SET    3,E
04BC CB DC          0691             SET    3,H
04BE CB DD          0692             SET    3,L
04C0                0693 ;
04C0 CB E6          0694             SET    4,M
04C2 DD CB 05 E6    0695             SET    4,IND(X)
04C6 FD CB 05 E6    0696             SET    4,IND(Y)
04CA CB E7          0697             SET    4,A
04CC CB E0          0698             SET    4,B
04CE CB E1          0699             SET    4,C
04D0 CB E2          0700             SET    4,D
04D2 CB E3          0701             SET    4,E
04D4 CB E4          0702             SET    4,H
04D6 CB E5          0703             SET    4,L
04D8                0704 ;
04D8 CB EE          0705             SET    5,M
04DA DD CB 05 EE    0706             SET    5,IND(X)
04DE FD CB 05 EE    0707             SET    5,IND(Y)
04E2 CB EF          0708             SET    5,A
04E4 CB E8          0709             SET    5,B
04E6 CB E9          0710             SET    5,C
04E8 CB EA          0711             SET    5,D
04EA CB EB          0712             SET    5,E
04EC CB EC          0713             SET    5,H
04EE CB ED          0714             SET    5,L
04F0                0715 ;
04F0 CB F6          0716             SET    6,M
04F2 DD CB 05 F6    0717             SET    6,IND(X)
04F6 FD CB 05 F6    0718             SET    6,IND(Y)
04FA CB F7          0719             SET    6,A
04FC CB F0          0720             SET    6,B
04FE CB F1          0721             SET    6,C
0500 CB F2          0722             SET    6,D
0502 CB F3          0723             SET    6,E
0504 CB F4          0724             SET    6,H
0506 CB F5          0725             SET    6,L
0508                0726 ;
0508 CB FE          0727             SET    7,M
050A DD CB 05 FE    0728             SET    7,IND(X)
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Addr B1 B2 B3 B4 E Line Label        Opcd   Operand

050E FD CB 05 FE    0729             SET    7,IND(Y)
0512 CB FF          0730             SET    7,A
0514 CB F8          0731             SET    7,B
0516 CB F9          0732             SET    7,C
0518 CB FA          0733             SET    7,D
051A CB FB          0734             SET    7,E
051C CB FC          0735             SET    7,H
051E CB FD          0736             SET    7,L
0520                0737 ;
0520 CB 26          0738 A.0520      SLAR   M
0522 DD CB 05 26    0739             SLAR   IND(X)
0526 FD CB 05 26    0740             SLAR   IND(Y)
052A CB 27          0741             SLAR   A
052C CB 20          0742             SLAR   B
052E CB 21          0743             SLAR   C
0530 CB 22          0744             SLAR   D
0532 CB 23          0745             SLAR   E
0534 CB 24          0746             SLAR   H
0536 CB 25          0747             SLAR   L
0538                0748 ;
0538 CB 2E          0749 A.0538      SRAR   M
053A DD CB 05 2E    0750             SRAR   IND(X)
053E FD CB 05 2E    0751             SRAR   IND(Y)
0542 CB 2F          0752             SRAR   A
0544 CB 28          0753             SRAR   B
0546 CB 29          0754             SRAR   C
0548 CB 2A          0755             SRAR   D
054A CB 2B          0756             SRAR   E
054C CB 2C          0757             SRAR   H
054E CB 2D          0758             SRAR   L
0550                0759 ;
0550 CB 3E          0760 A.0550      SRLR   M
0552 DD CB 05 3E    0761             SRLR   IND(X)
0556 FD CB 05 3E    0762             SRLR   IND(Y)
055A CB 3F          0763             SRLR   A
055C CB 38          0764             SRLR   B
055E CB 39          0765             SRLR   C
0560 CB 3A          0766             SRLR   D
0562 CB 3B          0767             SRLR   E
0564 CB 3C          0768             SRLR   H
0566 CB 3D          0769             SRLR   L
0568                0770 ;
0568 96             0771 A.0568      SUB    M
0569 DD 96 05       0772             SUB    IND(X)
056C FD 96 05       0773             SUB    IND(Y)
056F 97             0774             SUB    A
0570 90             0775             SUB    B
0571 91             0776             SUB    C
0572 92             0777             SUB    D
0573 93             0778             SUB    E
0574 94             0779             SUB    H
0575 95             0780             SUB    L
0576 D6 20          0781             SUI    N
0578                0782 ;
0578 AE             0783 A.0578      XRA    M
0579 DD AE 05       0784             XRA    IND(X)
```

```
Addr B1 B2 B3 B4 E Line Label          Opcd    Operand

057C FD AE 05      0785                XRA     IND(Y)
057F AF            0786                XRA     A
0580 A8            0787                XRA     B
0581 A9            0788                XRA     C
0582 AA            0789                XRA     D
0583 AB            0790                XRA     E
0584 AC            0791                XRA     H
0585 AD            0792                XRA     L
0586 EE 20         0793                XRI     N
0588               0794 ;
0588               0795 ; Now for the definitions
0588               0796 ;
0588    0020     = 0797 N              EQU     20H
0588 00 00         0798 NN             DW      0
058A    0005     = 0799 IND            EQU     5
058A    0030     = 0800 DIS            EQU     30H
058A               0801 ;
058A               0802 A.058A         END
```

4.6 SYMSAVE UTILITY

The SYMSAVE utility is an applications program that may be used to create an equate batch from a symbol table left in memory immediately after an assembly. This equate batch is stored as an editor source file and can be edited by the line editor and assembled by the assembler. The program is invoked from the MDOS executive by typing SYMSAVE followed by an ASCII filename parameter enclosed in double quotes and an optional ASCII mask string enclosed in double quotes.

```
[unit:]SYMSAVE "<filename>" ["<mask string>"]
```

The mask string can be up to ten characters long. It is used to save only those symbols in the symbol table that start with the specified mask string.

Example:

```
ADDR  B1 B2 B3  E LINE LABEL    OPCODE  OPERAND
ØØØØ              1ØØØ          ORG     4ØØØH
4ØØØ  C3 ØØ 4Ø    2ØØØ START    JMP     $
4ØØ3  Ø1          3ØØØ DATA1    DB      Ø1
4ØØ4  Ø2          4ØØØ DATA2    DB      Ø2
4ØØ5  Ø3          5ØØØ DATA3    DB      Ø3
4ØØ6              6ØØØ FINISH   END     START
```

Immediately after the above program is assembled, the symbol table is still resident in memory. To create a disk file of symbols from the above assembly type:

```
SYMSAVE "TEST"
```

The file TEST that SYMSAVE creates is an editor compatible source file which looks as follows:

```
ØØØ1 START     EQU     4ØØØH
ØØØ2 DATA1     EQU     4ØØ3H
ØØØ3 DATA2     EQU     4ØØ4H
ØØØ4 DATA3     EQU     4ØØ5H
ØØØ5 FINISH    EQU     4ØØ6H
```

If only the data symbols were required, the mask string parameter can be used as follows:

```
SYMSAVE "TEST1" "DATA"
```

The file TEST1 looks as follows:

```
ØØØ1 DATA1     EQU     4ØØ3H
ØØØ2 DATA2     EQU     4ØØ4H
ØØØ3 DATA3     EQU     4ØØ5H
```

This file contains only the symbols which start with the string DATA.

A symbol equate file can be used in other programs by using the assembler LINK pseudo-op.

Example:

```
ADDR  B1 B2 B3  E LINE LABEL      OPCODE  OPERAND
ØØØØ              1ØØØ            LINK    'TEST'
ØØØØ              2ØØØ            ORG     FINISH
4ØØ6  3E Ø1       3ØØØ BEGIN      MVI     A,DATA1
4ØØ8  32 Ø3 4Ø    4ØØØ            STA     DATA2
4ØØB  C3 ØØ 4Ø    5ØØØ            JMP     START
4ØØE              6ØØØ            END     BEGIN
```

By linking the equate batch file with the new program segment all of the symbols defined in the first program segment can be referenced in the new program segment.

4.7 FILECOPY UTILITY

The FILECOPY utility is an applications program that allows files to be copied from one disk to another or onto the same disk under a different filename. To improve speed in the process of copying a file, it uses all available memory after the end of the program as a buffer. To invoke the program from the MDOS executive type FILECOPY followed by a filename enclosed in double quotes and an optional newfilename enclosed in double quotes or a unit number by itself if the copied file is to have the same name as the original.

```
[unit:]FILECOPY "<[unit:]filename>" "<[unit:]newfilename>"
```

or

```
[unit:]FILECOPY "<[unit:]filename>" <unit number>
```

FILECOPY exits to the MDOS executive when it is done or if it encounters an error condition. The copied file has the same filetype as the original. Any file can be copied regardless of type or origin. This includes BASIC data and program files. Attempting to copy a file onto the same disk without specifying a newfilename results in a DUPLICATE NAME error.

4.8 DISKCOPY UTILITY

DISKCOPY is a special overlay utility that writes an absolute binary copy of one disk onto another. The utility overlays MDOS or BASIC. It uses all available memory during the copying process. The more memory in a system the faster the copying process. On average it takes about two minutes to copy and verify all 315k bytes of a MOD II disk. To invoke the utility from the MDOS executive, type:

```
DISKCOPY
```

A sign-on message is output:

```
MICROPOLIS DISKCOPY VS X.X - COPYRIGHT 1978
SPECIFY UNIT # FOR ORIGINAL (SOURCE) DISKETTE
?
```

DISKCOPY waits until the unit number is entered. When a number between Ø and 3 is entered it prompts:

```
SPECIFY UNIT # FOR DESTINATION DISKETTE
?
```

and waits until the unit number (Ø to 3) is entered. It then prompts:

```
PUT DISKETTES IN SPECIFIED UNITS
TYPE Y WHEN READY
?
```

and waits for a Y. A note of CAUTION, we strongly recommend placing a write protect tab on the original (source) diskette. It is possible to put the wrong diskette in the wrong drive or type the wrong unit numbers. If your original does not have a write protect tab and you make an error, the original can be overwritten. The write protect tab provides a physical interlock which disables the write electronics.

When a Y is typed DISKCOPY will start the copying process. During copying, the process can be temporarily halted between read source and write destination cycles by typing a control S. The process is restarted by typing any other key except a control C.

The control C will cancel the entry or copy process and prompt:

```
CANCELLED
MORE ?
```

If a Y is typed DISKCOPY starts from the top asking for the unit numbers again. If an N is typed DISKCOPY prompts:

```
PUT SYSTEM DISKETTE IN UNIT Ø
TYPE Y WHEN READY
?
```

When a Y is typed the disk in unit Ø is rebooted. If it's an MDOS diskette MDOS is booted. If the disk in unit Ø is a BASIC only disk or some other bootable system, it will be booted in and sign on. DISKCOPY is overlayed by the incoming system and is no longer in memory.

When the disk has been copied and verified correctly DISKCOPY outputs:

```
GOOD COPY
MORE ?
```

If the copy cannot be completed or does not verify correctly DISKCOPY outputs:

```
PERM I/O ERROR ON DESTINATION DISKETTE
```

or

```
PERM I/O ERROR ON SOURCE DISKETTE
```

indicating where the error occurred.

It is possible for single drive systems to make use of the DISKCOPY utility to copy from one disk to another. In this case it is imperative that the original diskette be write protected with a write protect tab. The procedure involves specifying the same unit number for both source and destination disks. Immediately after typing a Y in response to the TYPE Y WHEN READY prompt, type a control S. The DISKCOPY program will read as many tracks from the source disk as can be contained in main memory and then pause. When the select indicator light goes out, remove the source diskette and insert the destination diskette. Press the return key and as soon as the select indicator light comes on type a control S again. When the select indicator light goes out again, the data from the source disk has been written to the destination disk and one complete cycle is finished. This process is repeated, swaping the source and destination disks in and out until the entire disk is copied. After the last data is written onto the destination disk, the program goes directly into a verifying process and will not pause until this is over. When the source is placed back into the drive and the return key is pressed the system will prompt: GOOD COPY or output an error message as discussed above. At this point the copy is complete.

4.9 ERROR MESSAGES

This section is a summary of the error messages generated by the MDOS shared subroutines. The shared subroutines return an error code in the A register when an error exit occurs. These codes can be passed to the error message output routines to generate the proper error message.

Example:

A file is created by the following BASIC program:

```
1Ø DIM A$(248)
2Ø Z$=CHAR$(13):REM CARRIAGE RET
3Ø OPEN 1 "N:TEXTFILE":REM NEW FILE
4Ø INPUT A$:REM GET A LINE OF TEXT FROM CONSOLE
5Ø IF A$="EXIT" THEN 8Ø:REM END INPUT BY TYPING EXIT
6Ø PUT 1 A$+Z$:REM CONCATENATE CARR RTN AT END
7Ø GOTO 4Ø:REM LOOP TILL EXIT
8Ø CLOSE 1
9Ø END
```

This BASIC program writes one text line per record. Each line is terminated with a carriage return.

The file can be read by the following assembly language routine. Assume it has been assembled and given the name READ and an executable file type of 15. Typing READ "TEXTFILE" loads and executes the program.

```
ØØØØ            LINK   'SYSQ1'             ;MDOS EQUATE BATCH
ØØ1Ø            LINK   'SYSQ2'             ;MDOS EQUATE BATCH
ØØ2Ø            ORG    @APROGRAM           ;APPLICATIONS AREA
ØØ3Ø START      CALL   @CCRLF              ;CARRIAGE RETURN LINEFEED
ØØ4Ø            LDA    @NASCPAR            ;NUMBER OF ASCII PARAMETERS
ØØ5Ø            ORA    A                   ;IF ZERO
ØØ6Ø            JZ     @ERRORMES           ;ERROR
ØØ7Ø            MVI    C,Ø                 ;@ASCBUFFØ
ØØ8Ø            CALL   @TRANSFILENAME      ;MOVE INTO @ASCIIBUFFER
ØØ9Ø            MVI    B,Ø                 ;FILE NUMBER
Ø1ØØ            LDA    @DRIVENØ            ;UNIT NUMBER
Ø11Ø            MOV    C,A                 ;INTO C FOR OPEN
Ø12Ø            LXI    H,@FILEBUFFERØ      ;USE SYSTEM BUFFER Ø
Ø13Ø            CALL   @OPENFILE           ;OPEN THE FILE
Ø14Ø            JC     @DISKERROR          ;IF ERROR CODE IN A
Ø15Ø            CALL   @RFILEINF           ;CHECK THE FILE TYPE
Ø16Ø            JC     @DISKERROR          ;IF ERROR CODE IN A
Ø17Ø            MOV    A,B                 ;FILE TYPE
Ø18Ø            ANI    ØFCH                ;TYPE NOT ATTRIBUTES
Ø19Ø            ORA    A                   ;BASIC DATA FILES=Ø
Ø2ØØ            MVI    A,17                ;WRONG FILE TYPE MESSAGE
Ø21Ø            JNZ    @DISKERROR          ;ERROR
Ø22Ø NEXTCHR    MVI    B,Ø                 ;FILE NUMBER
Ø23Ø            CALL   @RFINXPOSI          ;READ FILE BYTE AT A TIME
Ø24Ø            JC     EXIT                ;END? OR ERROR?
Ø25Ø            MOV    B,C                 ;CHARACTER FOR OUTPUT
Ø26Ø            MOV    A,B                 ;INTO A FOR COMPARE
Ø27Ø            CPI    ØDH                 ;CARRIAGE RET END OF LINE
Ø28Ø            CZ     @CCRLF              ;IF CR DO CR LF
Ø29Ø            CALL   @COUT               ;OTHER CHR JUST OUTPUT
Ø3ØØ            JMP    NEXTCHR             ;LOOP TILL END-FILE
Ø31Ø EXIT       CPI    2                   ;END-FILE?
Ø32Ø            JZ     @CLOSEFILE          ;CLOSE AND RETURN TO MDOS
Ø33Ø            STC                        ;ERROR
Ø34Ø            JMP    @DISKERROR          ;ERROR MESSAGE IN A
Ø35Ø            END    START
```

Note the handling of the errors in lines 6Ø, 14Ø, 16Ø, 21Ø, 24Ø, and 31Ø-34Ø.

The error codes are summarized below. See appendix D for definitions of the error messages.

CODE#	MESSAGE
Ø	SYNTAX ERROR
1	PERM I/O ERR
2	END-FILE
3	DISK FULL
4	FILE NOT FOUND
5	DUPLICATE NAME
6	PARM ERR
7	DRIVE NOT UP
8	PERM FILE
9	WRITE PROTECT
1Ø	FILE NOT OPEN
11	COMMAND NOT FOUND
12	BAD FILE #
13	FILE OPEN
14	READ ONLY FILE
15	BAD RECORD #
16	CANCELLED
17	WRONG FILE TYPE
18	INDEX PAST EOR
19	LOAD ADDRESS ERROR

4.1Ø COPYFILE UTILITY

The COPYFILE utility is an applications program that allows files to be copied from one disk to another on a system with only one disk drive. The utility uses all the available memory after the end of the COPYFILE program as a buffer. To invoke the program from MDOS type COPYFILE followed by a filename:

```
[unit:] COPYFILE "<[unit:] filename>"
```

The COPYFILE program signs on:

```
INSERT SOURCE DISKETTE INTO DRIVE Ø
ARE YOU READY?
```

The system waits for a capital Y to be typed. Any other input is ignored except a control C which returns control to MDOS. When a Y is typed the COPYFILE program loads as much of the source file into memory as it can and then prompts:

```
INSERT DESTINATION DISKETTE INTO DRIVE Ø
ARE YOU READY?
```

Take the source diskette out of your drive and put the destination diskette into the drive. When ready type a capital Y. Any other input is ignored except a control C which returns control to MDOS. The COPYFILE program creates a file on the destination disk with the same name and filetype as the source file. It then writes the file from memory onto the destination diskette.

If the files is longer than can be held in memory at one time the COPYFILE program will prompt:

```
INSERT SOURCE DISKETTE INTO DRIVE Ø
ARE YOU READY?
```

The same procedure as above must be repeated until the whole file has been copied. When the copy is complete the COPYFILE program returns to MDOS which prompts:

```
>
```

If the COPYFILE program encounters any errors it displays the proper error message and returns to MDOS.

COPYFILE can copy any type or length file. This includes BASIC data and program files.

4.11 DEBUG - THE PDS 8Ø8Ø/8Ø85 PROGRAM DEBUGGER

Micropolis DEBUG is a utility program which facilitates checkout and debugging of 8Ø8Ø/8Ø85 machine language programs. It provides an environment in which the performance of a program can be monitored by starting and stopping program execution at user-specified points and by examining and/or changing the contents of relevant machine registers and memory locations. DEBUG cannot be used with non-8Ø8 Z8Ø code.

DEBUG and the program to be monitored must co-reside in the main system memory. Before DEBUG can be used an executable version must be obtained that uses a 4K block of memory which does not conflict with the program to be debugged. The process of creating an executable version of DEBUG configured for a specific memory space is described in Section 4.12.

DEBUG is invoked from the MDOS executive by typing the name of a configured DEBUG-XX version as created by the DEBUG-GEN utility (see Section 4.12). Example:

```
>DEBUG-7Ø

MICROPOLIS DEBUG VS. X.X - COPYRIGHT 1978
```

DEBUG signs on and displays an asterisk (*) which is the DEBUG Executive prompt. Program execution control and machine state examination and modification are performed by entering appropriate commands to the DEBUG Executive.

The program may be executed one instruction at a time (referred to as "single-stepping") with the machine state displayed after each step. Alternatively, the results of a program segment may be examined by placing a breakpoint at the end of the segment. When execution of the program is started, it will execute in real time until the breakpoint is reached. Control of the computer is then returned to the DEBUG Executive and the user may examine the contents of memory and the machine registers.

4.11.1 THE DEBUG EXECUTIVE

Operation of DEBUG facilities is controled by the DEBUG Executive. The executive prompts the user for a command with the character '*'.

Executive statements are entered by typing characters in sequence on the console keyboard. An executive statement is terminated by pressing the RETURN key. During the entry of a statement each character that is typed is echoed by the executive on the console display. Two control features may be used when entering a line.

1) When DEL or BACKSPACE is pressed the next previously typed character will be deleted from the line. A backarrow is echoed to the terminal display for each character deleted.

2) Holding down the control key and typing X (CNTL/X) will cause all of the current line to be cancelled. A carriage return line feed combination is echoed to the terminal display. The executive is positioned to accept entry of a new line.

An executive statement has the following form:

NAME [<hex> <hex>...<hex>]

The NAME in an executive statement is the name of one of the DEBUG commands. Command names are uppercase only and must not be preceded by any spaces. If the command name is not recognized by DEBUG a SYNTAX error message is displayed.

Executive statements consist of a NAME followed by up to four numeric parameters. There must be at least one space between the NAME and any parameters. All parameters must be separated from each other by at least one space. Entry of an executive statement with too many parameters or without the required spaces between fields will result in a SYNTAX error.

Numeric parameters in executive statements are unsigned hexadecimal values from Ø to FFFF. They represent such elements as memory addresses and register values. Entry of a numeric parameter with a value greater than FFFF or with illegal characters will result in a SYNTAX error.

4.11.2 DEBUG MEMORY RELATED COMMANDS

The DEBUG memory related commands are similar to those available under the MDOS executive (see Section 4.1) with the exeception of the LIST command which is unique to the DEBUG context. The syntax of these commands is illustrated with the aid of the following notation:

[ ] Option brackets. Any parameters enclosed between brackets are optional.

< > Symbol brackets. This space should be replaced by the item described.

4.11.2.1 THE DUMP COMMAND

DUMP <start addr.> [<end addr.>]

The DUMP command outputs a formatted hex display of the contents of a block of memory. Sequential memory locations are shown 16 to a line with the memory address at the left margin. If the <end addr.> is not entered only one byte is displayed. Example:

```
*DUMP 5ØØØ 5Ø11
5ØØØ  5Ø CØ 27 77  4F 33 4F CD  7D 9E 98 ØØ  6A FD 82 90
5Ø1Ø  77 2B
```

Notice that memory bytes are printed out in groups of four so that addresses inside the line may be more easily computed. The grouping follows the address.

```
*DUMP 5ØØ2 5Ø1F
5ØØ2  27 77  4F 33 4F CD  7D 9E 98 ØØ  6A FD 82 9Ø
5Ø1Ø  77 2B 54 56  F4 3E 23 2A  34 87 19 3D  21 2C 2A 2B
```

4.11.2.2 THE ENTR COMMAND

ENTR <start addr.>

The ENTR command allows data to be entered into memory directly from the console device. Example:

```
*ENTR 7ØØØ
*78 89
6F/
```

Three bytes were entered starting at location 7ØØØ hex. These were 78 at 7ØØØ, 89 at 7ØØ1, and 6F at location 7ØØ2.

Typing in an ENTR command places the executive in a special enter mode. While in the enter mode each line of values that is typed is entered into memory when the RETURN key is pressed. Until the RETURN key is pressed the standard backspacing and CNTL/X tools are available for line correction. The last value on the last line must be followed by a slash (/) to properly terminate the enter mode. Entry of a illegal hex value in any line will also cause termination of the enter mode with the message SYNTAX ERROR.

4.11.2.3 THE FILL COMMAND

FILL <start addr.> <end addr.> <byte>

The FILL command fills a block of memory with a specified byte. Example:

```
*FILL 7ØØØ 8ØØØ 9
```

Each byte of memory in the block from 7ØØØ to 8ØØØ is changed to a Ø9 by this command.

4.11.2.4 THE MOVE COMMAND

MOVE <source addr. start> <source addr. end> <dest. addr. start>

The MOVE command copies the source block of memory to the destination block. The source block is not changed. The destination block is changed to be an exact copy of the source block. Example:

```
*MOVE 3ØØØ 4ØØØ 7ØØØ
```

Each byte in the memory block from 3ØØØ to 4ØØØ is copied into the corresponding position in the memory block from 7ØØØ to 8ØØØ.

4.11.2.5 THE SEAR COMMAND

SEAR <start addr.> <end addr.> <byte>

The SEAR command searches a block of memory for all occurrences of the specified byte and displays all locations with a match. Example:

```
* SEAR 3ØØØ 3Ø2Ø 9F
3ØØ4 9F
3Ø18 9F
```

The block of memory from 3ØØØ to 3Ø2Ø is searched for all occurrences of a 9F. Location 3ØØ4 and location 3Ø18 both contain 9F. No other locations in the block contain 9F.

4.11.2.6 THE SEARN COMMAND

SEARN <start addr.> <end addr.> <byte>

The SEARN command searches a block of memory for all non-occurrences of a specified byte and displays all locations that do not match. Example:

```
* SEARN 3ØØØ 3Ø1Ø 67
3ØØ2 Ø9 67
3ØØ6 76 67
```

The block of memory from 3ØØØ to 3Ø1Ø is searched for all non-matches with the mask 67. Location 3ØØ2 contained a 9 rather than a 67, and 3ØØ6 contained a 76 rather than a 67.

4.11.2.7 THE COMP COMMAND

COMP <start addr. block1> <end addr. block1> <start addr. block2>

The COMP command compares two blocks of memory and displays address locations that do not compare and the data at those locations. Example:

```
* COMP 5ØØØ 5ØØF 5Ø1Ø
5ØØ4 Ø1 Ø9 5Ø14
```

The block of memory from 5ØØØ to 5ØØF is compared with the block of memory from 5Ø1Ø to 5Ø1F. One location fails to compare. Location 5ØØ4 contains Ø1 while the corresponding location, 5Ø14, in the second block contains Ø9.

4.11.2.8 THE LIST COMMAND

LIST <start addr.> <end addr.>

The LIST command displays the 8Ø8Ø/8Ø85 mnemonic form of the bytes contained in the specified memory block.

```
* DUMP  3ØØØ 3ØØ8
 3ØØØ   CA Ø2 37 B7  C3 1A 37 CB
```

```
*LIST  3ØØØ 3ØØ8
3ØØØ  JZ   37Ø2
3ØØ3  ORA  A
3ØØ4  JMP  371A
3ØØ8  CB   *
```

The memory block from 3ØØØ to 3ØØ7 contains three 8Ø8Ø/8Ø85 instructions. The byte following the third instruction is not a valid 8Ø8Ø/8Ø85 instruction. This is indicated by the '*' following its value.

4.11.3 DEBUG MACHINE REGISTER AND FLAG COMMANDS

The DEBUG commands in this category are used in conjunction with DEBUG's program execution control features during the process of monitoring a programs performance. Whenever the program execution is paused and the DEBUG Executive is waiting for a command, it is possible to display and/or alter the state of the 8Ø8Ø/8Ø85 registers and flags as they are relative to the last instruction executed in the program being monitored.

4.11.3.1 THE DISR COMMAND

DISR

The DISR command displays the contents of the processor registers and flags along with the next instruction to be executed. In addition the contents of memory at locations addressed by register pairs (e.g. at the address contained in BC) along with the word on the top of the stack are displayed. Example:

```
*DISR
  A FLAGS  BC   DE   HL   SP  @B @D @H @SP
 ØØ ZCMEH ØØØØ ØØØØ ØØØØ 1234 ØØ ØØ ØØ ØØØØ
 ØØØØ LXI  SP,1234
```

The second line of the display indicates the processor state. The columns @B, @D, @H and @SP indicate the contents of memory at the addresses contained in the respective register pairs. The flag values are indicated by the presence or absence of a character in the FLAGS column. The Z character indicates a zero condition, the C character a carry condition, the M character a negative sign condition (in the SIGN flag), the E character an even-parity condition and the H character a half-carry condition. Absence of any character indicates the opposite condition on the same flag.

The third line displays the address and mnemonic of the next instruction to be executed. The address of the instruction corresponds to the current value of the 8Ø8Ø program counter (PC) register in the context of the program that DEBUG is monitoring. The instruction is the one that will be executed next by a single step operation or when program execution is resumed by using a command such as the CONT or RET commands. Note that the state of the registers and flags as displayed by the DISR command reflects their values BEFORE the next instruction shown on the third line is executed.

4.11.3.2 REGISTER SETTING COMMANDS

REGISTERNAME <hex number>

The register setting commands allow the contents of the 8Ø8Ø/8Ø85 processor registers to be set to a specified value prior to the execution of the next instruction in the program being monitored. The general format of a register setting command is a register name followed by a hex data value.

The following register names may be used:

```
     A  B  C  D  E  H  L
     BC   DE   HL  SP  PC  @SP
```

The first line shows 8 bit registers and the second line shows 16 bit registers. PC is the program counter. @SP designates the 16 bit word on top of the machine stack.

The following examples would change the program counter value to 6ØF3, the A register value to 7, and the value at the top of the stack to C172.

```
*PC  6ØF3
*A   7
*@SP C172
```

4.11.3.3 FLAG SETTING COMMANDS

The flag setting commands allow the states of the 8Ø8Ø/8Ø85 processor flags to be set or reset prior to the execution of next instruction in the program being monitored. The commands set the flag state according to the mnemonic form used in assembly language. The commands are:

```
FZ   FNZ   FC   FNC   FP   FM   FPE   FPO   FH   FNH
```

The FZ and FNZ commands set the state of the ZERO flag to zero or non-zero.
The FC and FNC commands set the state of the CARRY flag to carry or no carry.
The FP and FM command set the state of the SIGN flag to positive or minus.
The FPE and FPO commands set the state of the PARITY flag to even or odd.
The FH and FNH commands set the state of the HALF-CARRY flag to half-carry or no half-carry.

Examples:

```
*FNZ
*FC
```

The state of the ZERO flag is set to non zero and the state of the CARRY flag is set to carry.

4.11.4 DEBUG MISCELLANEOUS UTILITY COMMANDS

The two commands in this category are the MATH command which is useful in doing address computations while engaged in a debug session, and the RST command which may be needed to avoid conflict with program usage of the processor restarts.

4.11.4.1 THE MATH COMMAND

MATH <hex number> <hex number>

The MATH command performs a 16 bit integer addition and subtraction on the two specified hex numbers. It displays the sum and difference. The MATH command is useful for length and address calculations. Example:

```
*MATH 4  5
ØØØ9  FFFF
```

4+5 equals 9 and 4-5 equals FFFF.

4.11.4.2 THE RST COMMAND

RST <vector number>

DEBUG normally uses the 'RST 6' restart vector of the 8Ø8Ø or 8Ø85 processor as its mechanism for implementing breakpoints (see Section 4.11.5.1). Some computers and/or a particular program may already be using 'RST 6' for a different purpose. In this case it is possible to change the RST vector used by DEBUG to one of the other available RST's, 1-5 or 7. Example:

```
*RST 7
```

The RST vector used by DEBUG is changed to RST 7 from its default usage of RST 6.

4.11.5 DEBUG PROGRAM EXECUTION CONTROL

DEBUG offers 3 modes of control to monitor progress through a program; the breakpoint mode, the single step mode, and the trace mode. There is a permanent breakpoint facility normally used in conjunction with the commands SET, DISB, CLR, EXEC and REPT. There is a temporary breakpoint facility used in conjunction with the commands CONT and RET. The single-step mode is controlled with the space bar. The trace mode is a form of continuous single-stepping. Use of these modes and their associated commands are detailed in this section.

4.11.5.1 THE BREAKPOINT MODE

Breakpoints provide a means to stop program execution at a given point. When program execution reaches that point control of the processor is transferred to DEBUG. Once in DEBUG, the results of the program section which was executed may be examined or modified.

In the breakpoint mode DEBUG replaces the instruction at a given address with one of the 'RST' instructions of the 8080/8085 (see 4.11.4.2 the RST command). Then DEBUG replaces the three bytes of code at the corresponding 'RST' vector location with a 'JMP' instruction to a routine inside itself. DEBUG then loads the processor's registers with the stored 'user program register' values and transfers control of the processor to the user's program. When the breakpointed instruction address is executed, the 'RST' that DEBUG had placed at that location causes the processor to 'CALL' the RST vector location which then causes the processor to 'JMP' back to DEBUG. DEBUG then stores the processor's registers in the 'user program registers' and replaces the original contents of both the breakpointed instruction and the RST vector location.

Because of the introduction of an 'RST' instruction into the program, when a breakpoint is encountered, at least one level of stack space must be available so that the return address back into the program can be stored. Therefore, when using the breakpoint mode the user must insure that at least one stack level will be available when the breakpoint is encountered.

Note that breakpoints cannot be used to DEBUG ROMed code because an 'RST' instruction cannot be patched into the code.

When a breakpoint is encountered during program execution, DEBUG will display the contents of the program registers in the following format:

```
 A  FLAGS  BC   DE   HL   SP   @B @D @H @SP
13         0000 0000 0000 01A2 00 00 00 14FE
```

Refer to the DISR command section for a detailed description of this display.

4.11.5.2 PERMANENT BREAKPOINTS

Permanent breakpoints are set using the SET command. These breakpoints are not cleared when control of the processor is returned to DEBUG. Permanent breakpoints are only cleared by the CLR command. Permanent breakpoints can be used as traps on such things as error routines or executive loops.

Note that permanent breakpoints do not leave a 'RST' instruction in the program code. The existence of a permanent breakpoint tells DEBUG to place a breakpoint in the code only when the program is executing. Thus the original program is intact whenever the DEBUG has control of the processor

4.11.5.3 THE SET COMMAND

SET <breakpoint #> <address>

The SET command defines a permanent breakpoint. The breakpoint # and the hex address at which the breakpoint will be set are entered with the command. More than one breakpoint # may be set with the same breakpoint address. However, an attempt to SET a breakpoint # which is already set will cause the message SYNTAX ERROR to be printed and the command to be ignored. A maximum of 4 breakpoint #'s may be set at any time. Example:

```
*SET  1 2354
```

Permanent breakpoint number 1 was set at location 2354 (hex).

4.11.5.4 THE DISB COMMAND

```
DISB
```

The DISB command displays all currently SET breakpoints.
Example:

```
DISB
Ø1 2354
Ø3 2365
```

The display indicates that breakpoint number 1 is set at address 2354 (hex) and breakpoint number 3 is set at address 2365 (hex). Breakpoints number 2 and 4 are not SET.

4.11.5.5 THE CLR COMMAND

```
CLR [<breakpoint #>]
```

The CLR command clears a SET breakpoint. If the optional breakpoint number is not entered, then all SET breakpoints will be cleared. If a breakpoint number is entered but is not currently SET, the message SYNTAX ERROR will be displayed.

Example:

```
*CLR  1
```

Permanent breakpoint number 1 is cleared.

4.11.5.6 THE EXEC COMMAND

```
EXEC <starting address>
```

The EXEC command transfers control of the processor to the user's program. The processor's PC register will be set to the entered starting address and execution will start there. If a breakpoint is encountered, control of the processor will be returned to DEBUG. If no permanent breakpoints are SET at that time, the program will retain control of the processor.

Example:

```
*EXEC  3Ø14

 A FLAGS  BC   DE   HL   SP   @B  @D  @H  @SP
ØØ Z C   ØØ12 Ø341 3674 Ø195 ØØ  ØØ  ØØ  3Ø54
35Ø7 JMP  3643
*
```

Program execution was started at location 3Ø14 (hex). A breakpoint was encountered at location 35Ø7 returning control back to DEBUG.

4.11.5.7 THE REPT COMMAND

REPT <breakpoint #> <repeat count>

The REPT command transfers control to the user's program until a permanent breakpoint has been hit a given number of times. The breakpoint number entered specifies the breakpoint address and the entered repeat count specifies the number of times it must be hit before control is transferred back to DEBUG. If any breakpoint other than the one being repeated is encountered, control will be transferred back to DEBUG and the repeat operation is cancelled. If the breakpoint # specified in the REPT command is not set, a SYNTAX error is displayed. Example:

```
*SET  1 3ØØØ
*ØØ   E  2ØØØ ØØØØ ØØØØ ØØØØ ØØ ØØ ØØ ØØØØ
 3ØØØ DCR  B
*ØØ      1FØØ ØØØØ ØØØØ ØØØØ ØØ ØØ ØØ ØØØØ
 3ØØ1 JMP  3ØØØ
*REPT  1 8
  A FLAGS  BC   DE   HL   SP  @B @D @H @SP
 ØØ    E  18ØØ ØØØØ ØØØØ Ø1AØ ØØ ØØ ØØ ØØØØ
*
```

The breakpoint at location 3ØØØ (hex) is allowed to be passed over 8 times before control is transferred back to DEBUG and the processor state is displayed.

4.11.5.8 TEMPORARY BREAKPOINTS

Temporary breakpoints are one-shot breakpoints which the user instructs DEBUG to place in the program by using the CONT or RET commands. When control of the processor returns to DEBUG, the breakpoints are cleared. Temporary breakpoints are the type normally used to follow the execution of the program from routine to routine.

4.11.5.9 THE CONT COMMAND

CONT [<break 1> [<break 2> [<break 3> [<break 4>]]]]

The CONT command continues execution of the user's program at the current PC location with up to four temporary specified breakpoints. If no temporary breakpoints are specified, then control will never return to DEBUG unless an already specified permanent breakpoint is encountered. Example:

```
*CONT  356F
  A FLAGS  BC   DE   HL   SP   @B @D @H @SP
ØØ    M   Ø12Ø Ø341 3674 Ø195  ØØ ØØ ØØ 3Ø54
35Ø7  DCR  A
*
```

Program execution is resumed at the next instruction indicated by the value of the user program PC register and execution continues until the breakpoint at location 356F (hex) is encountered, which returns control back to DEBUG.

4.11.5.10 THE RET COMMAND

RET

The RET command transfers control of the processor to the user's program with a temporary breakpoint set at the address which is on the top of the stack (@SP). This allows the user to 'RETURN' from a subroutine which was 'CALL'ed by the program.

If a breakpoint other than the 'RET' breakpoint is hit, control will return to the DEBUG and the 'RET' breakpoint will be cleared.

Note. The RET command should only be used after a 'CALL' type instruction has been executed or when the top of the stack contains a known return address. Otherwise a breakpoint might be placed at an address which is not a part of the program. (e.g. the last instruction was a 'PUSH' and therefore the top of the stack contains a data word instead of a return address) Example:

```
*DISR
  A FLAGS   BC   DE   HL   SP   @B @D @H @SP
 ØØ Z      ØØØØ ØØØØ ØØØØ ØØØØ ØØ ØØ ØØ ØØØØ
 2AØØ LXI   SP,3ØØØ
*ØØ Z      ØØØØ ØØØØ ØØØØ 3ØØØ ØØ ØØ ØØ 3243
 2AØ3 CALL  2BØØ
*ØØ Z      ØØØØ ØØØØ ØØØØ 2FFE ØØ ØØ ØØ 2AØ6
 2BØØ STC
*RET
  A FLAGS   BC   DE   HL   SP   @B @D @H @SP
 ØØ ZC     ØØØØ ØØØØ ØØØØ 3ØØØ ØØ ØØ ØØ 3243
```

After the second instruction single-step, the RET command causes a temporary breakpoint to be set at location 2AØ6 (which is the return address on the top of stack) and program execution is resumed. When the program reaches 2AØ6 control of the processor is returned to DEBUG and the processor state is displayed.

Exception Note: The following program fragment illustrates a special programming construct with which the RET command can not be used.

```
       Call MESSAGE
TEXT   DTH 'SIGNON'
       RET

MESSAGE   XTHL
          CALL @LINEOUT
          INX H
          RET
```

If an RET command is given after the call to MESSAGE has just been executed, the return address on the top of the stack is pointing to location TEXT. DEBUG puts a breakpoint at that location. MESSAGE then outputs the Signon text and returns without encountering the breakpoint because the return address has been modified by the called routine.

4.11.5.11 THE SINGLE STEP MODE

The single-stepping mode of program execution allows a detailed inspection of what the program is doing on an instruction by instruction basis. Each time the space bar is pressed in response to the DEBUG '*' prompt, DEBUG causes the next instruction in the program to be executed and displays the contents of the processor registers.

Example:

```
*DISR
  A FLAGS  BC    DE    HL    SP   @B @D @H @SP
13         ØØØØ ØØØØ ØØØØ Ø1A2 ØØ ØØ ØØ 14FE
2AØØ STC
*13 C      ØØØØ ØØØØ ØØØØ Ø1A2 ØØ ØØ ØØ 14FE
2AØ1 XRA   A
*ØØ Z E    ØØØØ ØØØØ ØØØØ Ø1A2 ØØ ØØ ØØ 14FE
2AØ2 STA  345F
```

At the '*' prompt the user typed a space which caused DEBUG to single-step an instruction and print the resulting register contents on the same line. In the single-step mode of operation, DEBUG makes a local copy of the instruction to be executed in its own buffers. DEBUG then executes the instruction in its buffers and stores the results. The single-step mode does not need to modify the program in any way which allows programs in ROM may be stepped through without problem.

4.11.5.12 THE TRACE MODE COMMAND

TRACE

The TRACE command operates as a continuous single-stepping command. It is used to provide a trace printout of the user's program. During a TRACE the Control S / Control functions provide pause and break control.

Example:

```
*TRACE
 ØØ    E  18ØØ ØØØØ ØØØØ Ø1AØ ØØ ØØ ØØ ØØØØ
 3ØØ1 JMP  3ØØØ
 ØØ    E  18ØØ ØØØØ ØØØØ Ø1AØ ØØ ØØ ØØ ØØØØ
 3ØØØ DCR  B
 ØØ    E  17ØØ ØØØØ ØØØØ Ø1AØ ØØ ØØ ØØ ØØØØ
 3ØØ1 JMP  3ØØØ
 ØØ    E  17ØØ ØØØØ ØØØØ Ø1AØ ØØ ØØ ØØ ØØØØ
 3ØØØ DCR  B
 ØØ       16ØØ ØØØØ ØØØØ Ø1AØ ØØ ØØ ØØ ØØØØ
 3ØØ1 JMP  3ØØØ
*
```

The program was put in TRACE mode. The Control C key was pressed and stopped the TRACE after 5 instructions had been executed.

Exception Note: The nature of Micropolis disk subsystems is such that a disk access must not be interrupted during the data transfer process which is accomplished by a program loop. For this reason it is not possible to TRACE successfully through portions of a program that call MDOS disk access routines, because the TRACE command effectively interrupts the program once every instruction.

4.11.6 INITIATING A DEBUG SESSION

Both DEBUG and the program to be monitored must be in memory at the same time. The program is loaded into memory first by using the LOAD command from the MDOS executive. DEBUG is then invoked from the MDOS executive by typing the name of a configured DEBUG version as created by DEBUG-GEN (see Section 4.12). The version invoked should not use any memory space that is required by the program to be monitored. Example:

```
>LOAD "TEST PROGRAM"
>DEBUG
MICROPOLIS DEBUG V.S. X.X - COPYRIGHT 1978
*
```

DEBUG signs on and displays its executive prompt. Monitoring of program execution is now controlled from the DEBUG executive.

If the program to be monitored is one which runs in the MDOS Application area, and which requires one or more ASCII or binary parameters that are normally input as part of an MDOS Executive statement, then the way to initiate program execution control is by SETting a permanent breakpoint at the address of the entry point (first instruction) of the program and then EXECuting the MDOS Executive at the warmstart address which is 4E7H. Example:

```
*SET 1 2BØØ
*EXEC 4E7
MICROPOLIS MDOS V.S. X.X - COPYRIGHT 1978
>APP "ASCIIPARM" 12

A   FLAGS   BC     DE     HL     SP   @B @D @H @SP
.....................................................
2BØØ LXI SP, Ø1AØ
```

Permanent breakpoint number 1 is set at the program entry point 2BØØ hex and execution is begun at the system warmstart address. The MDOS executive signs on and prompts for a command. The APP command is used to transfer control to the start of the program in the application area and to pass one ASCII and one numeric parameter. The breakpoint is then encountered. DEBUG outputs a register display and waits for additional single-step, breakpoint or other commands.

If the program to be monitored is one which can be executed directly without requiring any parameters from the MDOS executive, then the simplest way to initiate program execution control is to set the PC register to the program entry point address. Set the stack pointer to an appropriate address and then use the CONT command to set a temporary breakpoint at the first desired stop point and transfer control to the program. Example:

```
*PC 3ØØØ
*SP 1AØ
*CONT 3Ø2Ø
```

The program counter is set to 3ØØØ hex and the stack is set at 1AØ hex. A temporary breakpoint is set at 3Ø2Ø hex and program execution is begun at the PC value, 3ØØØ hex. When the temporary breakpoint is encountered DEBUG will output a register display and wait for a new command.

4.11.7 EXITING DEBUG

The user may exit DEBUG in one of two ways. First, the user may simply transfer control of the processor to the program permanently. This is done by clearing all permanent breakpoints with the CLR command and then using the CONT command without setting any temporary breakpoints. Second, the user may simply return to the MDOS executive. This is done by CLRing all permanent breakpoints and then typing:

```
*EXEC 4E7
```

This warmstarts the MDOS executive and leaves the program without any breakpoints set.

4.11.8 RE-ENTERING DEBUG

If control of the processor has been permanently given to the program, DEBUG may be restarted by executing the first address of the 1K boundary on which DEBUG is running. This 'warmstart' procedure will cause any breakpoints which were set in the program to be replaced by the original instructions.

An example of a situation where a restart of DEBUG would be necessary is as follows. A breakpoint was set in the program and control transferred by a CONT command. However, the program entered a loop which had a bug such that the loop was never exited. This caused the system to lock up. The only way to get control back to DEBUG is by restarting DEBUG.

4.11.9 SAMPLE PROGRAM DEBUGGING SESSION

This section contains a sample debugging session as an example of the use of various DEBUG features. The program being DEBUGged is listed in 4.11.9.1. Assume that the program and DEBUG are on disk unit Ø along with an MDOS system. The actual debugging session is shown in Section 4.11.9.2.

4.11.9.1 SAMPLE PROGRAM LISTING

```
3ØØØ 16 ØØ       ØØØØ              MVI    D,Ø
3ØØ2 21 8Ø Ø2    ØØ1Ø              LXI    H,28ØH
3ØØ5 CD    3Ø    ØØ2Ø LOOP:        CALL   SUB
3ØØ8 25          ØØ3Ø              DCR    H
3ØØ9 C2 Ø5 3Ø    ØØ4Ø              JNZ    LOOP
3ØØC 7D          ØØ5Ø              MOV    A,L
3ØØD ØF          ØØ6Ø              RRC
3ØØE 6F          ØØ7Ø              MOV    L,A
3ØØF D2 Ø5 3Ø    ØØ8Ø              JNC    LOOP
3Ø12 C9          ØØ9Ø              RET
3Ø13 F5          Ø1ØØ SUB:         PUSH   PSW
3Ø14 7C          Ø11Ø              MOV    A,H
3Ø15 B5          Ø12Ø              ORA    L
3Ø16 F1          Ø13Ø              POP    PSW.
3Ø17 C9          Ø14Ø              RET
```

4.11.9.2 DEBUGGING SESSION

The following text is a description of the debugging session listing which follows.

The first three lines show the test program being loaded into memory along with the load and execution of the DEBUG. Once DEBUG is loaded and running it signs on and displays its executive prompt '*'. At that point the PC and SP registers are initialized so that the program can be tested. A permanent breakpoint is set at the final RET instruction so that the program will not return illegally. Then the first three instructions of the program are single-stepped leaving the program inside the subroutine. The subroutine is RETurned from and execution is allowed to proceed to location 3ØØC using the CONT command. Then the TRACE command is used to let execution proceed. The TRACE is cancelled at location 3ØØ5. A permanent breakpoint is SET and the REPT command used to allow the inner loop (the CALL, DCR H and JNZ) to execute twice. After two loops control returns to DEBUG. The second breakpoint (the one used for the REPT) is cleared and the program is allowed to execute to the final RET instruction. Having finished testing the program, MDOS is warmstarted.

```
MICROPOLIS MDOS V.S. 4.Ø - COPYRIGHT 1978

>LOAD  "TEST"                  load program into memory
>DEBUG-7Ø                      run debug (7ØØØ hex)

MICROPOLIS DEBUG V.S. 4.Ø - COPYRIGHT 1978

*SP 1AØ                        set up a stack
*PC 3ØØØ                       set up PC
```

```
*DISR
 A  FLAGS  BC   DE   HL   SP  @B @D @H @SP
 8Ø ZC E  ØØØØ ØØØØ ØØØØ Ø1AØ C3 C3 C3 5845
 3ØØØ MVI  D,ØØ
*SET  1 3Ø12                     set breakpoint on final RET
*DISB
 Ø1 3Ø12
*8Ø ZC E   ØØØØ ØØØØ ØØØØ Ø1AØ C3 C3 C3 5845     single-step
 3ØØ2 LXI   H,Ø28Ø
*8Ø ZC E   ØØØØ ØØØØ Ø28Ø Ø1AØ C3 C3 11 5845     single-step
 3ØØ5 CALL 3Ø13
*8Ø ZC E   ØØØØ ØØØØ Ø28Ø Ø19E C3 C3 11 3ØØ8     single-step
 3Ø13 PUSH H
*RET                             return from SUB call
 A  FLAGS  BC   DE   HL   SP  @B @D @H @SP
 Ø2   M   ØØØØ ØØØØ Ø28Ø Ø1AØ C3 C3 11 5845
 3008 DCR  H
*CONT  300C                      set temporary break and go
 A  FLAGS  BC   DE   HL   SP  @B @D @H @SP
 Ø1 Z  E  ØØØØ ØØØØ ØØ8Ø Ø1AØ C3 C3 ØA 5845
 3ØØC MOV  A,L
*TRACE                           trace execution
 8Ø Z  E  ØØØØ ØØØØ ØØ8Ø Ø1AØ C3 C3 ØA 5845
 3ØØD RRC
 4Ø Z  E  ØØØØ ØØØØ ØØ8Ø Ø1AØ C3 C3 ØA 5845
 3ØØE MOV  L,A
 4Ø Z  E  ØØØØ ØØØØ ØØ4Ø Ø1AØ C3 C3 ØA 5845
 3ØØF JNC  3ØØ5
 4Ø Z  E  ØØØØ ØØØØ ØØ4Ø Ø1AØ C3 C3 ØA 5845
 3ØØ5 CALL 3Ø13                  Control C hit here
*SET 2 3ØØC                      set permanent break
*REPT  2 2                       execute inner loop twice
 A  FLAGS  BC   DE   HL   SP  @B @D @H @SP
 2Ø Z  E  ØØØØ ØØØØ ØØ2Ø Ø1AØ C3 C3 ØA 5845
 3ØØC MOV  A,L
*CLR  2                          clear breakpoint 2
*DISB                            display breakpoints
 Ø1 3Ø12
*CONT                            complete program
 A  FLAGS  BC   DE   HL   SP  @B @D @H @SP
 8Ø ZC E  ØØØØ ØØØØ ØØ8Ø Ø1AØ C3 C3 ØA 5845
 3Ø12 RET
*CLR                             clear all breakpoints
*EXEC  4E7                       warmstart MDOS

MICROPOLIS MDOS V.S. 4.Ø - COPYRIGHT 1978
```

4.11.10 USING DEBUG WITH BASIC

DEBUG is designed so that it is independent of the MDOS executive. The only part of PDS on which DEBUG relies is the console and printer I/O logic contained in the RES module. This independence makes it possible to use DEBUG in conjunction with Micropolis BASIC to debug user written machine language routines that BASIC accesses via its DEF FAA construct.

To use DEBUG in this way, its filetype must be changed to an overlay type C, so that it may be accessed with the BASIC LINK statement. This can be done from the MDOS executive by using the TYPE command.

The BASIC program and the machine subroutine should be loaded prior to accessing DEBUG. Also the end of BASIC's memory space must avoid conflict with the machine routine and the particular version of DEBUG being used. When these conditions are met DEBUG can be accessed from the BASIC monitor by using the statement LINK "DEBUG-XX". Example:

```
MICROPOLIS BASIC V.S. X.X - COPYRIGHT 1978

READY
LOAD "BASICPGM"
READY
LIST
1Ø DEF FAA=16R7Ø1Ø
2Ø A=FAA (1)
3Ø PRINT A
4Ø END
READY
MEMEND 16R7ØØØ
READY
LOAD "MROUTINE"
READY
LINK "DEBUG-74"

MICROPOLIS DEBUG V.S. X.X - COPYRIGHT 1978

*SET 1 7Ø1Ø
*EXEC 4E7

MICROPOLIS BASIC V.S. X.X - COPYRIGHT 1978

READY
RUN
A FLAGS ....
............        DEBUG Register display
7Ø1Ø PUSH H
*
```

From the BASIC monitor the file "BASICPGM" is loaded and listed. It is a program that accesses a machine language routine beginning at address 7Ø1Ø hex. BASIC's end of memory is set to 7ØØØ hex and the machine routine "MROUTINE" is loaded in above the end of BASIC. A version of DEBUG which starts at 74ØØ hex is then linked to. In DEBUG a permanent breakpoint is set at 7Ø1Ø hex, the beginning of the machine routine. Control is then transferred to the system warmstart address 4E7 hex and BASIC signs on again. A RUN command starts execution of the BASIC program, which accesses the machine routine when line 2Ø is executed. The DEBUG breakpoint is encountered and DEBUG outputs a register display and waits for a command. The machine routine accessed from BASIC may now be stepped through or otherwise debugged as required.

4.12 THE DEBUG-GEN UTILITY

The Micropolis DEBUG program is supplied in a non-configured form embedded within the DEBUG-GEN utility program. Before DEBUG can be used an executable version must be obtained by running the DEBUG-GEN utility.

DEBUG requires 4K of contiguous memory address space which may start on any 1K boundary above the beginning of the MDOS applications area. DEBUG-GEN accepts a memory space specification and creates a version of DEBUG that uses the specified memory space.

From the MDOS executive, DEBUG-GEN is invoked by entering the filename DEBUG-GEN like an executive statement (see Section 4.1.2) or by entering the command LOAD "DEBUG-GEN" followed by the command APP.

The program signs on with the message

```
DEBUG GENERATION PROGRAM VS. X.X.
```

and prompts for the memory address at which the DEBUG will run with the message

```
ENTER PAGE ADDRESS (2C-FØ) ?
```

Type a two digit hexadecimal number that corresponds to the high-order byte of the start address where the DEBUG will run. This address may only be on a 1K boundary. The program will ignore the lowest 2 bits of the response.

DEBUG-GEN creates a type 14 file on disk unit Ø and fills it with the relocated DEBUG system. The file name is "DEBUG-XX" where XX (hex) is the page address entered by the user.

Example:

```
MICROPOLIS MDOS V.S. 4.Ø - COPYRIGHT 1978

>DEBUG-GEN

DEBUG GENERATION PROGRAM V.S. X.X

ENTER PAGE ADDRESS  (2C-FØ) ? 7Ø

RUN FILE NAMED DEBUG-7Ø
>
```

In this example a program file named "DEBUG-7Ø" is created on disk unit Ø. This file is a running DEBUG package which will use the memory space from 7ØØØH to 7FFFH.

V MICROPOLIS DISK EXTENDED BASIC

5.0 INTRODUCTION

Micropolis Program Development Software consists of two systems, the Micropolis Diskette Operating System (MDOS) and Micropolis Disk Extended Basic. Both systems are supplied on a MASTER diskette included with each Micropolis disk subsystem. The auto-load bootstrap brings MDOS, which is the first system on the diskette, into memory. Control is transferred from MDOS to BASIC by typing the filename BASIC to the MDOS executive. It is also possible to create a BASIC only diskette so that BASIC may be directly loaded by the bootstrap system. See Chapter II, Section 2. This chapter describes the Micropolis BASIC interpreter and its associated BASIC programming language.

The Micropolis BASIC Interpreter is a special 8080 machine language program supplied on a master diskette included with the disk subsystem. It provides a simple and powerful means for developing, maintaining and executing BASIC programs on 8080 type microcomputer systems. The user interacts with the Interpreter through a terminal which consists of an input keyboard and an output display that may be video or printed hardcopy. Lines entered at the keyboard may be program lines which are stored in the program buffer or commands for immediate execution. A program in the program buffer may be modified in place, stored as a disk file, retrieved from disk and executed under control of the Interpreter. These functions and others are invoked by entering the appropriate immediate commands. Elements of the BASIC Interpreter and its use are described in Sections 5.1 and following.

The original BASIC programming language was developed by John Kemeny and Thomas Kurtz at Dartmouth College, Hanover, New Hampshire; Micropolis Extended Disk BASIC is an elaborated version of that language. BASIC consists of data types, operators, function references and key words which combine to form statements that can be grouped into executable BASIC programs. The details of these language elements and the rules for combining them are described in sections following.

5.1 ENTERING LINES TO THE BASIC INTERPRETER

The BASIC Interpreter is loaded into the main computer memory from MDOS or booted from a BASIC only diskette. At the end of this procedure the message READY is displayed at the terminal. This means that the Interpreter is in control and is waiting for a line to be input.

A line consists of not more than 250 characters typed in sequence. The entry of a line is terminated by depressing the RETURN key. If more than 250 characters are typed prior to the RETURN the Interpreter will output the message INPUT OVERFLOW and cancel the entire line.

During the entry of a line each character that is typed is echoed by the Interpreter on the terminal display. If the character typed is not part of the BASIC character set (see Section 5.15) it will not be echoed and will not be included in the line entered. The Interpreter also keeps track of the character count as a line is typed and automatically outputs a carriage return / line feed combination to the terminal display when the count exceeds the width of the display device. This combination is not included in the line count.

Two control features may be used when entering a line.

1) when DEL or RUBOUT key is depressed the next previously typed character will be deleted from the line. A back arrow is echoed to the terminal display for each character deleted. Neither the deleted characters nor the back arrows are included in the line count.

2) Holding down the control key and typing X (CNTL/X) will cause all of the current line to be cancelled. A carriage return line feed combination is echoed to the terminal display; the Interpreter is positioned to accept entry of a new line.

5.2 ENTERING A PROGRAM

The BASIC Interpreter recognizes a line as a program line by the presence of a leading line number. A BASIC program is entered one program line at a time using the normal line entry procedures. The message READY is not displayed after the entry of a program line. This permits consecutive program lines to be entered conveniently. As each program line is entered the Interpreter stores it in a program buffer which it maintains in the computer system's main memory.

Each line of a BASIC program is composed of a line number followed by one or more statements (see Section 5.20) which are separated from each other by a colon (:). The length of a program line may not exceed 250 characters including the digits in the line number. Each line number must be within the range 0 - 65529. Spaces preceding the first digit of a line number are ignored. Spaces embedded in a line number are not legal. All other spaces in a program line are preserved as entered..

Program lines are stored in the program buffer in numeric order by line number. The lines in the buffer at any given time constitute the current program. This program may be modified in three ways.

To insert a new program line, type in the new line including the line number. The interpreter will automatically place the new line in the program buffer in proper sequence.

To modify an existing program line enter the line number and the new statement or statements. The new line will automatically replace the old line in the program buffer that has the same line number.

To delete an existing program line type the line number followed by carriage return. The corresponding line will be eliminated from the program buffer. Note that multiple lines may also be eliminated by using the DELETE command as described in 5.4.

5.3 IMMEDIATELY EXECUTED LINES

Whenever a line is typed in, the Interpreter scans it from left to right until the first non blank character is encountered. If this character is a digit it is assumed to be the first digit of a line number and the line is treated as a program line. (see Section 5.2). If the first non blank character is not a digit then the line is interpreted for immediate execution.

Most normal BASIC statements may be entered for immediate execution. Exceptions are the DEF FN, DEF FA, and DATA statements which are only functional within a program. Multiple statements may be included in an immediate line by separating them with colons (:). BASIC statements are covered in Section 5.20.

Another form of immediate line is the command. Commands are operations which generally make sense only in immediate mode. Most of the commands in BASIC system relate to the program buffer and to the manipulation and execution of BASIC programs. The available commands are described in the following sections.

EDIT, RENUM and MERGE are three commands which function only in the immediate mode. These commands cause a SYNTAX error if they appear in a program.

5.3.1 THE BASIC EDIT COMMAND

EDIT linenumber

A specified line in the BASIC program buffer can be changed without retyping the entire line by using the EDIT command. EDIT linenumber is the form of this command. If the specified linenumber is not found in the current program buffer, the message STMT # NOT FOUND is displayed. BASIC processes an EDIT command by copying the specified line into a special editing buffer and setting an invisible pointer to point to the first digit of the linenumber that begins the text line. BASIC is then in the EDIT command mode. A separate set of single key commands is available for editing a line in the special edit buffer. The whole line including the linenumber can be edited.

5.3.1.1 ADVANCING THE BASIC EDIT POINTER - THE SPACE BAR

The invisible edit pointer in the special editing buffer may be advanced one position by pressing the space bar one time. The character to which the edit pointer is pointing will be displayed on the console. This indicates that the edit pointer has passed over the character. The edit pointer is then advanced so that it is now pointing at the next character in the text line immediately after the one that is displayed. The entire line can be displayed in this manner.

5.3.1.2 CHANGING THE NEXT CHARACTER - C

The character to which the edit pointer is pointing in the edit buffer can be changed by typing a c or C, followed by the new character. The new character is printed on the console and replaces the character in the edit buffer at that position. The edit pointer is advanced to point to the character immediately after the new displayed character.

5.3.1.3 DELETING THE NEXT CHARACTER - D

The character to which the edit pointer is pointing in the edit buffer can be deleted by typing a d or D. The deleted character is printed on the console enclosed in backslashes (/). The edit pointer is left pointing at the character immediately after the deleted character.

5.3.1.4 INSERTING CHARACTERS - I

Characters may be inserted into the line or at the end of the line by typing an i or I followed by the characters to be inserted. The insertion begins immediately before the character pointed to by the edit pointer. Characters are inserted in sequence as typed until the insert mode is terminated by depressing the ESC key. The edit pointer remains pointing to the same character that it pointed to when the insertion began. The insert mode may also be terminated by pressing the return key. This also terminates the EDIT command and replaces the line in the current text file with the newly edited version from the special editing buffer.

5.3.1.5 LISTING THE LINE IN THE SPECIAL EDITING BUFFER - L

The remainder of the line in the special edit buffer from the position of the edit pointer to the end of the line may be displayed by typing an l or L. The characters are displayed on the console followed by a carriage return-line feed. The edit pointer is reset to the beginning position. This command is useful to see what the line looks like before editing is completed. It may also be helpful to use this command immediately after entering the original EDIT command. This would display the line about to be edited without exiting the editing mode.

5.3.1.6 SEARCHING TO A SPECIFIED CHARACTER - S

The edit pointer may be advanced in the special editing buffer to the first occurrence of a specified character by typing an s or S followed by the character to search for. The characters from the position of the edit pointer up to but not including the searched for character are printed on the console. The edit pointer is left pointing at the first occurrence of the searched for character. If the search argument does not exist in the line then the entire line is printed and the edit pointer is positioned at the end of the line.

5.3.1.7 DELETING TO A SPECIFIED CHARACTER - K

Characters in the special editing buffer from the edit pointer position up to but not including a specified search character can be deleted by typing a k or K followed by the search character. The deleted characters are displayed on the console, enclosed in backslashes (/). If the search argument does not exist in the edit line, then all the characters from the edit pointer to the end of the line are deleted. The edit pointer is left pointing at the search character or at the end of the line.

5.3.1.8 QUITTING THE BASIC EDIT COMMAND MODE - Q

The EDIT command may be aborted without changing the line in the current text file by typing a q or Q. The partially edited line in the special editing buffer is abandoned. No changes are made to the current program buffer. BASIC is ready to accept a new command.

5.3.1.9 COMPLETING THE BASIC EDIT COMMAND - THE RETURN KEY

The line in the special editing buffer can be placed in the current program buffer by pressing the return key at any point while in the BASIC EDIT command mode. If the line number of the line in the special edit buffer matches a line number in the current program buffer, then the edited line replaces the corresponding line in the program buffer and the EDIT mode is completed. If there is no line in the current program buffer with the same line number as the line in the special edit buffer, then the edited line is inserted into the current program buffer in proper line number order. This feature facilitates the copying or repetition of program lines by changing only the line number during the edit.

5.3.2 THE RENUM COMMAND

```
RENUM
RENUM (starting-number)
RENUM (starting-number, increment)
RENUM (starting-number, increment, first-line-to-change)
```

Some or all of the lines in the current program buffer can be renumbered by using the RENUM command. This command renumbers lines in the program, changing line numbers, and line number references that follow branch statements. These statements are GOTO, GOSUB, ON...GOTO, ON...GOSUB, THEN, RESTORE. The ERROR, END, and ENDPAGE options of the OPEN statement are also affected.

The forms of this command are RENUM, RENUM (starting-number), RENUM (starting-number, increment), and RENUM (starting-number, increment, first-line-to-change). RENUM takes the line number of the first-line-to-change and sets it equal to the starting-number. The line number of each line after the first-line-to-change is then set to the value of the preceding new line number plus the increment value. If no first-line-to-change is specified, the first line in the program buffer is assumed. If no increment value is specified, the value 1Ø is used. If no starting-number is specified, the value 1Ø is used. Typing RENUM alone will produce a program numbered from 1Ø by 1Ø's. Examples:

Assume that the current program buffer contains the following program:

```
9 REM RENUM EXAMPLE PROGRAM
25 INPUT "VALUE";A
3Ø PRINT "THE SQUARE ROOT OF";A;"IS";SQR(A)
45 GOTO 25
```

The command RENUM (5Ø,3Ø,3Ø) would produce the following:

```
9 REM RENUM EXAMPLE PROGRAM
25 INPUT "VALUE";A
5Ø PRINT "THE SQUARE ROOT OF";A;"IS";SQR(A)
8Ø GOTO 25
```

The command RENUM would produce the following:

```
1Ø REM RENUM EXAMPLE PROGRAM
2Ø INPUT "VALUE";A
3Ø PRINT "THE SQUARE ROOT OF";A;"IS";SQR(A)
4Ø GOTO 2Ø
```

The command RENUM (1ØØ) would produce the following:

```
1ØØ REM RENUM EXAMPLE PROGRAM
11Ø INPUT "VALUE";A
12Ø PRINT "THE SQUARE ROOT OF";A;"IS";SQR(A)
13Ø GOTO 11Ø
```

The command RENUM (1ØØØ,1ØØ) would produce the following:

```
1ØØØ REM RENUM EXAMPLE PROGRAM
11ØØ INPUT "VALUE";A
12ØØ PRINT "THE SQUARE ROOT OF";A;"IS";SQR(A)
13ØØ GOTO 11ØØ
```

Several error conditions are checked before any renumbering is done. This is to safeguard the program against possible damage. As errors are detected error messages are printed along with the lines where the error occurred. No changes are made to the program if any errors are encountered and no renumbering can be successfully carried out until the errors are corrected.

Entering a RENUM command may result in the message NUMBER OUT OF RANGE followed by the line where the error occurred. This is an indication that the renumbering attempt lead to a line number greater than 65529. This can be corrected by entering a RENUM with a smaller increment value that does not cause a line number greater than 65529.

Entering a RENUM command may result in the message MEMORY OVERFLOW. This indicates that renumbering would create a program to long to be run in the memory currently available to BASIC. The program is not renumbered.

Entering a RENUM command may result in the message STMT # NOT FOUND without printing the offending line. This occurs when the specified first-line-to-change does not exist in the program. No change is made. Example; if the program is:

```
1Ø PRINT "TEST"
2Ø GOTO 1Ø
```

The command RENUM (1ØØ,1Ø,3Ø) would cause a STMT # NOT FOUND error because there is no line 3Ø at which to start renumbering.

Entering a RENUM command may result in the message STMT # NOT FOUND followed by the line where the error occurred. This indicates that a branch statement (GOTO,GOSUB, etc.) contained a reference to a line number that does not exist in the program. If this is intentional a stub line should be placed in the program to allow the RENUM to operate. This can be done by typing the line number with a REM statement as a place holder.

Entering a RENUM command may result in the message SYNTAX ERROR. This can be caused by several types of syntactical errors. If the line contains unbalanced quotes or parentheses the SYNTAX ERROR message is displayed, or if renumbering would cause a sequence error in the line numbering (e.g. the lines were numbered 1Ø,2Ø,3Ø,4Ø and you typed RENUM (1Ø,1Ø,3Ø). This would result in numbers 1Ø,2Ø,1Ø,2Ø which is not allowed.).

The RENUM command does not change line numbers following LIST, or DELETE. If these statements are used within a program they must be changed manually.

RENUM will not renumber line number references in scientific notation (1E3), or expressions (GOTO 90*8+3). Such references must be changed manually.

If computed GOTO's, GOSUB's or RESTORE's are used in the program they will more than likely be incorrect after renumbering unless extreme care is taken in selecting the renumbering parameters.
Example; if the program is:

```
1Ø DATA THIS,IS,A,TEST
2Ø DATA MORE,TEST,HERE,END
3Ø INPUT "WHICH DATA,1 or 2",A
4Ø RESTORE (1Ø*A)
5Ø READ A$,B$,C$,D$
```

The command RENUM (1ØØ,1Ø,3Ø) would renumber the executable part of the program while leaving the DATA statements unchanged.

```
1Ø DATA THIS,IS,A,TEST
2Ø DATA MORE,TEST,HERE,END
1ØØ INPUT "WHICH DATA,1 OR 2",A
11Ø RESTORE (1Ø*A)
12Ø READ A$,B$,C$,D$
```

The computed RESTORE on line 11Ø would still function after the program is renumbered. However, if lines 1Ø and 2Ø had been renumbered, then the program would not perform as intended.

The RENUM command can cause a line to expand to a length greater than 25Ø characters. Such a long line can only be created by RENUM and could not be entered from the keyboard because the input buffer is only 25Ø characters long. The Basic EDIT command uses the 25Ø character input buffer during editing. If renumbering causes a line longer than 25Ø characters and that line is later edited using the Basic EDIT command the line will be truncated at 25Ø characters by the editor.

5.3.3 THE MERGE COMMAND

MERGE "unit#:filename"

The MERGE command allows existing program files on disk to be incorporated with a program presently in the BASIC program buffer. The form of the command is MERGE "unit#:filename". The unit# is a number from Ø to three followed by a colon. If no unit number is specified, unit zero is assumed.

Lines are merged one at a time from the merge file into the current program buffer, starting with the first line in the merge file. If the line number in the merge file is the same as a line number presently in the program buffer, then the line from the file replaces the line in the buffer. If the line number in the merge file does not match any line number in the program buffer, then the line from the file is inserted in the current program buffer in proper line number order. When all lines from the merge file have been placed in the program buffer the MERGE is complete.

The entire merge file is loaded into memory following the program in the program buffer. Therefore the length of program in the program buffer plus the merge program must be less than the space currently available to BASIC, otherwise a LOAD OVERRUN message is output and the merge does not take place.

The MERGE command also needs some additional buffer space to perform the merge. If there is not enough room the message MEMORY OVERFLOW is output and the merge does not take place.

Large programs are often developed as modules. Each module is written with its test data and debugged separately. The following example shows a three part survey program. Part 1 reads the survey data and talleys the vote. This module is allocated line numbers from 1ØØØ to 2ØØØ. The data has been allocated lines 1Ø to 1ØØ and the printer output module is allocated lines 5ØØØ to 6ØØØ.

The program under test uses lines 1Ø-3Ø as test data, and lines 5ØØØ-5Ø1Ø prints the test results. The program looks as follows in the program buffer:

```
1Ø REM LIVE DATA SUPPLIED BY OTHER PART OF PROGRAM
2Ø REM TEST DATA.
3Ø DATA 1,1,2,2,3,3,4,4,Ø,1,4,1,99
1ØØØ REM PROCESS SURVEY MODULE.
1Ø1Ø T=1 :REM INIT TOTAL COUNTER
1Ø2Ø REM VALID DATA IS Ø=NO OPINION,1=YES,2=NO,99=END OF DATA.
1Ø25 READ C
1Ø3Ø IF C=Ø THEN T1=T1+1
1Ø4Ø IF C=1 THEN T2=T2+1
1Ø5Ø IF C=3 THEN T3=T3+1
1Ø6Ø IF C=99 THEN T=T-1:GOTO 5ØØØ
1Ø7Ø IF C<Ø OR C>2 AND C<>99 THEN PRINT "ITEM";T;"NOT VALID"
1Ø8Ø T=T+1
1Ø9Ø GOTO 1Ø25
5ØØØ REM TEST PRINT OUT ROUTINE
5Ø1Ø PRINT "NO OPINION=";T1;" YES=";T2;" NO=";T3;" TOTAL=";T
```

This process module with the temporary test data and print logic can be separately tested,debugged and then saved on disk with the command SAVE "PART1".

The real print module can then be developed as follows:

```
DELETE
5ØØØ REM PRINT MODULE
5Ø1Ø OPEN 1 "*P" ERROR 52ØØ
5Ø2Ø A$="ZZ9":B$="VZ9"
5Ø3Ø P1=T1/T:P2=T2/T:P3=T3/T
5Ø4Ø IF P1+P2+P3<>1ØØ THEN PRINT"PERCENT ERROR":STOP
5Ø5Ø PUT 1 TAB(6Ø);"NO"
```

```
5Ø6Ø PUT 1 TAB(1Ø);"RESPONSES";TAB(25);"YES  %";TAB(46)"NO  %";
5Ø7Ø PUT 1 TAB(6Ø)"OPINION  %"
5Ø8Ø PUT 1 REPEAT$("=",72)
5Ø9Ø PUT 1 TAB(12);FMT(T,A$);TAB(25);FMT(T1,A$);TAB(3Ø);FMT(P1,B$);
51ØØ PUT 1 TAB(45);FMT(T2,A$);TAB(51);FMT(P2,B$);TAB(6Ø);FMT(T3,A$);
511Ø PUT 1 TAB(69);FMT(P3,B$)
512Ø PUT 1 REPEAT$("-",72)
513Ø CLOSE 1: STOP
52ØØ PRINT ERR$:INPUT"CONTINUE",C$:GOTO 5Ø2Ø
```

When the real print module is debugged the command SAVE "PART2" saves it on the disk.

To test the system PART1 and PART2 are combined by typing the commands LOAD "PART1" and a carriage return, and then the command MERGE "PART2" and a carriage return. The combined programs are RUN using the test data. When these parts are debugged they are saved on disk by typing the command SAVE "PROGRAM" and a carriage return.

The data is entered into a separate file as follows:

```
DELETE
1Ø REM LIVE DATA
2Ø DATA 1,1,1,2,2,1,Ø,1,2,1
3Ø DATA Ø,2,2,2,1,2,2,1,1,1
4Ø DATA 1,1,1,2,2,1,2,1,Ø,Ø
5Ø DATA 99
```

And then saved by typing the command SAVE "DATA" and a carriage return. Several different data files can be produced if needed.

The final program is loaded in two parts by typing the commands: LOAD "PROGRAM" and a carriage return and then MERGE "DATA" and a carriage return. The final program appears as follows:

```
1Ø REM LIVE DATA
2Ø DATA 1,1,1,2,2,1,Ø,1,2,1
3Ø DATA Ø,2,2,2,1,2,2,1,1,1
4Ø DATA 1,1,1,2,2,1,2,1,Ø,Ø
5Ø DATA 99
1ØØØ REM PROCESS SERVEY MODULE.
1Ø1Ø T=1 :REM INIT TOTAL COUNTER
1Ø2Ø REM VALID DATA IS Ø=NO OPINION,1=YES,2=NO,99=END OF DATA.
1Ø25 READ C
1Ø3Ø IF C=Ø THEN T1=T1+1
1Ø4Ø IF C=1 THEN T2=T2+1
1Ø5Ø IF C=3 THEN T3=T3+1
1Ø6Ø IF C=99 THEN T=T-1:GOTO 5ØØØ
1Ø7Ø IF C<Ø OR C>2 AND C<>99 THEN PRINT "ITEM";T;"NOT VALID"
1Ø8Ø T=T+1
1Ø9Ø GOTO 1Ø25
```

```
5ØØØ REM PRINT MODULE
5Ø1Ø OPEN 1 "*P" ERROR 52ØØ
5Ø2Ø A$="ZZ9":B$="VZ9"
5Ø3Ø P1=T1/T:P2=T2/T:P3=T3/T
5Ø4Ø IF P1+P2+P3<>1ØØ THEN PRINT"PERCENT ERROR":STOP
5Ø5Ø PUT 1 TAB(6Ø);"NO"
5Ø6Ø PUT 1 TAB(1Ø);"RESPONSES";TAB(25);"YES  %";TAB(46)"NO  %";
5Ø7Ø PUT 1 TAB(6Ø)"OPINION  %"
5Ø8Ø PUT 1 REPEAT$("=",72)
5Ø9Ø PUT 1 TAB(12);FMT(T,A$);TAB(25);FMT(T1,A$);TAB(3Ø);FMT(P1,B$);
51ØØ PUT 1 TAB(45);FMT(T2,A$);TAB(51);FMT(P2,B$);TAB(6Ø);FMT(T3,A$);
511Ø PUT 1 TAB(69);FMT(P3,B$)
512Ø PUT 1 REPEAT$("-",72)
513Ø CLOSE1: STOP
52ØØ PRINT ERR$:INPUT"CONTINUE",C$:GOTO 5Ø2Ø
```

5.4 THE DELETE COMMAND

Groups of program lines may be eliminated from the current program buffer by using the DELETE command. There are four forms of this command.

Type DELETE X-Y to eliminate the lines numbered X through Y. Line number Y must be greater than line number X. If either line X or line Y or both are not in the current program buffer a LINE NOT FOUND message will be displayed and nothing will be deleted.

Type DELETE X- to eliminate line X through the last line in the current program buffer. If line X is not in the buffer a LINE NOT FOUND message will be displayed and nothing will be deleted.

Type DELETE -Y to eliminate the first line through line Y in the current program buffer. If line Y is not in the buffer a LINE NOT FOUND message will be displayed and nothing will be deleted.

Type DELETE to eliminate the entire contents of the current program buffer. The buffer will be set to empty and a new program may be entered.

5.5 THE LIST COMMAND

All or part of the program in the current program buffer can be listed on the terminal display device by using the LIST Command. There are four forms of this command.

Type LIST X-Y to display the lines numbered X through Y. Line number Y must be greater than line number X. If either line X or Y are not in the current program buffer the first present line number greater than X or Y will be used instead.

Type LIST X- to display the lines from line X through the last line in the current program buffer. If line X is not in the current program buffer the first present line number greater than X will be used instead.

Type LIST -Y to display the first line through line number Y in the current program buffer. If line Y is not in the current program buffer the first present line number greater than Y will be used instead.

Type LIST to display the entire content of the current program buffer.

5.6 THE SAVE COMMAND

A program in the current program buffer can be stored on disk for later retrieval by using the SAVE command.

SAVE "N: unit number: name of file" is the general form of the command.

The word SAVE and the quotation marks and the name of file must always be present. The name of file may be from 1 to 1Ø characters long. The characters which are legal in a file name are the letters A through Z, the digits Ø through 9, and ten special characters including comma (,), dash (-), period (.), slash (/), semi-colon (;), less than (<), equal (=), greater than (>), question mark (?) and at sign (@).

The N: is optional. If it is not included in the command the existing file with the specified name on the specified unit will be overwritten and replaced by the program in the program buffer. If no such file exists the message FILE NOT FOUND will be output. However, if the N: is included in the SAVE command then a new file will be created with the designated name on the designated unit. If N: is used and the file already exists on the specified unit the message DUPLICATE NAME will be output.

The unit number: is also optional. When present it consists of a single digit from Ø to 3 followed by the colon (:). It represents the address of the disk unit on which the specified file is to be replaced or created. If no unit number is specified in the SAVE command, unit Ø is assumed.

5.7 THE LOAD COMMAND

A previously stored program can be retrieved from disk and placed in the current program buffer by using the LOAD command.

LOAD "unit number: name of file" is the general form of the command.

The word LOAD and the quotation marks and the name of file must always be present. The name of file may be from 1 to 1Ø characters and may use the letters A-Z, the digits Ø-9 and the special characters (,), (-), (.), (/), (;), (<), (=), (?),(@),(>).

The unit number: is optional. If it is used it must consist of a single digit from Ø to 3 followed by a colon (:). It designates the address of the disk unit on which the specified file is to be found. If no unit number is specified, unit Ø is assumed.

If the filename specified in a LOAD command is not present on the specified unit the message FILE NOT FOUND will be output. When a program file is successfully loaded it replaces the contents of the current program buffer and all data associated with the last program in the buffer is lost. If the filename specified in the LOAD command is a data file (see section 5.21) which cannot be properly placed in the program buffer, the message NOT A LOAD FILE will be output.

5.8 THE DISPLAY COMMAND

The names of all files which are presently stored on a diskette are recorded in a special file on that diskette. This special file is known as the diskette directory and its name is always DIR. The names currently recorded in a diskette directory can be output to the terminal display by using the DISPLAY command.

DISPLAY "unit number: DIR" is the general form of the command.

The word DISPLAY and the quotation marks and the name DIR must be ⁿresent. The unit number: is optional. If it is not present unit Ø is assumed. If it is used it must consist of a single digit from Ø to 3 followed by a colon (:) It designates the address of the disk unit whose directory is to be displayed.

The DISPLAY command outputs the filenames five to a line. The first name shown should always be DIR. On disks where it is present the second name shown should always be BASIC.

If the diskette in the specified unit does not contain a valid directory file a PERM I/O ERR message will result because the disk cannot be accessed by the BASIC system.

5.9 THE SCRATCH COMMAND

A file that is stored on disk may be eliminated by using the SCRATCH command.

SCRATCH "unit number: name of file" is the general form of the command.

The word SCRATCH and the quotation marks and the name of file must always be present. The name of file may consist of 1 to 1Ø characters, including the letters A-Z, the digits Ø-9 and the special characters (,), (-), (.), (/), (;), (<), (=), (>), (?), (@).

The unit number: is optional. If it is used it must consist of a single digit from Ø to 3 followed by a colon (:). It designates the address of the disk unit from which the specified file is to be eliminated. If no unit number is specified, unit Ø will be assumed. If the specified file on the specified unit does not exist the message FILE NOT FOUND will be output.

When a file is SCRATCHed the storage space unused by that file is automatically freed and made available for reallocation.

5.10 THE RUN COMMAND

A BASIC program must be in the current program buffer in order to be executed by the interpreter. This may be accomplished by typing in the program from the input terminal or by using the LOAD command. Once a program is in the current program buffer it may be executed by using the RUN command.

RUN is the form of the command.

When the RUN command is entered, the interpreter resets all disk files to "closed", and frees all memory space previously allocated to variables from the last program run. It then begins execution of the program with the first program line in the buffer and proceeds to execute program lines in ascending order of line number. This sequence is altered only when particular program statements deliberately change the sequence by transferring control. Each program line is only executed when execution control reaches that line; it is executed each time that this occurs. Execution is halted when an END or STOP statement is encountered or when execution control processes the last line in the current program buffer and it does not alter the control sequence. At this point the interpreter displays the message READY and waits for a line to be entered.

5.11 INTERRUPTING A RUNNING PROGRAM

The execution of a program may be interrupted prior to completion by holding down the CONTROL key and typing C at the input terminal. The interpreter will respond by displaying the message INTERRUPT followed by the message READY.

The interruption generally occurs after the end of whatever program line was being executed when the CONTROL C was entered. In the case of the input statement and whenever characters are being output, the interrupt will occur immediately. Under these circumstances the remainder of the input or output will be lost if a continue is attempted (see section 5.12).

When program execution is interrupted, the value of all program variables remain as last assigned. Any open disk files remain open with file pointers current. Variables may be examined by using immediate PRINT statements and may be altered with immediate assignment statements. These are frequently used aids in debugging programs. However, if the program in the current program buffer is modified (lines deleted, inserted, or changed) then all variable and file information from the interrupted program is lost and the program can no longer be continued.

5.12 CONTINUING AN INTERRUPTED PROGRAM

If an executing program has been interrupted by the CONTROL C procedure and no changes have been made to the current program buffer, then the execution of the program may be continued by using the CONT command.

CONT is the form of the command.

When the CONT command is entered program execution is resumed at the point in the execution control sequence following the last program line executed. If continuation is not possible because no program has been interrupted or because the current program buffer has been altered, the message NOTHING TO RETURN TO will be displayed.

5.13 PROGRAM TRACING COMMANDS

Often, when developing a new program, it is useful to be able to follow the execution on a line by line basis. This capability is provided in the Micropolis BASIC system through the use of the FLOW and NOFLOW commands.

FLOW is the form of the command which enables this program line tracing capability. When the FLOW trace capability is enabled and the RUN command is entered the interpreter displays each program line immediately before it is executed. The FLOW trace remains enabled after the end of a program execution. It must be specifically disabled.

NOFLOW is the form of the command which disables the program line tracing capability.

5.14 BASIC SYSTEM ERROR HANDLING

Whenever the BASIC interpreter attempts to execute an immediate line which has just been entered or the next program line during program execution, it is possible that an error condition may arise. If this occurs the interpreter tries to indicate the problem by displaying an appropriate error message at the terminal.

If the line in error is an immediate line then the error message will be directly followed by the message READY. All or part of the erroneous line may not have been executed.

If the line in error is a program line, the line number and text of the erroneous line are displayed after the error message and before the READY message. All or part of the erroneous program line may not have been executed. Program execution is not continuable after an error.

Appendix A specifies the error messages which may be printed by BASIC and their probable causes.

5.15 THE BASIC CHARACTER SET

BASIC recognizes all printing ASCII characters except the SHIFT O (5F HEX) backspace character and the RUB OUT (7F HEX) character. However, lower case symbols may only be used in REM statements and in literal strings. The character set, along with the decimal, hexadecimal and octal values of the corresponding ASCII codes are listed in table 5.1.

5.16 BASIC DATA

BASIC programs operate on two types of data: Numeric and String. Numeric data includes integers and real (floating point) numbers. Character string data items consist of a sequence of characters chosen from the BASIC character set. This includes letters, numbers, special characters and blanks. A data item may be a constant which has an unchanging value, or a variable which may assume different values during the execution of a program. A variable may be either simple or grouped with other variables of like data type into a structure called an array, and referenced as a member of the array.

5.16.1 CONSTANTS

A constant is an unvarying value. It is expressed as its actual value. A constant may be a numeric value, or a character string value.

5.16.1.1 NUMERIC CONSTANTS

Numeric constants may be integers or real numbers.

An integer is a positive or negative whole number which may be defined as a decimal number or in any number base (radix) up to 36. The format of an integer may be:

Integer format:	-nn....n	Example:	-93784
Radix format:	-xxRnn....n	Example:	-16R7B2

Where (-) is an optional sign, xx is the number base, R indicates radix format, and nn....n is the number expressed with the digits Ø-9 and the letters A-Z (for radix format). The range of an integer specified in decimal format is 1-5E (2*ISIZE) to 5E (2*ISIZE). See SIZES statement for definition of ISIZE. The maximum value of an integer specified in radix format is 65535. A DIGIT BEYOND RADIX error occurs if a digit or letter is used that is invalid for the radix specified.

A real number is a positive or negative number which includes a decimal point and fractional part or a number expressed in scientific notation. The formats of a real number may be:

Real format:	-nn....n.nn...	Example:	-2.677
Scientific format:	-nn...nE-xx	Example:	257E-4
	-nn...n.nn...E-xx	Example:	-12.231E14

Where nn...n.nn... represents the number expressed using the digits Ø-9 and a decimal point; an optional minus sign (-) denotes a negative number or exponent, E specifies scientific notation and xx represents the exponent expressed with the digits Ø-9.

The range of a real number is 1E-61 to (1E62)-1.

BASIC CHARACTER SET IN COLLATING SEQUENCE

CHAR	DECIMAL	HEX	OCTAL	CHAR	DECIMAL	HEX	OCTAL
(space)	32	20	040	@	64	40	100
!	33	21	041	A	65	41	101
"	34	22	042	B	66	42	102
#	35	23	043	C	67	43	103
$	36	24	044	D	68	44	104
%	37	25	045	E	69	45	105
&	38	26	046	F	70	46	106
'	39	27	047	G	71	47	107
(	40	28	050	H	72	48	110
)	41	29	051	I	73	49	111
*	42	2A	052	J	74	4A	112
+	43	2B	053	K	75	4B	113
,	44	2C	054	L	76	4C	114
-	45	2D	055	M	77	4D	115
.	46	2E	056	N	78	4E	116
/	47	2F	057	O	79	4F	117
0	48	30	060	P	80	50	120
1	49	31	061	Q	81	51	121
2	50	32	062	R	82	52	122
3	51	33	063	S	83	53	123
4	52	34	064	T	84	54	124
5	53	35	065	U	85	55	125
6	54	36	066	V	86	56	126
7	55	37	067	W	87	57	127
8	56	38	070	X	88	58	130
9	57	39	071	Y	89	59	131
:	58	3A	072	Z	90	5A	132
;	59	3B	073	[	91	5B	133
<	60	3C	074	\	92	5C	134
=	61	3D	075	]	93	5D	135
>	62	3E	076	↑	94	5E	136
?	63	3F	077	←	95	5F	137

Table 5.1 Standard Collating Sequence

5.16.1.2 STRING CONSTANTS

A character string is a sequence of valid BASIC characters. Entered as a constant, a string must be enclosed in quotes ("). Quotes within a string must be doubled (the constant " is entered as " " " "). The length of a string is the number of characters. The maximum length of all character strings within a program is set by the SIZES statement.

5.16.2 VARIABLES

Variables may be integer, real, or string. The amount of memory used for each of the 3 types can be defined in a SIZES statement before execution of a BASIC program. ISIZE defines the memory space for integers; RSIZE for real variables; and SSIZE for character strings.

5.16.2.1 INTEGER VARIABLES

Integer variables are designated by any letter followed by a percent sign (%).

The range of an integer is from 1-5E(2*ISIZE) to 5E(2*ISIZE). The internal format is 2 BCD digits per byte stored in tens complement. If an attempt is made to store a number that exceeds the range a CONVERSION error occurs.

5.16.2.2 REAL VARIABLES

Real variables are indicated by any letter (not enclosed in quotes) or a letter followed by a digit. The range of a real is 1E-61 to (1E62)-1. The precision or level of accuracy is 2(RSIZE-1) decimal digits.

The Internal Storage Format Is:
Byte 1: 1 bit sign and 7 bit exponent (excess 64)
Byte 2 thru RSIZE: 2 BCD digits per byte.

5.16.2.3 STRING VARIABLES

A string variable is designated by a letter followed by a dollar sign ($). String variables may have a length of up to 25Ø characters. The default value of maximum string length is defined by the SSIZE parameter of the SIZES statement. The maximum SIZE of any particular string may be declared in a DIM statement, which supercedes the SIZES statement. If a string which is longer than the maximum length is assigned to a variable, it will be truncated on the right.

The internal format of a string variable is:

Byte 1: Maximum string length
Byte 2: Current string length
Byte 3 thru N: Any character, 1 character per byte
    (N= 2+ Maximum string length found in Byte 1)

5.16.2.4 CONVERSIONS

Automatic conversion between integer and real data types is provided which allows mixed-mode arithmetic. A real value is converted to an integer by truncating the fractional part while preserving the sign of the number.

Conversion between string and numeric data types is provided by the STR$, VAL, FMT, CHAR$, and ASC functions. See section 5.18.1.2 for description of these functions.

5.16.2.5 ARRAYS

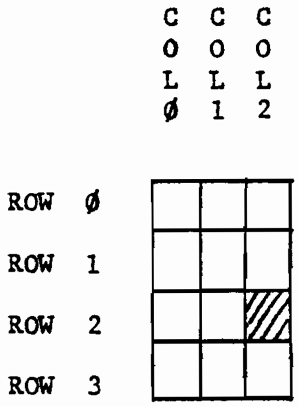
Numeric and character string data may be stored in memory as arrays. An array is a set of variables of one data type (numeric or character) identified by a single variable name. A numeric array is denoted by a single letter or a single letter followed by a percent sign (%) and may have 1 to 4 dimensions. A string array is denoted by a single letter followed by a dollar sign ($) and may have 1 to 3 dimensions. Both types of array are zero indexed. An array must be declared in a DIM statement which defines the number of dimensions and the index range in each dimension. An array indexing error occurs if an attempt is made to reference an element of an array which has not been defined in a DIM statement.

A one dimensional array is a simple linear list in which the elements of the array are stored sequentially in memory. For example, an array A which has a dimension of 4 is stored:

```
A  (Ø)
A  (1)
A  (2)
A  (3)
A  (4)
```

An element of a one dimensional array is referenced by the array name and by the index of the element within the array, enclosed in parentheses. The 4th element of array A in the above example is A (3). The index may be specified by a constant, as in this example, a numeric variable, or a numeric expression.

A two dimensional array is conceptualized as a table organized by rows and columns. An array B dimensioned as B (3,2) would be represented as:



Array B(3,2)

An element of a 2 dimensional array is referenced by the array name and the row and column indices. The shaded element in the above illustration is referred to as B(2,2), where the first index is the row index and the second is the column index.

The elements of a 2 dimensional array are stored sequentially in memory in column major order, that is column by column. The elements of the array B would be stored:

B (Ø,Ø)
B (1,Ø)
B (2,Ø)
B (3,Ø)
B (Ø,1)
B (1,1)
B (2,1)
B (3,1)
B (Ø,2)
B (1,2)
B (2,2)
B (3,2)

As with one-dimensional arrays, the row and column indices may be specified by a constant, a numeric variable or a numeric expression.

3 and 4 dimensional arrays are extensions of the two dimensional concept. An element of one of those arrays is referenced by the array name and the appropriate number of indices.

5.16.3 OUTPUT FORMATS

A numeric data item is converted to a string when it is output to the terminal. Unless the output format is explicitly specified by use of the FMT function, a numeric value will be output in one of three default formats according to the following rules:

1) The negative sign (if present) precedes the number
2) A space is output in place of a positive sign
3) A space is output following the number.
4) A number is either a whole number or a decimal number. A whole number is a number without a fractional part. A decimal number is a number with a whole and a fractional part.
5) The output formats are: Whole, Decimal and Scientific.

```
    Whole:     (-)xxxxxxxb̸
    Decimal :     (-)xxx ... x.xxxb̸
    Scientific:     (-)n.xxxxx E(-)TTb̸

           (-) = minus sign if negative, blank if positive
            x  = digit position
            n  = one non-zero digit
            E  = signifies exponent
           TT  = exponent
            b̸  = blank
```

6) The value of an integer variable is output in whole format.
7) A constant or the value of a real variable is output as follows:
    a) If the constant or value is a whole number having less than or equal the number of digits specified by RSIZE, then whole format is used.
    b) If the constant or value is a decimal number greater than or equal to .1 and having less than or equal the number of digits specified by RSIZE, then decimal format is used.
    c) Otherwise, scientific format is used.

String data is output without modification.

The maximum output line length is 25Ø characters. If an attempt is made to output a line longer than the maximum length, i.e.,by trying to output 2 strings of 25Ø characters with the same print statement. The characters in excess of 25Ø are truncated and the message "WARNING--TRUNCATED OUTPUT" is output.

5.17 BASIC OPERATORS

Operators are symbols which specify operations to be performed upon data items. BASIC recognizes 4 classes of operations:

Numeric(arithmetic); String; Relational; and Logical.

5.17.1 Numeric Operators

Numeric operators specify arithmetic operations to be performed upon numeric data items and numeric function references. A numeric data item may be a constant, a simple numeric variable or a numeric array element. Numeric operators are classified as binary operators which perform operations with 2 data items, and unary operators which perform operations upon single data items.

The binary operators are listed below:

Symbol	Operation
↑	Exponentiation
/	Division
*	Multiplication
\	Integer Division (X\Y = Int(X/Y))
-	Subtraction
+	Addition

The unary operators are listed below:

Symbol	Operation
-	Negation
+	No effect

The "+" symbol is recognized as a unary operator to allow constructs such as A= +7 and A= +B to be syntactically correct although the "+" has no effect.

5.17.2 String Operators

One operator is recognized for string data items: concatenation. A string data item may be a string constant, string variable or string array element, or a string function reference.

Symbol	Operation
+	Concatenation

The "+" operator yields a string composed of the characters in the string data item to the left of the operator followed by the characters in the string data item to the right of the operator.

EXAMPLE: If A$ = "ABCD" and B$ = "EFGH" the operation A$ + B$ yields the string "ABCDEFGH"

5.17.3 Relational Operators

Relational operators allow the comparison of the values of numeric or string data items.

The relational operators are listed below:

Symbol	Meaning
<	Less Than
>	Greater Than
=	Equal to
<=	Less than or equal to
>=	Greater than or equal to
<>	Not equal to

A relational operator is used in an expression of the form (Data Item 1 operator Data Item 2) which yields a single value as follows: The values of the two data items are compared. Based upon this comparison if the expression is true, the value "true" (1) is returned. If the expression is false, the value "false" (Ø) is returned.

EXAMPLE: If A=1 and B=2 then

A<B Yields a value of 1
A=B Yields a value of Ø

The data items compared must both be the same data type (numeric or string) or a type error results.

String comparison is performed as follows: Starting from the leftmost character, two strings are compared character-by-character until there is a mis-match or the end of one of the strings is reached. If there is a mis-match, the string containing the character which is higher in the collating sequence is considered "greater" than the other string. If the end of one of the strings is reached without a mis-match and the strings are not of the same length then the longer string is "greater". If the end of one string is reached and the strings are of the same length then the strings are "equal".

5.17.4 Logical Operators

The relational operators as described in section 5.17.3 return a value of "true" or "false". This type of value is referred to as a boolean value and is represented in Micropolis BASIC as an integer. Truth or falsity is determined by converting the integer to a 16 bit binary number. If the least significant bit of the binary number is Ø then the value is false, else the value is true. Logical operators specify operations to be performed with boolean values as described below:

Binary Logical Operators

Operator: AND

Expression: VAL 1 AND VAL 2

Truth Table

VAL 1	VAL 2	RESULT
True	True	True
True	False	False
False	True	False
False	False	False

Operator: OR

Expression: VAL 1 OR VAL 2

Truth Table

VAL 1	VAL 2	RESULT
True	True	True
True	False	True
False	True	True
False	False	False

Unary Logical Operators

Operator: NOT

Expression: NOT VAL

Truth Table

VAL	RESULT
True	False
False	True

The primary function of the logical operators is to allow the formation of complex expressions which evaluate to a single value of "true" or "false".

EXAMPLE: A<=B AND C=Ø

A secondary function is provided by the 16 bit implementation of Boolean values. The logical operators perform the above defined functions across the full 16 bits. This allows you to perform the AND, OR and Complement (NOT) functions in the same manner as the elementary 8080 instructions. The utility of this feature is illustrated in the following examrle which is a serial I/O handler for an IMSAI SIO board.

```
8ØØØ  REM INPUT ROUTINE - RETURNS CHAR IN A
81ØØ  A = IN  (3) AND 2:  IF A =Ø GOTO 81ØØ:! WAIT INPUT READY
82ØØ  A = IN  (2) AND 16R7F: RETURN:! MASK PARITY AND RETURN
83ØØ  REM OUTPUT CHARACTER IN A
84ØØ  B= IN  (3) AND1:   IF B=Ø GOTO 84ØØ:! WAIT OUTPUT READY
85ØØ  OUT(2) = A:  RETURN:! OUTPUT AND RETURN
```

NOTE: This example will not work for I/O to the terminal device. The BASIC interpreter checks for input from the terminal between execution of BASIC statements and will gobble any character received unless it is a CTL/C.

5.18 BASIC FUNCTIONS

Functions are included in the BASIC language to provide commonly required computations. A function reference consists of the name, followed by its arguments. The arguments are enclosed in parenthesis and separated from each other by commas.

A function returns a single value.

BASIC recognizes two types of functions: Intrinsic functions which are built into BASIC; and user defined functions.

5.18.1 Intrinsic Functions

Intrinsic functions may be classified as numeric, string, special and file. The functions relating to files are discussed in the file I/O section.

5.18.1.1 Numeric Functions

The numeric functions provide most of the commonly used trigonometric and math functions. The math package computes these functions with up to 2Ø digits of precision, which requires RSIZE to be set less than or equal to 1Ø. Attempting to use the math functions with RSIZE greater than 1Ø will cause a PRECISION ERROR. The numeric functions are detailed in table 5.2.

Table 5.2 NUMERIC FUNCTIONS

Function Reference	Value
ABS(x)	The absolute value of x, where x is a numeric expression.
ATN(x)	The arctangent of x, where x is a numeric exnression. Returns value in the range $-\pi/2$ to $\pi/2$.
COS(x)	The cosine of x, where x is a numeric ex-ression in radians.
EXP(x)	The value of e raised to the power x, where x is a numeric exnression.
FIX(x)	The whole number part of x with any fractional part truncated and the sign preserved, where x is a numeric expression.
FRAC(x)	The fractional part of x with the sign preserved, where x is a numeric expression.
INT(x)	The greatest integer not greater than x, where x is a numeric exnression.
LN(x)	The logarithm of x to the base e, where x is a numeric exnression with a value greater than Ø.
LOG(x)	The logarithm of x to base 1Ø, where x is a numeric expression with a value greater than Ø.
MAX(x,y)	The greater value, x or y, where both x and y are numeric expressions.
MIN(x,y)	The lesser value, x or y, where both x and y are numeric expressions.
MOD(x,y)	x modulo y which is equal to x-(y*INT(x/y)). Both x and y must be numeric exnressions.

Table 5.2 (cont)

Function Reference	Value
RND(x)	Generates a pseudo random number between Ø and 1. The argument x is a numeric expression which controls the number generated as follows: If x is non zero, RND generates a number using x as the seed. If x=Ø, the last random number generated is used as the seed. Reneatedly calling RND with x=Ø generates a sequence of rseudo random numbers.
SGN(x)	+1 if the sign of x is nositive, -1 if the sign of x is negative, Ø if x is Ø.
SIN(x)	The sine of x where x is a numeric expression in radians.
SQR(x)	The positive square root of x, where x is a positive numeric expression.
TAN(x)	The tangent of x, where x is a numeric expression in radians.

5.18.1.2 String Functions

String functions are provided to compare strings, manipulate substrings and to convert between numeric and string data types. The string functions are detailed in table 5. 3.

Table 5. 3. STRING FUNCTIONS

Function Reference	Value
ASC(s$)	The ASCII code of the first character in string s$. Returns a numeric value
CHAR$(x)	Returns the character whose ASCII code is x
FMT(x,y$)	Returns a string consisting of the value x formatted by the picture contained in string y$. The argument y$ can be any expression evaluating to a string. Each character in the string (except a V) represents one character in the result string. The following characters are used to format the digits of a number: 9-- A digit position of the number leading zeroes are output as "Ø" Z-- A digit position. Leading zeroes are replaced by blanks. V-- Decimal point alignment. If V is not specified, the decimal point is assumed to be at the far right resulting in truncation of the fractional part of the number. $-- A digit position. If more than 1 $ appears in the string then the digit position closest to the leading non-zero digit of the number contains a "$" and the leading zeroes are blanked. *-- A digit position. Leading zeroes are replaced by asterisks. ,-- A comma appearing before the leading digit is replaced with a blank, asterisk or dollar sign according to the context. All other characters are output unchanged. If the number is too large to fit in the format specified, the entire string is filled with question marks (?).

Table 5.3 (continued)

Function Reference	Value
INDEX (x$, y$)	The position in string x$ of the first occurrence of string y$. If string y$ is not a substring of x$, then Ø is returned.
LEFT$ (x$, n)	Returns n leftmost characters of x$.
LEN (x$)	Returns length of x$.
MID$ (x$,n,y)	Returns y characters from string x$ starting with character n.
MAX (x$,y$)	The greater, string x$ or string y$. See the collating sequence in Table 5.1.
MIN (x$,y$)	The lesser, string x$ or string y$. See the collating sequence in Table 5.1.
REPEAT$ (x$, n)	The character string with string x$ repeated n number of times.
RIGHT$ (x$, n)	The n rightmost characters of string x$.
STR$ (n)	Converts the number n to a string.
VAL (x$)	Converts the string x$ to a number. The contents of x$ may be numeric digits or a numeric expression. EXAMPLE: If A$ = "2+2", then VAL (A$)=4
VERIFY (x$, y$)	Verifies that all characters in string x$ are also in y$. Returns the position of the first character in x$ which is not found in y$. If all characters in x$ are in y$ returns Ø.

5.18.1.3 Special Functions

Micropolis BASIC provides several other functions which pertain neither to numbers nor strings. These special functions are detailed in Table 5.4.

Table 5.4 SPECIAL FUNCTIONS

Function Reference	Value
IN(x)	Inputs a value from I/O port x. The value of x must be greater than Ø and less than 256.
PEEK(x)	Returns the contents of memory location x. The value of x must be greater than Ø and less than 65536.
PGMSIZE	Returns the size of the program currently occupying the program buffer in bytes.
SPACELEFT	Returns the amount of space left in the program buffer in bytes.

5.18.2 User Defined Functions

Micropolis BASIC provides the ability to define two types of functions: BASIC functions and assembly language functions.

5.18.2.1 User Defined BASIC Functions

BASIC allows the user to define functions which consist of BASIC expressions and which are referenced in the same manner as the intrinsic functions. A BASIC function is defined in a DEF statement which has the following form:

```
DEF     FN(letter)  (parameter) = expression

          Function    Optional      Expression which provides
            Name      Parameter     the value of the function
```

The characteristics of a function definition are:

1) Function Name--consists of the characters "FN" and one of the letters A-Z yielding up to 26 user-defined BASIC functions.

2) Parameter--a function may optionally include a parameter which passes a value to the function when it is referenced. The parameter which appears in the function definition is a "dummy parameter". For example, consider the function defined by:

```
1Ø DEF  FNZ(X) = X↑3+X↑2+A+B
```

The parameter X is a "dummy" in the sense that when the function is referenced, the value passed in the function reference is used in the place of "X". The parameter is only used in the definition to indicate the form of the expression. However, the variables A and B are actual variable names.When the function is referenced, the current values of A and B are used in evaluating the expression.

3) Expression--a function may be defined as either a string function or a numeric function by the form of the expression. The expression may be any BASIC expression which yields a single value of the appropriate data type.

A function reference consists of the 3 character function name and the parameter (enclosed in parentheses) if a parameter is included in the function definition. A function reference yields a single value and can be used as a data item in any expression not restricted to constants. A small program using the above defined function is given below as an example:

```
10 DEF FNA(X)=X↑3+X↑2+A+B
20 INPUT A,B,C
30 PRINT FNA(C)
40 GOTO 20
READY
RUN
? 2,3,1
  7
? 0,1,2
13
?
INTERRUPT
READY.
```

Below is an example of a string function.

```
5 SIZES(5,4,80)
10 DEF FNB(S$)=REPEAT$(S$,N)
20 INPUT A$,N
30 B$=FNB(A$)+"ISN'T THIS REPETITIVE?"
40 PRINT B$

READY
RUN
? "AGAIN AND ",4
AGAIN AND AGAIN AND AGAIN AND AGAIN AND ISN'T THIS REPETITIVE?


READY
```

See the "DEF FN" statement for more detailed information.

5.18.2.2 Assembly Language Functions

Micropolis BASIC allows the user to define Assembly Language "Functions" which provide linkage to assembly language subroutines. The linkage allows a BASIC program to pass from 1 to 4 arguments to an assembly language subroutine and provides for a result to be passed back to the basic program when the assembly language subroutine returns control.

An Assembly Language Function is defined as follows:

```
DEF  FA (letter)= expression
```

The function name consists of the characters "FA" and one of the letters A-Z yielding up to 26 assembly language functions. The expression is a numeric expression which specifies the memory address of the subroutine entry point.

An assembly language function reference consists of the 3 character name followed by a list of arguments enclosed in parentheses.

Examples:

```
1ØØ  A = FAA
2ØØ A$ = FAB (B$, C$)
```

Up to 4 arguments may be passed to an Assembly Language Function and 1 result may be passed back as the value of the function reference.

The arguments and result are passed through the following locations which define the subroutine linkage:

LOCATION	LABEL	DESCRIPTION
Ø4BCH	ARG1	Pointer to the first argument
Ø4BEH	ARG2	Pointer to the second argument
Ø4CØH	ARG3	Pointer to the third argument
Ø4C2H	ARG4	Pointer to the fourth argument
Ø4C4H	NARGS	Number of arguments passed
Ø4C5H	RSIZE	Values of RSIZE, ISIZE and SSIZE as described in Section 5.2Ø.26
Ø4C6H	ISIZE	
Ø4C7H	SSIZE	
Ø1AØH	RESULT	25Ø byte result buffer

When an assembly language subroutine is referenced, the basic interpreter sets the pointers in the linkage table to point to the values of the arguments, indicates the number of arguments passed in NARGS, and calls the subroutine. When the subroutine returns, the interpreter expects to find the value returned by the subroutine, if any, in the result buffer.

The format of the arguments pointed to by ARG1-4 and of the result returned is:

BYTE Ø - Type Indicator
1 - Real
2 - Integer
3 - String

BYTE 1-N- Refer to Section 5.16.2 "Variables" for the internal storage format for each variable type. The length of each variable type is specified by RSIZE, ISIZE and SSIZE.

The general procedure for using assembly language subroutines is as follows:

1) Load BASIC from MDOS or directly from a BASIC only SYSTEM DISK.

2) Set the memory space used by BASIC using the MEMEND statement to reserve space above BASIC for your subroutine.

3) Load the subroutine using the LOAD command. Execution of an object file load within a program is allowed.

4) Define the name and entry point of the subroutine with the DEF FA Statement. The subroutine may now be used.

The assembly language program example on the following pages demonstrates most of the principles involved in passing arguments and returning results. It was created by using the assembly language development tools of the MDOS system. The source program was entered with LINEEDIT and then assembled with ASSM to produce an object file named CONCAT which can be loaded by BASIC.

The CONCAT subroutine expects two string arguments to be passed and returns a string which is composed of the second argument concatenated with the first argument. If only one argument is passed, the result string is "argument error". If both arguments are not strings, the string returned is "type error".

Note: This example is not complete - a proper subroutine of this type would have to handle the special cases of null strings and checking to see if the maximum string length has been exceeded, etc.

```
ØØØØ               ***********************************
ØØØØ               *                                 *
ØØØØ               *     ASSEMBLY LANGUAGE           *
ØØØØ               *     SUBROUTINE LINKAGE          *
ØØØØ               *     DEMO 1978                   *
ØØØØ               *                                 *
ØØØØ               ***********************************
ØØØØ               *
ØØØØ               *
ØØØØ               *
ØØØØ       Ø1AØ    RESULT  EQU    1AØH
ØØØØ       Ø4BC    ARG1    EQU    4BCH
ØØØØ       Ø4BE    ARG2    EQU    ARG1+2
ØØØØ       Ø4CØ    ARG3    EQU    ARG1+4
ØØØØ       Ø4C2    ARG4    EQU    ARG1+6
ØØØØ       Ø4C4    NARGS   EQU    ARG1+8
ØØØØ       Ø4C5    RSIZE   EQU    ARG1+9
ØØØØ       Ø4C6    ISIZE   EQU    ARG1+1Ø
ØØØØ       Ø4C7    SSIZE   EQU    ARG1+11
ØØØØ               *
ØØØØ               *
ØØØØ                       ORG    624ØH
624Ø               *
624Ø               * THIS DEMO ACCEPTS TWO ARGUMENTS
624Ø               * WHICH ARE STRINGS AND RETURNS
624Ø               * ARG1 CONCATENATED WITH ARG2.
624Ø               *
624Ø               *
624Ø 3A C4 Ø4      NBRCK   LDA    NARGS    ;CHECK FOR TWO
6243 FE Ø2                 CPI    2        ;ARGUMENTS.
6245 C2 8D 6Ø              JNZ    NBRER    ;IF NOT TWO - ERROR.
6248 2A BC Ø4      TYPCK   LHLD   ARG1     ;ELSE, CHECK TYPE OF
624B 7E                    MOV    A,M      ;ARG1. IT MUST
624C FE Ø3                 CPI    3        ;BE A STRING.
624E C2 87 6Ø              JNZ    TYPERR   ;IF NOT  - ERROR.
6251 2A BE Ø4              LHLD   ARG2     ;ELSE, CHECK ARG2
6254 7E                    MOV    A,M      ;IT ALSO MUST
6255 FE Ø3                 CPI    3        ;BE A STRING.
6257 C2 87 6Ø              JNZ    TYPERR   ;IF NOT - ERROR.
625A               *
625A               * BOTH ARGUMENTS ARE VALID STRINGS
625A               *
625A 11 AØ Ø1              LXI    D,RESULT ;SETUP RETURN
625D 3E Ø3                 MVI    A,3      ;PARAMITER AS A
625F 12                    STAX   D        ;STRING TYPE.
626Ø 13                    INX    D        ;SKIP OVER
6261 13                    INX    D        ;LENGTH FOR
6262 13                    INX    D        ;NOW
6263 AF                    XRA    A        ;ZERO LENGTH
6264 47                    MOV    B,A      ;COUNTER.
6265 2A BC Ø4              LHLD   ARG1     ;MOVE FIRST
6268 CD 79 6Ø      MSTP    CALL   MOVE     ;ARGUMENT TO RESULT
626B 2A BE Ø4              LHLD   ARG2     ;MOVE SECOND
626E CD 79 6Ø              CALL   MOVE     ;AGRUMENT TO RESULT
6271 78                    MOV    A,B      ;GET LENGTH COUNT
6272 32 A1 Ø1              STA    RESULT+1 ;PUT COUNT INTO
6275 32 A2 Ø1              STA    RESULT+2 ;RESULT.
6278 C9                    RET             ;DONE, RETURN TO BASIC
```

```
6079                 *
6079                 * MOVE ARGUMENTS TO RESULT.
6079                 * HL REGISTERS HAS ARGUMENT ADDRESS.
6079                 * DE REGISTERS HAS POSITION IN RESULT.
6079                 * B REGISTER IS COUNT
6079                 *
6079 23              MOVE     INX     H          ;SKIP TYPE
607A 23                       INX     H          ;SKIP MAX LENGTH
607B 4E                       MOV     C,M        ;GET LENGTH OF STRING
607C 23                       INX     H
607D 7E              MOVE1    MOV     A,M        ;GET CHARACTER
607E 12                       STAX    D          ;PUT IT INTO RESULT
607F 13                       INX     D          ;NEXT
6080 23                       INX     H
6081 04                       INR     B          ;COUNT +1
6082 0D                       DCR     C          ;LENGTH -1
6083 C2 7D 60                 JNZ     MOVE1      ;LOOP TILL DONE
6086 C9                       RET                ;DONE
6087                 *
6087                 *
6087 21 9E 60        TYPERR   LXI     H,TYPMSG
608A C3 90 60                 JMP     EMSG
608D                 *
608D 21 AB 60        NBRER    LXI     H,NBRMSG
6090 11 A0 01        EMSG     LXI     D,RESULT   ;PUT MESSAGE IN RESULT
6093 3E 03                    MVI     A,3        ;STRING TYPE
6095 12                       STAX    D
6096 13                       INX     D
6097 13                       INX     D
6098 13                       INX     D
6099 AF                       XRA     A          ;ZERO COUNT
609A 47                       MOV     B,A
609B C3 68 60                 JMP     MSTR       ;MOVE TO RESULT
609E                 *
609E                 * ERROR MESSAGES
609E                 *
609E 00 00 0A        TYPMSG   DB      0,0,10
60A1 54 59 50                 DT      'TYPE ERROR'
60A4 45 20 45
60A7 52 52 4F
60AA 52
60AB                 *
60AB 00 00 0E        NBRMSG   DB      0,0,14
60AE 41 52 47                 DT      'ARGUMENT ERROR'
60B1 55 4D 45
60B4 4E 54 20
60B7 45 52 52
60BA 4F 52
60BC                 *
60BC                          END     NBRCK
```

Listing of and output from a BASIC program that utilizes the CONCAT assembly language routine.

```
READY
LIST
1Ø DIM A$(25Ø),B$(25Ø),C$(25Ø)
2Ø MEMEND 16R5FFF
3Ø LOAD "CONCAT"
4Ø DEF FAA=16R6Ø4Ø
5Ø INPUT A$
6Ø INPUT B$
7Ø C$=FAA(A$,B$)
8Ø PRINT C$
9Ø GOTO 5Ø
READY
RUN
? 12345
? 6789Ø
123456789Ø
? NOW IS THE TIME
? FOR ALL GOOD MEN
NOW IS THE TIMEFOR ALL GOOD MEN
?
INTERRUPT
6Ø INPUT B$
READY
PRINT FAA(A$)
ARGUMENT ERROR
READY
PRINT FAA(A,B)
TYPE ERROR
READY
PRINT FAA("12345","6789Ø")
123456789Ø
READY
```

Pages 5-30 through 5-32 left blank intentionally.

5.19 BASIC EXPRESSIONS

A BASIC expression is a combination of data items and function references connected by operators. An expression specifies an operation or series of operations that yields a single value, which is referred to as the value of the expression. Data items may be constants, simple variables, or array elements. Operators may be arithmetic, string, relational, and logical.

5.19.1 Evaluation of Expressions

BASIC contains a precise set of rules which define the manner in which expressions are evaluated:

1) Operator Precedence -- Operators encountered in an expression are performed in the following order:

    1) Function references
    2) Unary operators
    3) Arithmetic & string operators
    4) Relational operators
    5) Logical operators

2) Operators which have the same level of precedence are performed in the order in which they are encountered in scanning the expression from left to right.

3) The normal rules of precedence & order of evaluation may be overridden by the use of parentheses to partition an expression into subexpressions. Nesting of subexpressions is limited by the overall complexity of the expression. If an expression is too complex it may cause a STACK OVERFLOW error. In this case, the expression should be broken into two expressions.

4) Expressions containing subexpressions are evaluated from the innermost subexpression outward to the next level of parenthesis until all parenthetical expressions have been evaluated. Within a subexpression the rules given for operator precedence and order of evaluation apply.

5.19.2 Numeric Expressions

A numeric expression consists of numeric function references, numeric operators, and numeric data items and evaluates to a numeric result. Operations are performed in the following order:

1) Function references
2) Unary + and -
3) Exponentiation
4) Division and Multiplication
5) Integer division
6) Addition and Subtraction

Parentheses may be used to force evaluation in the exact order desired.

EXAMPLES:

1. 2*3+7*4

This expression is evaluated as follows: (V(x) indicates the value of x)

1) 2*3 yields 6
2) 7*4 yields 28
3) V(2*3) + V(7*4) yields 34

2. 2*(3+7) *4

This expression is evaluated as follows:

1) 3+7 yields 1Ø
2) 2* V(3+7) yields 2Ø
3) V(2*V(3+7)) *4 yields 8Ø

5.19.3 String Expressions

A string expression consists of string function references, string operators, and string data items and evaluates to a string result. Operations are performed in the following order:

1) Function references
2) Concatenation

EXAMPLE: Let B$ = "The number is"

B$+STR$(134)

This expression is evaluated as follows:

1) STR$(134) yields " 134 "
2) V (STR$(134)) is concatenated with the current value of B$ which yields "The number is 134 "

5.19.4 Logical Expressions

A logical expression consists of numeric and string expressions combined with relational and logical operators. The value of a logical expression is a Boolean value. Operations are performed as follows:

1) Function references are performed.
2) The NOT operation is performed.
3) Numeric and string exnressions are evaluated.
4) Relational operations are performed
5) The AND onerations are performed
6) The OR operations are performed
7) Parentheses may be used to force evaluation in the exact order desired

EXAMPLE:

```
A+2<=3   AND B+3<5    OR NOT (B$="A")
```

This expression is evaluated as follows:

1) The value of B$ is compared with "A" (Note: if narentheses had not been used, BASIC would have tried to nerform NOT B$ which would have given an error) Temporary result T1 is set =1 if B$="A" else is set =Ø
2) T1 is complemented
3) A+2 is evaluated
4) B+3 is evaluated
5) The value of A+2 is compared with 3 and a temporary result T2 is set =Ø if A+2>3 or 1 otherwise.
6) The value of B+3 is compared with 5 and T3 is set =Ø if B+3 is greater than or equal to 5 else is set =1.
7) T2 is ANDed with T3 yielding T4
8) The value of the expression is obtained by OR'ing T4 with T1

Note: The NOT operator complements the 16 bit representation of Boolean values so the final value of this expression is 65535 if true and 65534 if false.

5.20 BASIC STATEMENTS

BASIC statements specify operations to be performed in a BASIC program, and describe the data and operating environment of the program.

Every BASIC statement consists of a keyword followed by a list of zero or more expressions which specifies the operation to be performed by the statement.

Multiple statements may be included in the same program line separated by the colon (:) (see section 5.2).

The statements included in the BASIC language are listed alphabetically and described in detail in the following pages. Conventions of notation used are:

1) $\left\{\begin{matrix}A\\B\\C\end{matrix}\right\}$ Indicates a choice of one of the items enclosed.

2) [ ] Indicates optional items.

3) Parentheses ( ) used in definitions must be included as illustrated.

5.20.1 DATA $\left\{\begin{matrix}\text{numeric constant}\\\text{string constant}\end{matrix}\right\}$, $\left\{\begin{matrix}\text{numeric constant}\\\text{string constant}\end{matrix}\right\}$, . . .

```
150 DATA  25, "APRIL 1, 1977", 26E-3
```

The DATA statement is used to define a list of data internal to a BASIC program which may be accessed with the READ statement. When a BASIC program is started, the DATA pointer is initialized to point to the first data item in the first DATA statement in the program. When a READ statement is executed, one value is read from the list for each variable specified and the pointer is advanced to point to the next data item. When the data items in a DATA statement are depleted, the pointer is set to point to the first data item in the next DATA statement encountered in the program such that all the data values contained in DATA statements constitute a contiguous list. The RESTORE statement can be used to re-position the DATA pointer to point to the first data item of any DATA statement within the program.

The DATA statement is non-executable and may therefore appear anywhere within a program.

5.20.2 DEF FN letter [(function parameter name)] = expression

```
10     DEF    FNA   = X+Y+Z
100    DEF    FNL(A)= (4*3.1415*A)/3
150    DEF    FNR(M$)= REPEAT$(M$,5)
```

The DEF FN statement is used to define a function. The name of the function defined is "FN" followed by one of the letters A-Z. Each function name may be defined only once in a given program.

For example, if the statement 110 DEF FNN= 3.1415*R2 were used in a program. 260 DEF FNN (M$)=REPEAT(M$,5) could not be used because the function names are identical. The statement 260 DEF FNM (M$)=REPEAT(M$,5) would be legal.

A function parameter is optional. If present, it is a dummy parameter and its name may be any simple variable name. A function will return a numeric or string value depending upon the form of the expression.

A DEF FN statement is non-executable and may appear anywhere in a program.

5.20.3 DEF FA letter = numeric expression

```
90  DEF FAA = 16R7000
```

The DEF FA statement is used to define a function which provides linkage to an assembly language subroutine. The function name consists of the letters "FA" and one of the letters A-Z. The expression contains the starting address of the assembly language subroutine. See section 5.18.2.2 "Assembly Language Functions" for details of linkage and passing arguments.

```
5.20.4  DIM letter [%] (I1, I2, ... I4)
        DIM letter $(length)
        DIM letter $(I1, ... I3,length)

             1Ø  DIM  A (2,4)
             2Ø  DIM  B%(2,3,4,5)
             3Ø  DIM  A$(4Ø)
             4Ø  DIM  A$(2,3,4Ø)
```

The DIM statement is used to define the maximum length of string variables and to define the number of dimensions and index ranges for arrays.

The first form of the DIM statement is used to define a numeric array. The array name consists of one of the letters A-Z. An optional percent sign (%) may follow the letter to denote an integer array. The array may have 1 to 4 dimensions as defined by the number of parameters (I). The value of each I defines the maximum value of the index for that dimension.

The second form is used to set the maximum length of a string variable. The name of the variable is one of the letters A-Z followed by the dollar sign ($). The length specified must be less than or equal to 250 and overrides the default length specified in the SIZES statement.

The third form is used to define a string array. The array name consists of one of the letters A-Z followed by the dollar sign ($). A string array may have 1 to 3 dimensions as defined by the number of parameters (I) specified. The value of each I defines the maximum value of the index for that dimension. The last parameter specified in the parameter list is the maximum length of each string element.

Dimension statements are executed dynamically, therefore the parameters may be either constants or expressions.

```
5.20.5  END
             1ØØØØ   END
```

The END statement is optional in BASIC. Execution will terminate when the END statement is executed and may not be continued with the CONT command. It is recommended that an END statement be the last statement of a program to serve as a listing aid. Its presence ensures that the listing is complete.

5.20.6 EXEC string expression

```
100 EXEC A$
```

The EXEC statement is a feature unique to Micropolis BASIC. The EXEC statement causes the string expression to be passed to the BASIC Interpreter and to be executed as a statement. The expression may consist of one or more BASIC statements separated by colons(:). The expression passed is checked for syntax errors and then executed if valid. The following program is given as an example of the power inherent in this statement. The program accepts arithmetic statements from the terminal and prints the results -- effectively operating the terminal as a desk calculator.

```
LIST

10 INPUT A$: EXEC "PRINT "+A$: GOTO 10
READY
RUN
? 2+2
 4
? SIN(3.14159/4)
 .70710595
?
```

5.20.7 FLOW

```
1Ø FLOW
```

The FLOW statement turns on the program trace feature which aids in debugging BASIC programs. The program trace will output to the terminal the program line of each statement which is executed. The program line will be output again if the THEN portion of an IF . . . THEN statement is executed. The program trace is turned off by the NOFLOW statement.

```
5.20.8  FOR numeric  = numeric       TO numeric     [STEP numeric    ]
            variable   expression       expression  [      expression]
```

```
        3Ø  FOR X = 1 TO 3Ø
        4Ø  FOR Y = 3Ø to Ø STEP -1
        5Ø  FOR X = A to B
```

The FOR statement initiates the repeated execution of a set of statements following it. The set begins with the statement immediately following the FOR statement. The set ends with the NEXT statement that contains the same variable as the FOR statement. The numeric variable controls the number of times the set of statements is to be executed and is called the loop variable. The set of statements to be executed is referred to as a FOR . . NEXT loop.

The expressions specify the initial value of the loop variable, the terminal value of the loop variable, and the value to be added to the loop variable after each pass through the loop (step). The step parameter is optional; when not specified, a default value of +1 is used.

The statements within the FOR . . . NEXT are executed until the value of the loop variable is stepped outside the range defined by the initial and terminal values.

The STEP value can be negative, as in:

```
     2Ø FOR I = 1ØØ to Ø STEP -1Ø
```

This statement would cause the initial value of the loop variable I to be set at 1ØØ, subtract 1Ø from the loop variable each time the loop was completed, and terminate executing the loop when the loop variable contained the value Ø.

The statement 15 FOR J = Ø TO Ø would cause the FOR loop to be executed one time. That is, the statements between the FOR J. . . . and the NEXT J statements would be executed once before the loop variable of Ø + 1 would be compared to the limit value of Ø. At this point the loop variable limit would have been exceeded and program execution would fall through to the next line number.

A set of FOR . . .TO. . .NEXT statements may be nested within one or more sets of FOR. . .TO. . .NEXT statements. For example:

```
     1Ø  FOR K  = 1 TO 9Ø
     2Ø  FOR L  = 1 TO 15
     3Ø  PRINT K,L
     4Ø NEXT L
     5Ø NEXT K
```

When nesting FOR. . .TO. . .NEXT statements it is imperative that the inside loop (in this case the L loop) be completely enclosed within the outer loop.

If the above statements had been entered incorrectly as follows:

```
10  FOR K = 1 TO 90
20  FOR L = 1 TO 15
30  PRINT K,L
40  NEXT K
50  NEXT L
```

The error message "MISSING FOR" would occur when the "NEXT L" statement is encountered.

If a GOTO or IF. . .THEN statement is executed from within a loop, the program execution will continue in a normal manner. BASIC will continue the loop from the current value of the loop variable if the loop is re-entered at some later point.

5.20.9 GOSUB $\left\{\begin{array}{l}\text{linenumber}\\ \text{numeric expression}\end{array}\right\}$

```
210 GOSUB 1ØØØ
```

The GOSUB statement causes a set of statements to be executed as a subroutine.

When a GOSUB statement is executed, control is transferred to the first statement whose line number is specified in the GOSUB statement. The referenced line number and all statements following it will be executed until a RETURN statement is encountered. Control is then returned to the statement following the GOSUB. Consider the following:

```
15Ø GOSUB  21Ø: PRINT A + B
16Ø END
21Ø INPUT X,Z
22Ø A  = X + 1:  B = Z-1Ø
23Ø RETURN
```

When line number 15Ø is executed, control is transferred to line number 21Ø. Line 21Ø and 22Ø are executed, then 23Ø, the RETURN statement. The RETURN causes control to be transferred to the statement immediately following the GOSUB. Therefore, the sum of A + B will be printed before the program ends.

GOSUB statements can be nested. That is, a subroutine can contain a GOSUB statement that references another subroutine. Control will be returned to the first subroutine when the RETURN statement of the second is executed. The message STMT # NOT FOUND will be output if a GOSUB statement references a line number that does not exist in the program.

BASIC allows an expression to be used as the line number. If this is done, care must be taken to insure that the value of the expression is a positive real number. The fractional part of the number will be truncated in forming the line number. A NUMBER OUT OF RANGE error will occur if the number is invalid.

```
5.20.10  GOTO  { line number        }
               { numeric expression }

                1ØØ  GOTO  5ØØØ
                2ØØ  GOTO  A+B
```

The GOTO statement causes control to be transferred to the first statement in a specified program line. A GOTO statement may reference any line in a program, including its own line. The line number may be specified as a constant or a numeric expression Care must be taken to ensure that the expression evaluates to a positive real value. The fractional part of the number will be truncated in forming a line number. If the value is invalid, a NUMBER OUT OF RANGE error will occur. If the line number does exist in the program, a STMT # NOT FOUND will occur.

```
5.20.11  IF logical expression { [THEN] STATEMENT  [:STATEMENT] }
                               {  THEN  line number             }

                 1Ø   IF   A < B   THEN  PRINT "*"

                 2Ø   IF   A = 2   GOTO  1ØØ

                 3Ø   IF   A = 4   THEN  1ØØ

                 4Ø   IF   A  = 2 AND C = 3 THEN D = 2: GOTO 1ØØØ
```

The first form of the TF statement provides conditional execution of one or more statements based upon the value of a logical expression.

The statements subject to conditional execution must all reside within the same program line as the IF statement. If the logical expression evaluates to "true", then the statements are executed. If the expression evaluates to "false", then all remaining statements within the line are ignored. The keyword THEN is optional in this form.

The second form of the IF statement provides a conditional program branch based upon the value of a logical expression. If the expression evaluates to "true", control is transferred to the first statement in the specified program line. If the expression evaluates to "false", program execution continues at the next sequential program line. The line number must be specified as a constant. If the line number specified does not exist in the program, a STMT # NOT FOUND error occurs.

5.20.12 INPUT ["prompstring"$\left\{\begin{matrix};\\,\end{matrix}\right\}$] variable list

```
10  INPUT A,A$
20  INPUT "ENTER NUMBERS"; A,B
```

The INPUT statement prompts for data to be entered from the terminal and waits for the user to enter the data. If a prompt string followed by a semicolon (;) is included, the string is output, followed by a question mark (?) before waiting. If a prompt string followed by a comma (,) is included, the string is output and then the question mark is output on the next line before waiting for entry. If no prompt string is included, a question mark is output to the next terminal line before waiting for input.

One value must be entered for each variable in the variable list. Values may be numeric or string constants separated from each other by the current string delimiter. Strings entered do not need to be enclosed in quotes (") unless they contain the string delimiter. If a string constant is erroneously entered in place of a numeric constant, a TYPE ERROR occurs, followed by the message REENTER FROM BEGINNING. This means that all values in the variable list should be entered again in proper order. The last value entered is delimited by a carriage return. If too few values are entered, INSUFFICIENT INPUT is output to the terminal and the statement waits for more input to satisfy the variable list. If too many values are entered, EXTRA INPUT IGNORED is output to the terminal and the program continues execution.

5.20.13 [LET] variable = expression

```
10  LET A = 5
20  A$ = "FAT HIPPO"
```

The LET statement causes the expression to be evaluated and assigns the resulting value to the variable. The data type of the expression and the variable must be the same type or a "TYPE ERROR" results. The LET keyword is optional.

5.20.14 MEMEND numeric expression

```
10  MEMEND  16R7ØØØ
```

The MEMEND statement is used to define the upper limit of the memory space used by BASIC. One of the main applications of this statement is to reserve memory for assembly language subroutines which may be placed above the address specified by the expression.

5.20.15 NEXT numeric variable

```
1Ø  NEXT X
```

The NEXT statement terminates the loop initiated by the FOR statement that contains the same variable. While the loop is being executed, each time control reaches the NEXT statement, the loop variable is incremented by the STEP value, or by 1 if a STEP value was not defined.

When loop execution terminates, control passes to the statement following the NEXT statement.

If a NEXT statement is encountered prior to the execution of a FOR statement naming the same loop variable, a MISSING FOR error occurs.

5.20.16 NOFLOW

```
5ØØ   NOFLOW
```

The NOFLOW statement turns off the program flow trace which may be activated by a FLOW statement.

5.20.17 ON numeric expression GOTO line number list

```
1ØØ  ON  K+5  GOTO 2ØØ, 3ØØ, 4ØØ
2ØØ  ON  J    GOTO A+50, 4ØØ,B
```

The ON...GOTO statement causes control to be transferred to the line number whose positional value in the line number list is equal to the expression. If the exnression is zero or greater than the number of lines in the list, control is passed to the next statement. If the expression is fractional, the fraction is truncated prior to the GOTO being executed. If the expression is negative a NUMBER OUT OF RANGE error occurs. The line numbers in the line number list may be numeric constants or numeric expressions. If a line number in the list does not exist a STMT # NOT FOUND error occurs.

5.20.18 ON numeric expression GOSUB line number list

```
100  ON X  GOSUB 500, 600, 700, 800
200  ON Z+2 GOSUB B,C, 600
```

The ON...GOSUB statement causes execution of the subroutine beginning at the line number whose positional value in the line number list is equal to the value of the numeric expression.

If the expression is zero or greater than the number of lines in the list, control is passed to the next statement. If the expression is fractional, the fraction is truncated prior to the GOSUB being executed. If the expression is negative a NUMBER OUT OF RANGE error occurs.

The line numbers in the line number list may be numeric constants or numeric expressions. If a line number in the list does not exist a STMT # NOT FOUND error occurs.

When a RETURN statement is encountered in the subroutine, control returns to the statement followng the ON...GOSUB statement.

5.20.19 OUT (numeric expression 1) = numeric expression 2

```
100  OUT (16R10) = 20
```

The OUT statement causes the value of expression 2 to be output to the I/O port specified by expression 1. Both expressions must be numeric expressions with values in the range Ø to 255 or a NUMBER OUT OF RANGE error occurs.

5.20.20 POKE (numeric expression 1) = numeric expression 2

```
100  POKE (16R6000) = 200
200  POKE (A) = B
```

The POKE statement stores the value specified by expression 2 in the memory location specified by expression 1. Expression 1 must be in the range Ø to 65535 and expression 2 must be in the range Ø to 255. If the value for either expression is outside of the specified range, a NUMBER OUT OF RANGE error occurs. Care must be exercised to ensure that the location POKE'd does not cause BASIC to crash.

5.20.21 PRINT expression $\left\{\begin{matrix};\\,\end{matrix}\right\}$ [TAB(numeric expression]. . .

```
1ØØ  PRINT A;B;C
2ØØ  PRINT TAB(1Ø); "THE ANSWER IS"; FMT(A,"ZZZ9V.99")
```

The PRINT statement causes the value of the expressions in the expression list to be output to the terminal. Expressions are output in the formats described in section 5.16.3. "Output Formats".

An output line consists of up to 250 characters and is partitioned into 16 character print fields. Print position within an output line is controlled as follows:

1) An expression is output starting at the current print position. Each expression must be separated from the next expression by a comma (,) or a semicolon (;).

2) If the expression is followed by a semicolon, the print position is set to the next position following the last character output for the expression. If the expression is the last expression of the PRINT statement then output generated by subsequent PRINT statements will start at this position on this line of the output on the terminal.

3) If the expression is followed by a comma, the print position will be set to the beginning of the next 16 character print field after outputting the expression. If the expression is the last expression of the PRINT statement then output from subsequent PRINT statements will begin at this position on this line of output on the terminal.

4) If the last expression of the PRINT statement is not terminated by a comma or semicolon then the print position is set to the first character of the next line after outputting the value of the expression.

5) The print position may be explicitly set by including references to the tab function which operates only in PRINT or PUT statements. TAB moves the print position to the position specified by the value of the tab function parameter. If the position is already beyond the specified value when the print

statement is executed then the specified value is simply ignored.

BASIC contains a parameter which specifies the length of a physical output line on the terminal. If a print line which is longer than the terminal width is output, carriage returns and line feeds will automatically be inserted to wrap the output across as many physical lines as necessary.

5.20.22 READ variable list

```
1Ø  READ A,B,C$
```

The READ statement reads values from the BASIC programs internal data list which is created by including data statements within the program. One value is read from the data list for each variable appearing in the variable list. If there is insufficient data in the data list to satisfy the variable list then RAN OUT OF DATA will be output. If a string value is read for a numeric variable then a TYPE ERROR will occur. Values are read sequentially from the data list unless the pointer which points to the next value to be read is repositioned by use of the RESTORE statement.

5.20.23 REM remark text

```
1Ø  REM  THIS JUNK IS A REMARK AND IS NOT EXECUTED
```

The REM statement is used to include comment text. The character (!) may also be used to include comments in a program line. The REM statement and any characters following a (!) character in a program line are non-executable and are ignored.

5.20.24 RESTORE [numeric expression]

```
1Ø  RESTORE
2Ø  RESTORE 25
```

The RESTORE statement is used to position the data list pointer which allows control of the sequence in which data items are read from the program's internal data list. The pointer will be set to the first data item of the data statement whose line number is specified by the numeric expression. If an expression is not specified, the pointer will be set to the first item in the first data statement appearing in the program.

5.20.25 RETURN

```
1ØØ  RETURN
```

The RETURN statement transfers control to the statement immediately following the last GOSUB statement executed. If a RETURN statement is encountered prior to the execution of a GOSUB statement the error message NOTHING TO RETURN TO is output to the terminal.

```
5.20.26  SIZES  ( numeric      numeric      numeric      [numeric   ] )
                ( constant 1,  constant 2,  constant 3,  [constant 4] )

                20  SIZES  (5,4,8Ø)
                30  SIZES  (6,5,4Ø,3ØØØ)
```

The SIZES statement is used to specify the number of bytes of storage to be used for real variables (RSIZE), integer variables (ISIZE) and string variables (SSIZE), and the maximum program size when using chained program segments (see section 5.21.2.6). Constant 1 - constant 3 are positive integer constants. The value of constant 2 specifies ISIZE which must be greater than 1 and less than RSIZE. The value of constant 1 specifies RSIZE which must be greater than ISIZE and less than 3Ø. The value of constant 3 specifies SSIZE which must be greater than Ø and less than 251.

Constant 4 is an optional parameter. If it is present it specifies the maximum number of bytes allocated for program size, after which variable space allocation begins.

If no SIZES statement is executed, the default SIZES are (5,3,4Ø).

The SIZES statement may not be executed if any variables are already allocated. If any of the constraints described are violated, a SIZES ERROR error occurs.

```
5.20.27  STOP
                100  STOP
```

The STOP statement causes the execution of a BASIC program to cease. The execution may be resumed from the line following the STOP statement with a CONT command.

```
5.20.28  STRING  string expression

                1Ø STRING ";"
```

The STRING statement defines the current string delimiter used to terminate a string accessed by an INPUT or GET statement. The end of string will be signified by either the end of the record or the first occurence of the string delimiter. If a STRING statement has not been executed, the default delimiter is the comma (,).

5.21 BASIC DISK FILE I/O

A file is a data structure which may be accessed as a named entity and consists of a collection of data grouped into elementary units called records. The file structure is generally used for storing data on mass storage devices such as a disk. Disk Extended BASIC provides the ability to create and access files stored on the disk. Common maintenance operations such as renaming or deleting a file are included.

5.21.1 Disk Files

Each file stored on a diskette is identified by a file name, which may be from 1 to 1Ø characters long. The characters may be letters, digits 0-9, or the special characters period (.), slash (/), or hyphen (-).

The minimum amount of space required to store a file is one track. When a "new" file is opened, a complete track is allocated. This track and any other track assigned by the BASIC file system to this file remain unavailable to any other file until released by the user. The maximum number of files that can be stored on a disk is a function of the number of tracks available on the disk. The Mod I disk drive provides 35 tracks per diskette; Mod II provides 77 tracks per diskette. One track per diskette is required for the file directory, so the maximum number of files is either 34 or 76. Conversely, the maximum size of a file is 34 or 76 tracks. Each track consists of 16 sectors of 256 bytes per sector. A file is accessed sector by sector; therefore a "record" is 1 sector.

Actual placement of files is maintained by the BASIC file system. One track is allocated for each "new" file opened. When 16 records have been written to a particular file, another track is allocated. The file appears contiguous to the program, even if it is not stored on contiguous tracks. It is not possible to store one file on more than one disk; that is, a file may not span disks.

Files may be stored in 3 formats: Program, Object and Data.

1) Program Files - A program file is a BASIC program which was stored by a SAVE command as described in section 5.6. The data consists of the BASIC program text as it resided in the program buffer with keyword compression. A LOAD command will load the data from a program file into the BASIC program buffer.

2) Object Files - An object file is an image of a block of memory which was saved using the memory range option of the SAVE command. A LOAD command will read the data back into the memory locations from which it was saved. This is the format in which assembly language programs may be stored on the disk.

3) Data Files - Data files contain data created by and are accessible to BASIC programs by use of the PUT and GET statements. Each execution of a PUT statement stores 1 record in the file. Data within each record is represented as ASCII characters.

Each record is a 25Ø character string. A data file may not be loaded using the LOAD command. Micropolis BASIC provides the ability to access the records of a data file either sequentially or directly. (commonly referred to as random access)

In addition to the format, a file may also have Write Protect and Permanent attributes.

1) Write Protect - A file which is Write Protected cannot be re-written but may be deleted by a SCRATCH command. This is a software Write Protect not related to the physical Write Protect provided by a Write Protect tab installed on a diskette. If a physical Write Protect tab is installed on a diskette, all operations which attempt to modify a file or the directory will yield a WRITE PROTECT error.

2) Permanent - A Permanent file may be re-written but may not deleted by a SCRATCH command.

A file may be both Permanent and Write Protected.

Several Keywords are provided to manipulate disk files as described below:

5.21.2 Disk File Commands

Commands are provided to load and save program or object files, delete file, and to display a list of the files which reside on a diskette. Although commands may appear in a BASIC program, commands will generally be executed in Immediate mode. All disk commands reference the directory of the desired diskette. If the diskette is not loaded or a malfunction exists in the disk drive which causes it to return a not ready status the message DRIVE NOT UP will be output to the terminal when a command is executed. If the drive is unable to read or write on the diskette properly then a PERM I/O ERROR will result.

5.21.2.1 DISPLAY string expression

```
DISPLAY "1: DIR"
DISPLAY A$
```

The DISPLAY command will output the directory of the diskette loaded into the drive specified by the string expression. The value of the string expression must be of the form:

" [unit:] DIR" where unit is the drive

unit address in the range of Ø to 3. If omitted, drive Ø is assumed. If the string is a constant it must be enclosed in quotes ("). If a directory does not exist on the diskette a FILE NOT FOUND error results.

5.21.2.2 LOAD string expression

```
LOAD "2:DEMOPGM"
```

The LOAD command loads a program or object file into memory. The file is specified by the string expression which must evaluate to the following form:

" [unit:] filename" where unit is the

unit address in the range Ø to 3. If omitted, unit Ø is assumed. The file name may be any valid filename. If the string is a constant it must be enclosed in quotes ("). If the desired file does not reside on the diskette a FILE NOT FOUND error results. If the file is a data format file, a NOT A LOAD FILE error results.

5.21.2.3 PLOADG string expression

```
PLOADG "Ø:NEXTSEG"
```

The PLOADG statement operates like a combined LOAD command and RUN command. It loads the program file named in the string expression into the current program buffer and then transfers control directly to the logic of the RUN command. All variables and file status from the preceding program are reset to the initialize condition and execution begins with the first line of the new program.

The PLOADG statement may be used to cause automatic execution of several program files in sequence. This is accomplished by using a PLOADG statement as the last executed statement of each program in the sequence, such that it names, loads and begins the next program in the sequence. Note, however, that no program variables or open files are retained from one program or segment to the next.

The string expression in the PLOADG statement must evaluate to the following form:

```
" [unit:] filename"
```

where unit is the unit address in the range Ø to 3. If omitted, unit Ø is assumed. The file name may be any valid filename. If the string is a constant, it must be enclosed in quotes ("). If the desired file does not reside on the diskette a FILE NOT FOUND error results. If the file is a data format file, a NOT A LOAD FILE error results. If the file is an object file rather than a program file, it will be loaded just as if a LOAD command had been used and the current program will continue executing with the statement after the PLOADG statement.

5.21.2.4 SAVE string expression [memory address range]

```
SAVE  "N:1:NEWPRG"
SAVE  "N:LOADER"   16R7ØØØ, 16R7DFF
```

The SAVE command stores program format or object format files on the diskette. The file is specified by the string expression which must evaluate to the following form:

```
" [N:] [unit:]filename"
```

If the file to be saved does not already exist on the diskette, the "N:" must prefix the unit/file name to cause the creation of a new file in the directory on the diskette. The unit is the drive unit address in the range Ø-3. If omitted, unit Ø is assumed. If the string is a constant it must be enclosed in quotes (").

The filename may be any valid filename.

If the memory range option is not included, the contents of the BASIC program buffer will be stored in the desired file in -rogram format.

If the memory range option is specified it must be of the form:

numeric expression 1, numeric expression 2

The numeric expressions must evaluate to positive real values in the range Ø - 65535. Fractional parts will be truncated. The contents of memory from expression 1 to expression 2 will be stored in the desired file in object format.

If "N:" is not specified for a new file, a FILE NOT FOUND error results. If a file has a Write Protect attribute, it cannot be overwritten and a WRITE PROTECT error will occur if an attempt is made to save it. If a file specified as new already exists a DUPLICATE NAME error occurs.

5.21.2.5 SCRATCH string expression

```
SCRATCH "1:JUNKFILE"
```

The SCRATCH command deletes a file from the diskette directory and releases the tracks allocated to the file for use by other files. The file to be scratched is specified by the expression which must evaluate to the form:

"[unit:] filename" where the unit is

the drive unit address in the range Ø - 3. The filename may be any valid filename. If the expression is a constant it must be enclosed in quotes ("). If the unit address is omitted, unit Ø is assumed.

If the specified file does not exist, a FILE NOT FOUND error results. If the file has a permanent file attribute then it cannot be deleted and a PERM FILE error occurs.

5.21.2.6 CHAIN string expression

```
99Ø CHAIN "NEXTPART"
```

The CHAIN statement loads the BASIC program file specified in the string expression into the current program buffer and then transfers execution control to the first line of the newly loaded program segment. This operation is similar to the PLOADG statement with the important exception that the CHAIN statement preserves all allocated variables, user defined assembly language functions, SIZES parameters, and the current string delimiter from the last program segment. These preserved values are passed to the newly loaded program segment which may use them just as if it had assigned them. Note that open file information and user defined BASIC functions are not preserved by the CHAIN statement. If any files are open when a CHAIN is executed they are implicitly closed. This means that the filenumber is disassociated from the filename and made free for reuse; but the directory is not updated and therefore any changes in the length of the file are not recorded. In general, all open files should be properly CLOSEd before executing a CHAIN statement.

The CHAIN statement is a powerful tool which facilitates the construction of programs much larger than available system memory would otherwise permit. It makes it possible to transfer data and control from section to section of a very large program that has been divided into separately loadable segments. To use the CHAIN statement effectively certain rules must be observed.

1) The program size of a segment being chained in cannot be greater than the program size of the program currently in the program buffer. If this condition does occur a LOAD OVERRUN error will be reported. A procedure for avoiding this condition is to specify the size of the largest program in a chained program set as the fourth argument of a SIZES statement (see section 5.20.26). This SIZES statement should appear as the first statement of the first executed program of the chained set. The program size of each segment can be determined by LOADing it and using the PGMSIZE function (see section 5.18.1.3). Assuming a set of three program files named SEG1, SEG2, SEG3, the following example illustrates the procedure:

```
LOAD "SEG1"
READY
PRINT PGMSIZE
472
READY
LOAD "SEG2"
PRINT PGMSIZE
526
READY
LOAD "SEG3"
PRINT PGMSIZE
126
READY
```

In this example the largest PGMSIZE is 526. If SEG1 were the first file to be executed and the standard system precisions were desired, then the statement SIZES (5,3,4Ø,526) would be included as the first statement of SEG1.

2) All files should be closed before executing a CHAIN statement.

3) A CHAIN statement should not normally be executed from within a FOR-NEXT loop. If this is done only the current value of the loop index variable will be preserved across the CHAIN.

4) A CHAIN statement should not normally be executed from within a subroutine. If this is done the RETURN information for that subroutine is lost across the CHAIN.

5) A program segment which is to be CHAINed should not normally contain a SIZES statement since SIZES statements cannot be executed after any variables have been allocated. The only exception is the case of the SIZES statement used to set the maximum program size. A special internal test allows such a statement to be chained back to as necessary.

5.21.2.7 LINK string expression

LINK "MDOS"

LINK "DISKCOPY"

The LINK command loads the overlay file specified in the string expression into memory and transfers control to the execution address of the overlay. This command is designed primarily for use with Micropolis supplied overlay files such as MDOS and DISKCOPY. These files completely replace BASIC in memory when LINKed to. They take over the control of the computer system and provide their own operating commands and dialogue.

The string expression must evaluate to a valid filename. The file must be an overlay type C through F. If the specified file is not found or the disk unit is not ready, control will return to BASIC where the error will be reported. If an unrecoverable disk error occurs during the LINKing process, the system will execute a soft halt. This is done because BASIC has already been partially destroyed and the new system has not been successfully loaded. The computer must be reset and a new system booted in.

The LINK command can be used to load and transfer control to a machine language program file that runs in high memory above the end of BASIC (see MEMEND statement). It can return to the BASIC interpreter by jumping to the system warmstart address.

5.21.3 DISK I/O STATEMENTS

BASIC statements are provided which allow a BASIC program to create and transfer data to and from data format files, and to perform certain file maintenance functions on any type file such as renaming a file or changing the attributes of a file. The operation of disk I/O statements differs from the disk commands as follows:

1) Disk I/O statements refer to files through a program "File Number". An OPEN statement must be executed to associate a file on the diskette with a program file number.

2) When all I/O operations on a file are complete, a file must be closed by executing a CLOSE statement. Closing a file consists of updating the directory to reflect all operations which have been performed since the file was opened, and disassociating the file from the program file number. CAUTION: A file which has been written to must ALWAYS be closed or data written to the file may be lost.

Prior to any operation which accesses the disk, BASIC ensures that the drive is ready to accept commands. If the diskette is not loaded or a malfunction exists which prevents the drive from performing operations then a DRIVE NOT UP error results. If the disk is unable to perform the specified read/write operation properly, a PERM I/O ERROR results.

A program file number may be in the range Ø to 9. As many as 1Ø files may be open at once within a program. If an I/O statement attempts to access a file which has not been opened by an OPEN statement then a FILE NOT OPEN error results.

If an I/O statement specifies a file number outside the range Ø to 9 then a NOT A FILE# error occurs.

5.21.3.1 OPEN file number string expression options

```
1Ø  OPEN 1  "N: NEWFILE"
2Ø  OPEN 2  "JOE" END 1ØØØ ERROR 5ØØØ
```

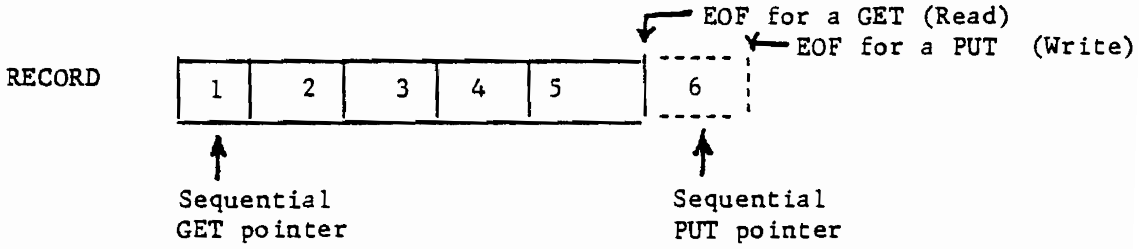
The OPEN statement opens the specified file for access by disk I/O statements. The file is selected by the string expression which must evaluate to the form:

```
"[N:][unit:] filename"
```

If the file to be opened does not exist on the diskette, the characters "N:" must be included in the unit/filename to cause the creation of a new file in the directory. The file created is a data format file. The unit specifies the drive unit address which must be in the range Ø-9. The filename may be any valid filename. If the string is a constant, it must be enclosed in quotes ("). If the unit address is omitted, unit Ø is assumed. If the specified file does not exist and is not declared as a new file, a FILE NOT FOUND error occurs. If a file specified as new already exists, a DUPLICATE NAME error occurs.

The filenumber must be a numeric expression with a value of Ø - 9. The filename specified will be associated with this file number until the file is closed and all file I/O directed to the file number will be performed using this file.

Each open file has two associated pointers which point to the next record to be accessed in a sequential PUT or GET statement. When a file is opened, the sequential GET pointer is initialized to point to the first record. The sequential PUT pointer is initialized to point to the record following the last record. The last record in the file is considered the end of the file for GET statements. The last record +1 is considered the end of file for PUT statements. For example a 5 record file would have pointers initialized as follows:



An open file may be read from and written to both sequentially and directly by record.

The open statement includes several options which are listed below:

1) CLEAR - The CLEAR option overrides the normal initialization of the sequential GET & PUT pointers. The pointers are initialized so that the file is empty. A subsequent GET will encounter an end-of-file. A PUT will write into record 1. This option is generally used to initialize the pointers for re-writing a file sequentially.

2) END numeric expression

   The END option specifies the line number to GOTO when the end-of-file is encountered during a read operation. The numeric expression must evaluate to a positive real number which is a valid program line within the program when the fractional part, if any, is truncated. If the line does not exist, a STMT # NOT FOUND error occurs. This option allows the BASIC program to handle an end-file condition without the program being aborted. If the END option is not specified, the normal end-file handling is to abort the program with an END-FILE error.

3) ERROR numeric expression

The ERROR option specifies the line number to GOTO if a disk I/O error occurs. The numeric expression must evaluate to a positive real number which is a valid program line within the program when the fractional part, if any, is truncated. If the line does not exist, a STMT # NOT FOUND error occurs. This option allows a BASIC program to handle disk I/O errors without being aborted. If the error option is not included, a disk I/O error will cause the appropriate error message to be output and abort the program. the ERR function may be used in the error handling program section to determine the type of error.

5.21.3.2 PUT filenumber RECORD record number expression List

```
100  PUT 1 A;B;C
200  PUT 1 A;A$+","; B
300  PUT 1 RECORD 3 A;B;C
```

The PUT statement causes the values of the expressions in the expression list to be written onto a record of the file specified by the filenumber expression. The filenumber must be a numeric expression having a value of the digits 0 - 9 when the fractional part, if any, is truncated.

Each execution of a PUT statement writes one record into the file.

Each disk record is composed of a 250 character string and is, in fact, a print line. Each expression in the expression list is evaluated, converted to a string if the resulting value is numeric, and is placed in the string in exactly the same way that print lines are built. The rules for building the string are as follows:

1) The record string is partitioned into 16 character fields. A pointer which is initialized to point to the first character in the string keeps track of the next position in the string to be loaded.

2) Expressions are evaluated as they are encountered in scanning the expression list and from left to right, and are converted to strings according to the formats described in section 5.16.3 "Output Formats". The resulting string is loaded into the record string beginning at the pointer position. Each expression must be separated from the next expression by a comma(,) or a semicolon(;).

3) If the expression is followed by a comma(,) after the expression has been loaded into the string, the string is padded with enough blanks to position the pointer to the beginning of the next 16 character field.

4) If the expression is followed by a semicolor(;), after the expression has been loaded into the string the pointer is set to the character position following the last character of the expression.

5) After all expressions have been loaded into the record string, any remaining characters in the string are padd with blanks and the record string is written onto the diskette.

EXAMPLE: If A = 1ØØ and B = -2.5, the statement:

```
1ØØ  PUT 1 A;B
```

would cause the following record to be written on the disk: (Note: ƀ denotes a blank)

$$\underbrace{\text{"ƀ1ØØƀ}}_{A}\ \text{-}\ \underbrace{\text{2.5 ƀ}}_{B}\underbrace{\text{ƀ ... ƀ"}}_{\text{24Ø Character pad}}$$

The Statement

```
1ØØ  PUT 1 A,B
```

would cause the following record to be written to the disk:

$$\underbrace{\text{"ƀ1ØØƀ}}_{A}\underbrace{\text{ƀƀƀƀƀƀƀƀƀƀƀ}}_{\text{PAD}}\ \underbrace{\text{- 2.5 ƀ}}_{B}\underbrace{\text{ƀ ... ƀ"}}_{\text{229 Character pad}}$$

The expressions in the expression list may be numeric and string in any order subject to the following restrictions: (1) If a string expression follows a numeric expression it must be immediately preceded by the current string delimiter. (2) The last character of a string expression must be the current string delimiter. These restrictions Must Be Strictly Followed or the expression will not be properly read back.

On Input, numeric values are delimited by blanks. The output format of numeric values always follows the value with a blank, so numeric strings built as described will always read back correctly. Strings, however, may contain embedded blanks. The input logic which reads a record from the disk looks for the current string delimiter to denote the end of a string. If a string follows a numeric value, the blank following the numeric field will be included in the string unless the current string delimiter precedes the string.

One solution to this problem is to concatenate the string delimiter on all string variable references, include the string delimiter in all string constants, and precede all string expressions following numeric expressions with the string delimiter.
EXAMPLE:

To write the values of A,B$,C, E$ and F$ on the diskette, the PUT statement would be

```
        1ØØ  PUT 1 A;",","+B$+",",";C;",","+E$+",",";F$+","
        (This example uses the default delimiter, comma (,))
```

If it is desired to change the string delimiter, the following approach could be used to implement the previous example:

```
        1Ø  D$ = ";" :!  SET STRING DELIMITER
        2Ø  STRING D$
                 .
                 .
                 .
                 .

        1ØØ  PUT 1 A;D$+B$+D$;C;D$+E$+D$;F$+D$
```

If this approach is used, the string delimiter must be the same when a record is read as when it was written or incorrect results will be obtained.

If the record option is not included, the record is written into the file at the record number specified by the sequential PUT pointer. The pointer is then incremented by 1.

If the record number option is included, the record is written into the record specified by the record number expression. The record number expression must have a value which is a positive real number. The fractional part is truncated. If the record number is greater than the end-of-file as described in 5.21.3.1, a PARM ERROR occurs.

NOTE; Writing a record directly by use of the RECORD option does not affect the sequential put pointer. The pointer will only be moved by a sequential PUT or execution of a PUTSEEK statement.

If an attempt is made to write more than 25Ø characters into a record, the first 25Ø characters will be written and the remaining characters will be truncated. A warning message WARNING - TRUNCATED OUTPUT will be output to the terminal.

5.21.3.3 GET filenumber RECORD record number variable list

```
100  GET  1 A,B,C$
200  GET  1 RECORD 100  A,B C$
```

The GET statement reads a record from the file specified by the filenumber expression and assigns the values read to the variable list. The filenumber expression must evaluate to one of the digits Ø - 9. The fractional part, if any, is truncated.

If a string is read for numeric variable, a TYPE ERROR results. If too few values exist in the record string to satisfy the variable list, a RAN OUT OF DATA error occurs. If an attempt is made to get a record which is past the last record, an END FILE error occurs.

If the RECORD option is not included, the record read is the record specified by the sequential GET pointer. The sequential GET pointer will then be incremented by 1.

If the RECORD option is included, the record read is the record specified by the recordnumber expression. The expression must evaluate to a positive real number. The fractional part will be truncated.

NOTE: The sequential GET pointer is not affected by a direct GET. The pointer will only be modified by a sequential GET or by execution of a GETSEEK statement.

5.21.3.4 CLOSE filenumber

```
100  CLOSE 1
```

The CLOSE statement causes the file specified by the filenumber expression to be closed for disk I/O. The filenumber expression must evaluate to one of the digits Ø - 9 when the fractional part is truncated.

Closing a file consists of updating the file entry in the diskette directory to reflect all operations which were performed upon the file since it was opened, and disassociating the file from the program filenumber. As a rule, all files which are opened in a program should be closed before the program terminates. All files which have been written into must be closed or the directory will not be updated and data written into the file may be lost. Any files which are left open are implicitly closed by a RUN command or any command that modifies the program buffer, such as a DELETE, LOAD or line insertion/deletion. Implicit closure does not update the directory.

5.21.3.5 ATTRS (filenumber) = numeric expression

```
          1ØØ  ATTRS (2) = 19
```

The ATTRS statement sets the file attributes of the file referenced by the filenumber to the value of the numeric expression. The filenumber expression must evaluate to one of the digits Ø-9 when the fractional part is truncated. The numeric expression, when the fractional part is truncated, must evaluate to a valid combination of the attribute values which are described below:

VALUE	ATTRIBUTE
16	Program File
8	Object File
2	Permanent File
1	Write Protect

A file which does not have a Program or Object attribute is assumed to be a Data Format file. Some examples are:

```
19 = 16+2+1 = Write protected, permanent, program file
 9 = 8+1     = Write protected, object file
26 = 16+8+2 = Invalid combination - This would identify
              a file as being a Permanent Program file and
              Object file, which is not possible.
```

A main intent of the ATTRS statement is to allow the user to change the Write Protect and Permanent attributes only. The File Format attributes should not be changed. The current value of the attribute parameter may be accessed by the ATTR function.

5.21.3.6 EOF (filenumber) = expression

```
       15Ø  EOF (9) = 5Ø
```

The EOF statement sets the file length parameter of the file referenced by the file number to the value of the expression. The filenumber expression must evaluate to one of the digits Ø - 9 when the fractional part is truncated. The expression must evaluate to a positive real number. The fractional part will be truncated. The EOF statement is used to <u>decrease</u> the length of a file. The value of the expression should be set to 1 greater than the last record number. For example if a file contains 1ØØ records and it is desired to delete the last 50 records, the statement

```
       1ØØ  EOF (1) = 51
```

would cause record 5Ø to be the last accessable record. The following cautions apply to the use of EOF statement:

1) The EOF statement does not reset the sequential PUT/GET pointers. If they are set beyond the new EOF an END-FILE error will occur if a PUT or GET is attempted. Reset the pointers to the proper values with the GETSEEK and PUTSEEK statements.

2) <u>Do Not Set The EOF Beyond</u> the true length of the file. Any sectors remaining on the last allocated track may be read by a GET and will yield garbage.

3) Resetting the EOF does not release the now unused tracks for system use. De-allocate the unused tracks by executing a FREESPACE statement.

5.21.3.7 FREESPACE filenumber

```
100  FREESPACE 1
```

The FREESPACE statement de-allocates any tracks allocated to the file referenced by filenumber which are beyond the current end of file. Filenumber expression must evaluate to one of the digits Ø - 9 when the fractional part is truncated. If there are no excess tracks allocated an "END FILE" error results.

5.21.3.8 GETSEEK (filenumber) = numeric expression

```
5Ø  GETSEEK (1) = 2Ø
```

The GETSEEK statement sets the sequential GET pointer associated with the filenumber to the value of the numeric expression. The filenumer expression must evaluate to one of the digits Ø - 9 when the fractional part is truncated. The numeric expression must evaluate to a positive real number. The fractional part is truncated. The value must be greater than zero and less than or equal to the last record number or a PARM ERROR or END FILE error will occur when a sequential GET is performed. The current position of the pointer may be accessed by using the RECGET function.

5.21.3.9 PUTSEEK (filenumber) = numeric expression

```
1ØØ  PUTSEEK (2) = 3Ø
```

The PUTSEEK statement sets the sequential PUT pointer associated with the filenumber to the value of the numeric expression. The filenumber expression must evaluate to one of the digits Ø - 9 when the fractional part is truncated. The numeric expression must evaluate to a positive real number. The fractional part is truncated. The value must be greater than zero and less than the last record number +2 or a PARM ERROR will occur when a sequential PUT is performed. The current value of the pointer may be accessed by using the RECPUT function.

5.21.3.1Ø RENAME (filenumber) = string expression

```
1ØØ RENAME (1) = "NEWNAME"
```

The RENAME statement changes the name of the file referenced by the filenumber to the value of the string expression. The filenumber expression must evaluate to one of the digits Ø - 9 when the fractional part is truncated. The string expression must evaluate to a valid file name. The current name can be accessed using the NAME function.

5.21.4 DISK I/O FUNCTIONS

Disk File I/O functions are included within BASIC to provide information about a currently open file. Each function reference includes a file number expression which must evaluate to one of the digits Ø - 9 when the fractional part is truncated. If the specified file number does not have a file currently opened to it a FILE NOT OPEN error occurs. The disk file I/O functions are detailed in table 5.5.

TABLE 5.5 DISK I/O FUNCTIONS

Function Reference	VALUE
ATTR (n)	Returns the attribute parameter associated with file n. See section 5.21.3.5 for a description of the value.
ERR	Returns the error code associated with the last disk error. The error codes are: Ø - No Error 1 - Permanent I/O Error 2 - End-File 3 - Disk Full 4 - File Not Found 5 - Duplicate Name 6 - Parameter Error 7 - Drive Not Up 8 - Permanent File 9 - Write Protect 11 - Invalid File Name 12 - Printer Attention The error code is not reset by a successful operation, so is meaningless unless an error occurs.
ERR$	Returns the error message string associated with the last disk error.
NAME (n)	Returns a string containing the name of the file associated with file number n.
RECGET (n)	Returns the value of the sequential GET pointer associated with file number n.
RECPUT (n)	Returns the value of the sequential PUT pointer associated with file number n.
SIZE (n)	Returns the SIZE (in records) of the file associated with file number n.
TRACKS (n)	Returns the number of disk tracks currently allocated to file number n.
FREETR (n)	Returns the number of disk tracks currently available for allocation (free) on the disk unit associated with file number n.

5.22 BASIC PRINT FILE OUTPUT

Micropolis BASIC provides a set of print file output features for systems which have a hard copy printer device in addition to the standard keyboard-display terminal. This section specifies each of the printer related language features and discusses how to use the available features to solve some common printer programming problems.

5.22.1 Printer Related Language Features

The printer related language features consist of seven statement and option keywords. They achieve a high flexibility of output control by expanding the disk file I/O scheme to include print file and terminal file output and by adding a physical device assignment capability. Following are descriptions of each statement syntax and function.

5.22.1.1 OPEN filenumber string expression option(s)

```
1Ø OPEN 1 "*P" PAGESIZE 66 ENDPAGE 9ØØ
2Ø OPEN 2 "*T"
3Ø OPEN 7 "*N"
```

The syntax of the OPEN statement in this context is the same as that for disk files as shown in section 5.21.3.1. The statement associates a filenumber with a filename specified in the string expression. The filenumber must be a numeric expression with a value of Ø - 9. The string expression which contains the filename must have one of three specific values which designate a particular output print device.

1) Filename *P associates the filenumber being opened with the system printer.

2) Filename *T associates the filenumber being opened with the display element of the system terminal.

3) Filename *N associates the filenumber being opened with a null output device. The output directed to that file will be discarded or drained.

Any other filename will be interpreted as a disk file name per section 5.21.3.1.

There are two print file options available with the OPEN statement:

a) PAGESIZE numeric expression

This option allows the programmer to set a limit value for an internal system counter which counts the number of lines output to the associated filenumber. The counter is incremented on each PUT statement to the associated file, unless that PUT statement ends in a comma or semicolon (see section 5.22.1.2). Each time the limit count is reached, the counter is reset and the system checks for a corresponding ENDPAGE option.

The numeric expression must evaluate to a whole number from Ø - 65535. If a print file is opened without a PAGESIZE option the internal limit value defaults to a value of 66 which is the number of lines per page on standard 11 inch forms.

b) ENDPAGE linenumber

This option specifies a program line number to which the system will perform a GOSUB each time that the limit is reached on the internal lines per page counter. The linenumber must be a numeric expression which evaluates to a legal linenumber. That line should be the beginning of a subroutine which programs some appropriate end of page actions and which ends with a RETURN statement. The RETURN will go back to the statement immediately after the PUT statement which triggered the end of page action.

If no ENDPAGE option is specified for a given file the internal lines per page counter is just reset each time the limit is reached and processing continues normally.

5.22.1.2 PUT filenumber expression list

```
15 PUT Ø  "TOTAL = "; A1, "ITEM NAME ="; B$
25 PUT 7  A, B;
```

The PUT statement causes the values of the expressions in the expression list to be assembled into an output record which is then output to the print file device associated with the filenumber. The filenumber must be a numeric expression with a value in the range Ø - 9. The expression list consists of a sequence of constants and/or variables separated by commas or semicolons. The rules by which the output record is assembled are the same as those for PRINT statements as detailed in section 5.20.21. Separate carriage width wraparound control is provided for the printer device. If the expression list ends with a comma or semicolon then no carriage return line feed is output. In this case the internal lines per page counter of the associated file is not incremented. (see section 5.22.1.1 - PAGESIZE option). The TAB and FMT functions may be used in PUT statements.

5.22.1.3 CLOSE filenumber

```
9Ø CLOSE 6
99 CLOSE 2
```

The CLOSE statement causes the file specified by the filenumber expression to be closed for output. The filenumber must be in the range Ø - 9. When a print file is closed the associated filenumber is freed for use in a subsequent OPEN to another file.

Any files which are left open are implicitly closed by a RUN command or by any command that modifies the program buffer, such as DELETE, LOAD or line insertion change.

5.22.1.4 ENDPAGE filenumber

```
25  ENDPAGE  7

28  ENDPAGE R6
```

The ENDPAGE statement is related to the ENDPAGE option described in section 5.22.1.1. However, it is syntactically and functionally distinct. Its function is to end the current output page of the designated filenumber and thereby position the output device to the beginning of the next logical page. The filenumber must be a numeric expression with a value in the range Ø - 9. When the ENDPAGE statement is executed the current value of the lines per page counter associated with filenumber is subtracted from its limit value. The result determines the number of empty lines which are output to the file device to complete the current logical page. When the ENDPAGE statement is complete the associated lines per page counter is reset to mark the beginning of the next logical page.

5.22.1.5 ASSIGN (physical device number, logical stream indicator, device width, null count)

```
1Ø ASSIGN (2,1,8Ø,6)
2Ø ASSIGN (2,2,132)
3Ø ASSIGN (1,1)
```

The ASSIGN statement is a dual purpose statement which provides the ability to specify the connections of physical output print devices to logical output streams and the values for carriage width and nullcount of the referenced physical device. The physical device number must be a numeric expression which evaluates to a 1 or a 2. The logical stream indicator must be a numeric expression which evaluates to a 1, 2 or 3. The device width and nullcount must be numeric expressions with values in the range 1 - 255. They are optional parameters in the ASSIGN statement. If they are not included, the values corresponding to the referenced physical device are not changed. If only the device width is included, then the nullcount is left unchanged. Note however that specifying a nullcount requires that a device width also be specified, i.e., if the statement only contains three arguments, the third will always be treated as a device width.

Logical output stream number 1 consists of all output generated by system messages, keyboard echoing, PRINT statements, LIST commands, and PUT statements when the corresponding filenumber is open to *T. Logical output stream 2 consists of all output generated by LISTP commands and by PUT statements when the corresponding filenumber is open to *P. The logical stream indicator may be set to a value of 3 to represent both logical output streams 1 and 2.

Physical device number 1 represents the display element of the keyboard display device that is configured as the system terminal. (see section 3.3.1 on terminal configuration). Physical device number 2 represents the hard copy print device which is configured as the system printer. (see section 3.3.4).

The output of a logical stream is directed to all physical devices which are assigned to it. A physical device may be assigned to one or both logical streams. Whenever a physical device is ASSIGNed its previous assignment state is effectively cancelled. A list of legal device connections follows:

ASSIGN (1,1) - connects terminal display to stream 1 only

ASSIGN (1,2) - connects terminal display to stream 2 only

ASSIGN (1,3) - connects terminal display to stream 1 and stream 2

ASSIGN (2,1) - connects printer to stream 1 only

ASSIGN (2,2) - connects printer to stream 2 only

ASSIGN (2,3) - connects printer to stream 1 and stream 2

In its initialized state BASIC connects the terminal to stream 1 only and the printer to stream 2 only. This state can be restored by executing an ASSIGN (1,1) followed by an ASSIGN (2,2).

When the terminal and printer devices are configured each device has a carriage width and a nullcount parameter associated with it. These parameters may be altered under program control by specifying optional 3rd and 4th arguments in an appropriate ASSIGN statement. The width parameter determines the maximum number of spaces on each line for the given device. When a line is output that is longer than width the autowrap feature is activated and a carriage return line feed is inserted between character number width and width +1. The autowrap feature may be disabled at configuration time. The width parameter may be changed on a given device by restating the current device assignment with a new width argument. For example, if the terminal were currently assigned to stream 1 with a width of 80, it could be changed to a width of 72 with the statement ASSIGN (1,1,72). Note that any such change remains in effect until a subsequent ASSIGN statement alters it or until the system is reloaded. The nullcount parameter is one greater than the number of nulls which are output after each carriage return output to a given device. It is important with unbuffered character serial devices which may lose characters while the carriage is being returned. The nullcount parameter for a given device may be dynamically changed by restating the current device assignment and WIDTH with a new nullcount. For example, if the printer were currently assigned to stream 2, 132 columns, no nulls (nullcount = 1), it could be changed to stream 2, 132 columns, 5 nulls by using the statement ASSIGN (2,2,132,6).

Because BASIC is an interactive language it depends on the availability of a display device for system messages and keyboard echoing. An interlock is therefore built in to ensure that stream 1 always has at least one device assigned to it. If an ASSIGN statement is processed the result of which would violate this condition, then physical device 1 is automatically assigned to stream 1 as part of the ASSIGN being processed.

5.22.1.6 LISTP X - Y

```
LISTP
LISTP 1Ø
LISTP -1Ø
LISTP 1Ø-
LISTP 1Ø-1ØØ
```

The LISTP command causes a listing of the program in the current program buffer to be directed to logical output stream 2 which is normally connected with the system printer. This COMMAND is analogous to the LIST command (see section 5.5) with two exceptions. The LIST command directs its output to logical stream 1 which is normally connected to the system terminal display. The LISTP command outputs a paginated.listing with three blank lines at the top and bottom of each page and 6Ø lines of listing as standard. (see 5.22.1.7).

X and Y must be legal linenumber constants.

LISTP prints the entire program buffer.

LISTP X prints only line X if present or the first line greater than X if no line X exists.

LISTP X- prints all lines starting with X or the first greater than X through the end of the program buffer.

LISTP -Y prints from the beginning of program buffer thru line Y or the first greater than Y.

LISTP X-Y prints from line X or first greater than X through line Y or first greater than Y.

5.22.1.7 PAGESIZE numeric expression

```
PAGESIZE 42
```

The PAGESIZE command is related to the LISTP command. It causes the number of lines of listing per page of the LISTP command to be set to the value of the numeric expression in the PAGESIZE statement. This number is the number of actually printed lines not including the 3 blank lines at the top and bottom of each page. For example, to list a program on paper which holds 48 lines per page, the statement PAGESIZE 42 would be the proper value to use. When BASIC is configured the default value for this parameter is 6Ø.

NOTE that the PAGESIZE statement as described here is syntactically and functionally distinct from the PAGESIZE option of the OPEN statement as described in 5.22.1.1

5.22.2 Notes On Printer Related Programming

Used properly and with care the printer related language features in Micropolis BASIC provide for highly flexible and efficient programming of many common print file related functions. This section provides some examples and commentary.

5.22.2.1 Separating Print Files and Interactive Messages

There is a large variety of applications which can be programmed in the following three part structure:

1) Output to the terminal display a sequence of prompting messages which lead the user through a process of entering variable data from the terminal keyboard.

2) Process the input data through algorithms which create desired output data.

3) Output to the printer one or more pages which present the desired output data with proper labelling in an appropriate report format.

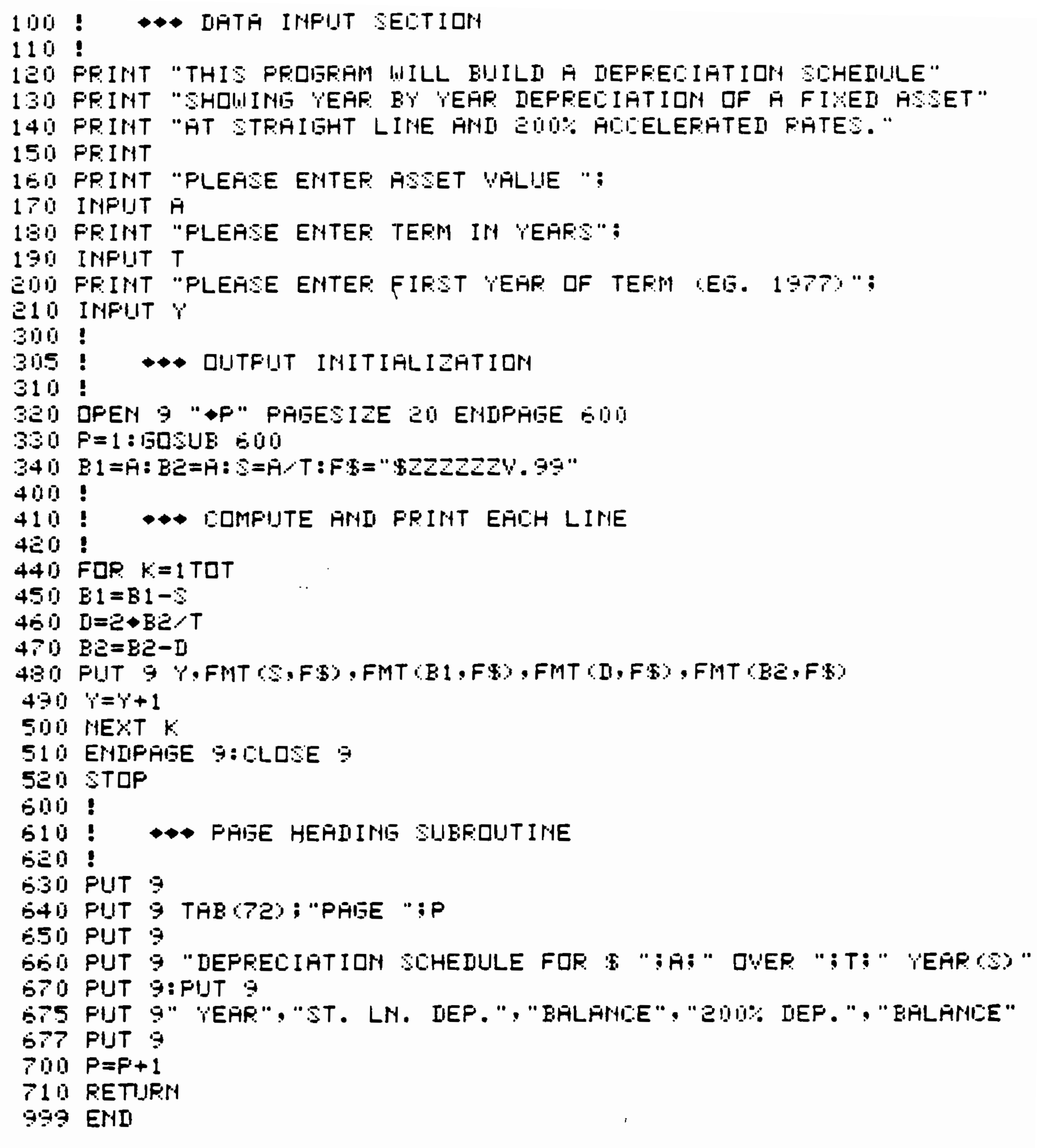
This structure requires the ability to separate output which is normally intended for the operators terminal from output which is normally intended for the system printer. In Micropolis BASIC the separation may be accomplished by using PRINT statements for terminal display messages and PUT statements to open print files for system printer output. The technique is illustrated by the following program for building a depreciation schedule chart.

```
100 !    ◆◆◆ DATA INPUT SECTION
110 !
120 PRINT "THIS PROGRAM WILL BUILD A DEPPECIATION SCHEDULE"
130 PRINT "SHOWING YEAR BY YEAR DEPRECIATION OF A FIXED ASSET"
140 PRINT "AT STRAIGHT LINE AND 200% ACCELERATED RATES."
150 PRINT
160 PRINT "PLEASE ENTER ASSET VALUE ";
170 INPUT A
180 PRINT "PLEASE ENTER TERM IN YEARS";
190 INPUT T
200 PRINT "PLEASE ENTER FIRST YEAR OF TERM (EG. 1977)";
210 INPUT Y
300 !
310 !    ◆◆◆ PRINT OUT CHART HEADINGS
320 !
330 OPEN 9 "◆P"
340 PUT 9:PUT 9
350 PUT 9 "DEPRECIATION SCHEDULE FOR $ ";A;" OVER ";T;" YEAR(S)"
360 PUT 9:PUT 9
370 PUT 9" YEAR","ST. LN. DEP.","BALANCE","200% DEP.","BALANCE"
380 PUT 9
400 !
410 !    ◆◆◆ COMPUTE AND PRINT EACH LINE
420 !
430 B1=A:B2=A:S=A/T:F$="$ZZZZZZV.99"
440 FOR K=1TOT
450 B1=B1-S
460 D=2◆B2/T
470 B2=B2-D
480 PUT 9 Y,FMT(S,F$),FMT(B1,F$),FMT(D,F$),FMT(B2,F$)
490 Y=Y+1
500 NEXT K
510 CLOSE 9
999 END
```

```
RUN
THIS PROGRAM WILL BUILD A DEPRECIATION SCHEDULE
SHOWING YEAR BY YEAR DEPRECIATION OF A FIXED ASSET
AT STRAIGHT LINE AND 200% ACCELERATED RATES.

PLEASE ENTER ASSET VALUE ? 100000
PLEASE ENTER TERM IN YEARS? 25
PLEASE ENTER FIRST YEAR OF TERM (EG. 1977)? 1980


DEPRECIATION SCHEDULE FOR $  100000  OVER  25  YEAR(S)


 YEAR               ST. LN. DEP.    BALANCE          200% DEP.        BALANCE

 1980               $  4000.00      $ 96000.00       $  8000.00       $ 92000.00
 1981               $  4000.00      $ 92000.00       $  7360.00       $ 84640.00
 1982               $  4000.00      $ 88000.00       $  6771.20       $ 77868.80
 1983               $  4000.00      $ 84000.00       $  6229.50       $ 71639.29
 1984               $  4000.00      $ 80000.00       $  5731.14       $ 65908.15
 1985               $  4000.00      $ 76000.00       $  5272.65       $ 60635.50
 1986               $  4000.00      $ 72000.00       $  4850.84       $ 55784.66
 1987               $  4000.00      $ 68000.00       $  4462.77       $ 51321.88
 1988               $  4000.00      $ 64000.00       $  4105.75       $ 47216.13
 1989               $  4000.00      $ 60000.00       $  3777.29       $ 43438.84
 1990               $  4000.00      $ 56000.00       $  3475.10       $ 39963.7
 1991               $  4000.00      $ 52000.00       $  3197.09       $ 36766.6
 1992               $  4000.00      $ 48000.00       $  2941.33       $ 3382   3
 1993               $  4000.00      $ 44000.00       $  2706.02       $ 311     9
 1994               $  4000.00      $ 40000.00       $  2489.54       $ 2862    3
 1995               $  4000.00      $ 36000.00       $  2290.37       $ 26339.36
 1996               $  4000.00      $ 32000.00       $  2107.14       $ 24232.21
 1997               $  4000.00      $ 28000.00       $  1938.57       $ 22293.63
 1998               $  4000.00      $ 24000.00       $  1783.49       $ 20510.14
 1999               $  4000.00      $ 20000.00       $  1640.81       $ 18869.33
 2000               $  4000.00      $ 16000.00       $  1509.54       $ 17359.78
 2001               $  4000.00      $ 12000.00       $  1388.78       $ 15971.00
 2002               $  4000.00      $  8000.00       $  1277.68       $ 14693.32
 2003               $  4000.00      $  4000.00       $  1175.46       $ 13517.85
 2004               $  4000.00      $       .00      $  1081.42       $ 12436.42

READY
```

5.22.2.2 Paginating Print Files

When the number of lines in a print file spans several printed pages it is often required to print the file with page numbers, headings and an equal number of lines on each page. The ENDPAGE statement and the PAGESIZE and ENDPAGE options of the OPEN statement provide a useful set of tools for accomplishing this goal. The following example shows the depreciation schedule program of section 5.22.2.1 modified to print on 2Ø line pages with each page numbered and titled. Note the use of the PAGESIZE and ENDPAGE options in line 32Ø in conjunction with the page heading subroutine at line 6ØØ. NOTE also the use of the ENDPAGE statement in line 51Ø which ejects the last report page and leaves the printer at the top of the next blank page.



```
100 !    ◆◆◆ DATA INPUT SECTION
110 !
120 PRINT "THIS PROGRAM WILL BUILD A DEPRECIATION SCHEDULE"
130 PRINT "SHOWING YEAR BY YEAR DEPRECIATION OF A FIXED ASSET"
140 PRINT "AT STRAIGHT LINE AND 200% ACCELERATED RATES."
150 PRINT
160 PRINT "PLEASE ENTER ASSET VALUE ";
170 INPUT A
180 PRINT "PLEASE ENTER TERM IN YEARS";
190 INPUT T
200 PRINT "PLEASE ENTER FIRST YEAR OF TERM (EG. 1977) ";
210 INPUT Y
300 !
305 !    ◆◆◆ OUTPUT INITIALIZATION
310 !
320 OPEN 9 "◆P" PAGESIZE 20 ENDPAGE 600
330 P=1:GOSUB 600
340 B1=A:B2=A:S=A/T:F$="$ZZZZZZV.99"
400 !
410 !    ◆◆◆ COMPUTE AND PRINT EACH LINE
420 !
440 FOR K=1TOT
450 B1=B1-S
460 D=2◆B2/T
470 B2=B2-D
480 PUT 9 Y,FMT(S,F$),FMT(B1,F$),FMT(D,F$),FMT(B2,F$)
490 Y=Y+1
500 NEXT K
510 ENDPAGE 9:CLOSE 9
520 STOP
600 !
610 !    ◆◆◆ PAGE HEADING SUBROUTINE
620 !
630 PUT 9
640 PUT 9 TAB(72);"PAGE ";P
650 PUT 9
660 PUT 9 "DEPRECIATION SCHEDULE FOR $ ";A;" OVER ";T;" YEAR(S)"
670 PUT 9:PUT 9
675 PUT 9" YEAR","ST. LN. DEP.","BALANCE","200% DEP.","BALANCE"
677 PUT 9
700 P=P+1
710 RETURN
999 END
```

```
READY
RUN
THIS PROGRAM WILL BUILD A DEPRECIATION SCHEDULE
SHOWING YEAR BY YEAR DEPRECIATION OF A FIXED ASSET
AT STRAIGHT LINE AND 200% ACCELERATED RATES.

PLEASE ENTER ASSET VALUE ? 100000
PLEASE ENTER TERM IN YEARS? 25
PLEASE ENTER FIRST YEAR OF TERM (EG. 1977)? 1980

                                                                   PAGE  1

DEPRECIATION SCHEDULE FOR $  100000  OVER  25  YEAR(S)


 YEAR          ST. LN. DEP.    BALANCE        200% DEP.       BALANCE

 1980          $  4000.00      $ 96000.00     $  8000.00      $ 92000.00
 1981          $  4000.00      $ 92000.00     $  7360.00      $ 84640.00
 1982          $  4000.00      $ 88000.00     $  6771.20      $ 77868.80
 1983          $  4000.00      $ 84000.00     $  6229.50      $ 71639.29
 1984          $  4000.00      $ 80000.00     $  5731.14      $ 65908.15
 1985          $  4000.00      $ 76000.00     $  5272.65      $ 60635.50
 1986          $  4000.00      $ 72000.00     $  4850.84      $ 55784.66
 1987          $  4000.00      $ 68000.00     $  4462.77      $ 51321.88
 1988          $  4000.00      $ 64000.00     $  4105.75      $ 47216.13
 1989          $  4000.00      $ 60000.00     $  3777.29      $ 43438.84
 1990          $  4000.00      $ 56000.00     $  3475.10      $ 39963.73
 1991          $  4000.00      $ 52000.00     $  3197.09      $ 36766.63

                                                                   PAGE  2

DEPRECIATION SCHEDULE FOR $  100000  OVER  25  YEAR(S)


 YEAR          ST. LN. DEP.    BALANCE        200% DEP.       BALANCE

 1992          $  4000.00      $ 48000.00     $  2941.33      $ 33825.30
 1993          $  4000.00      $ 44000.00     $  2706.02      $ 31119.28
 1994          $  4000.00      $ 40000.00     $  2489.54      $ 28629.73
 1995          $  4000.00      $ 36000.00     $  2290.37      $ 26339.36
 1996          $  4000.00      $ 32000.00     $  2107.14      $ 24232.21
 1997          $  4000.00      $ 28000.00     $  1938.57      $ 22293.63
 1998          $  4000.00      $ 24000.00     $  1783.49      $ 20510.14
 1999          $  4000.00      $ 20000.00     $  1640.81      $ 18869.33
 2000          $  4000.00      $ 16000.00     $  1509.54      $ 17359.78
 2001          $  4000.00      $ 12000.00     $  1388.78      $ 15971.00
 2002          $  4000.00      $  8000.00     $  1277.68      $ 14693.32
 2003          $  4000.00      $  4000.00     $  1175.46      $ 13517.85

                                                                   PAGE  3

DEPRECIATION SCHEDULE FOR $  100000  OVER  25  YEAR(S)


 YEAR          ST. LN. DEP.    BALANCE        200% DEP.       BALANCE

 2004          $  4000.00      $       .00    $  1081.42      $ 12436.42
```

5.22.2.3 Spooling Print Files To Disk For Later Output

The commonality of the OPEN, CLOSE and PUT statements to both disk and print files makes it possible to alter a print file program so that the output is saved in a disk file instead of sent to the printer. The procedure is to change the filename in the relevant OPEN statement from "*P" to some appropriate disk filename. For example, line 320 in the depreciation program listing might be changed to

```
320 OPEN 9 "N:DEP-REPORT" PAGESIZE 20 ENDPAGE 600
```

A print file that has been spooled to disk in this manner can be printed out at a later time by using the following program:

```
5 INPUT "ENTER PAGE WIDTH OF FILE TO BE PRINTED";A
10 DIM A$(A)
20 STRING CHARS(16RFF)
30 INPUT "ENTER NAME OF FILE TO BE PRINTED";A$
40 OPEN 1 A$ END 90
50 OPEN 2 "*P"
60 GET 1 A$
70 PUT 2 A$
80 GOTO 60
90 CLOSE 1
100 CLOSE 2
110 END
```

Note that the string into which each disk record is read must be dimensioned to a length which matches the expected page width of the report (lines 5 and 10). This ensures that the extra blank padding that fills each disk record will not be printed out causing extra blanks lines on most printers.

Note also that line 20 changes the system string delimiter to a value that is illegal in normal print files. This ensures that the entire content of each line will be assigned to and printed from A$ regardless of which characters appear in the print file. If this were not done any commas in the print file would cause erroneous output.

5.22.2.4 Draining File Output To A Null Device

During the program development and test process or in a reduced system hardware environment it is sometimes useful to run a program which outputs one or more files and be able to suppress one or more of the output files while the rest of the program runs normally. In Micropolis BASIC this is easily accomplished by changing the filename in the open statement of each file to be suppressed to a "*N". When the program is run all output to "*N" files will be suppressed or drained away without otherwise affecting program operation. The following program illustrates this idea.

```
1Ø DIM A$(4,3Ø)
2Ø FOR J=1 TO 4:A$(J)="":NEXT J
3Ø INPUT " FIRST LINE ";A$(1)
4Ø INPUT "SECOND LINE ";A$(2)

5Ø INPUT " THIRD LINE ";A$(3)
6Ø INPUT "FOURTH LINE ";A$(4)
7Ø B$="LABELS"
8Ø INPUT "ADD TO DISK FILE (Y/N)";X$
9Ø IF X$ = "Y" THEN B$="*N"
1ØØ C$="*P"
11Ø INPUT "PRINT LABEL  (Y/N)";X$
12Ø IF X$= "Y" THEN C$="*N"
13Ø X$=","
14Ø OPEN 1 B$
15Ø PUT 1 A$(1)+X$+A$(2)+X$+A$(3)+X$+A$(4)+A$
16Ø CLOSE 1
17Ø OPEN 2 C$
18Ø FOR J=1 TO 4:PUT 2 A$(J):NEXT J
19Ø CLOSE 2
2ØØ GOTO 2Ø
```

The file output section attempts to add four lines of input to a label file and then print a copy of the new label entry. If either or both of these functions is refused by the operator during the input section, the program changes the filename variable for the associated OPEN statement to "*N". When the output section executes the refused function output is simply drained, i.e. not output anywhere.

5.22.2.5 Echoing Of Terminal Output To Printer

On systems with a video terminal and printer device it is often desirable to obtain a hard copy audit trail of all system program operation, including all of the prompts and system messages normally directed to the terminal only. This is easily done by using the statement

```
ASSIGN (2,3).
```

This statement causes the hard copy printer to be connected to logical output stream 1 which includes all print statements, input dialogue, keyboard echoing, *T files, and system messages; and to logical output stream 2 which includes all *P print files. Thus everything aimed at the terminal thru stream 1 will also go to the printer.

This echo mode remains active until changed. The statement ASSIGN (2,2) will restore the system to normal which is device 1 (terminal) connected to stream 1 and device 2 (printer) connected to stream 2.

(This page left blank deliberately.)

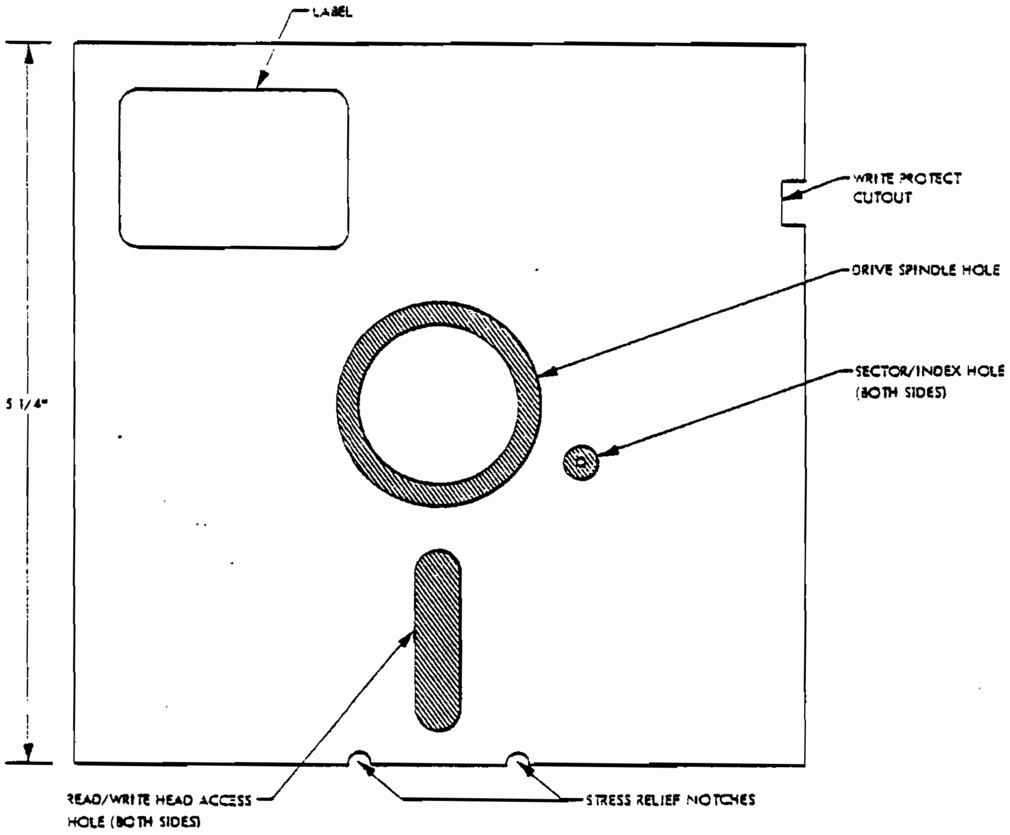

LABEL
WRITE PROTECT CUTOUT
DRIVE SPINDLE HOLE
SECTOR/INDEX HOLE (BOTH SIDES)
5 1/4"
READ/WRITE HEAD ACCESS HOLE (BOTH SIDES)
STRESS RELIEF NOTCHES

Figure 6.1

VI. DISK SUBSYSTEM THEORY AND DIRECT PROGRAMMING

6.0 INTRODUCTION

This section describes the Micropolis flexible disk subsystem in sufficient detail to enable an experienced 8Ø8Ø assembly language programmer to implement a disk driver.

6.1 FUNDAMENTALS OF THE FLEXIBLE DISK: MEDIA

6.1.1 Recording Medium

The recording medium used with the Micropolis flexible disk subsystem is illustrated in Figure 6.1. The medium consists of a thin, oxide coated circular disk permanently housed in a protective plastic jacket. The disk rotates freely within the jacket, which is lined with a material that cleans the disk as it rotates. Several holes in the plastic jacket allow a disk drive to access the disk. When a diskette is loaded into a drive, the disk is clamped to a motor-driven spindle through the drive spindle hole. The read/write head and the load pad which presses the disk against the head, access the disk through the read/write head access holes. A photo detector senses sector and index holes through the sector/index hole. A switch in the disk drive senses the Write Protect cutout. If a Write Protect tab is placed over the cutout, the diskette may be read, but may not be written on. If the cutout is open, both read and write operations may be performed.

6.1.2 Disk Data Format

Figure 6.2 illustrates the format of data recorded on the diskette. Data is recorded on the diskette on concentric tracks. The outermost track is Track Ø and the innermost track is 76 in Mod II subsystems and Track 34 in Mod I subsystems. Each track has an unformatted capacity of 625Ø bytes. Disk data transfers are performed on a block basis, which would require a 625Ø byte RAM buffer in the computer for a full track size block. This buffer size is wasteful of memory, so the actual format used divides a track into blocks of more manageable size called sectors. The format used in the Micropolis flexible disk subsystem divides each track into 16 sectors. The beginning of each sector is indicated by a sector hole punched in the disk. This hole is sensed by a sector/index sensor in the disk drive. An index hole is located halfway between the holes for sector 15 and sector Ø and indicates the next hole is sector Ø.

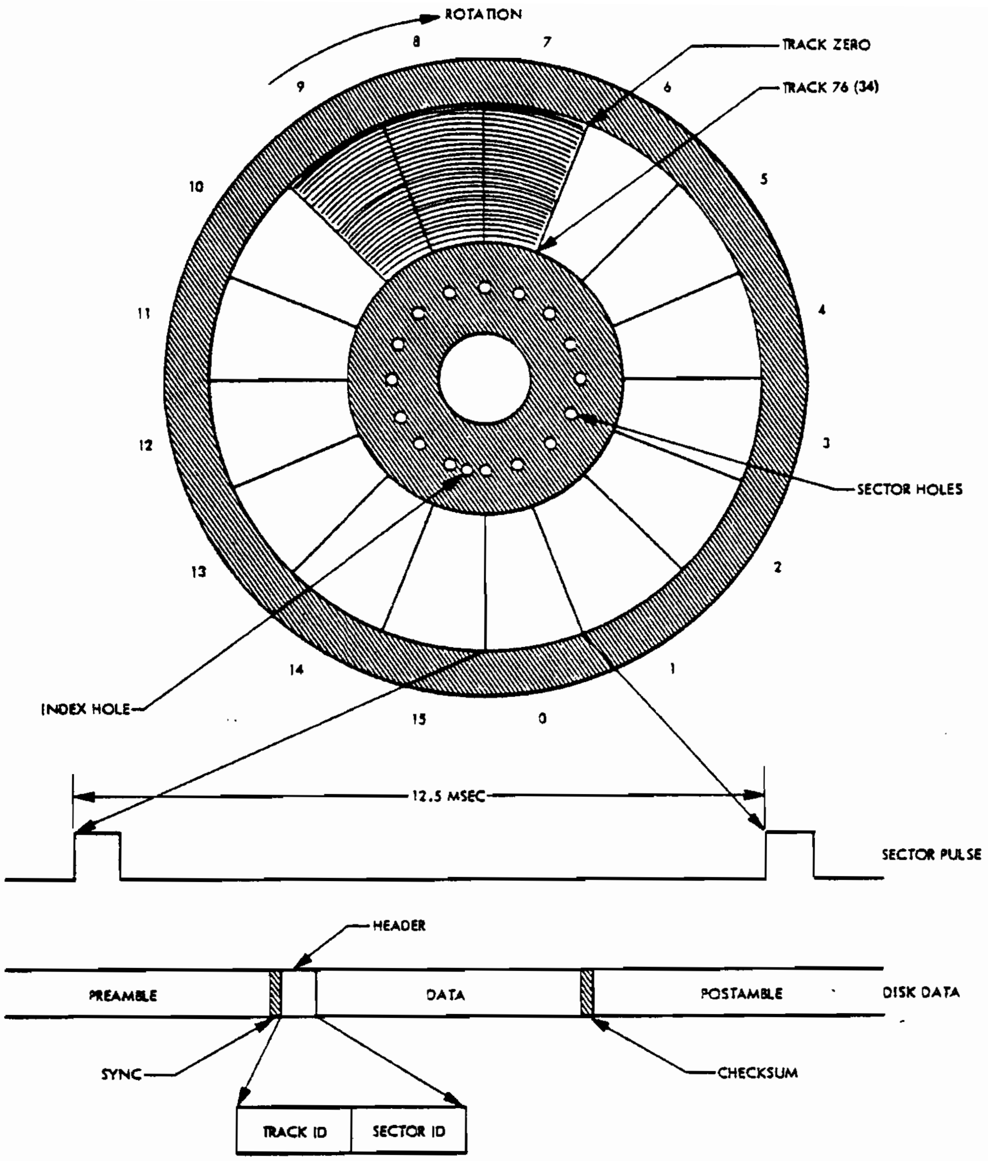

ROTATION
8
7
TRACK ZERO
9
6
TRACK 76 (34)
10
5
11
4
12
3
SECTOR HOLES
13
2
14
1
INDEX HOLE
15
0
12.5 MSEC
SECTOR PULSE
HEADER
PREAMBLE
DATA
POSTAMBLE
DISK DATA
SYNC
CHECKSUM
TRACK ID
SECTOR ID

Figure 6.2

Each sector has an unformatted caoacity of anproximately 39Ø bytes. However, not all of the available storage space can be used for data. The electronics in the disk drive and the nature of the media and drive mechanism require a certain amount of space be given up to accommodate the electronic characteristics and to allow sufficient tolerance in the recording format to permit interchanging diskettes between different disk drives. Briefly, the factors which must be taken into account are: mechanical tolerance in the physical distance between sector holes punched in the disk; alignment of the sector/index sensor with respect to the read/write head; response of the sector/index sensor and logic; disk speed variation; write clock frequency tolerance; and, acquisition time of the read data decoder.

The recommended sector format is illustrated in Figure 6.2. This is the format used in disk files created by the Micropolis Disk Extended BASIC software and is the format required by the disk bootstrap located on the controller board. This format was designed to make the best trade-off between storage capacity and tolerance margins. Although other formats could possibly utilize more storage capacity, they would be incompatible with the bootstrap and a complete discussion of the engineering considerations necessary to design another format is beyond the scope of this section.

A disk sector consists of the following fields:

1) Preamble: The preamble is composed of anoroximately 4Ø bytes of zero (Ø) data bits. The oreamble is automatically generated by the disk controller and is necessary to orovide tolerance for the mechanical alignment and electrical characteristics of the sector/index sensor. It also provides a field of known data pattern for synchronization of the read data decoder.

2) Sync: The sync byte is a byte of ØFFH data which is used in the disk controller to define the beginning of useful data.

3) Header: The header is a 2 byte block consisting of the binary track address of the track on which the sector resides (Ø-76 (34)) and the address of the sector (0-15). The header is used to verify that the proper sector is being accessed in a disk I/O operation.

4) Data: The data field consists of 266 bytes of user data.

5) Checksum: The checksum is a one byte error detection code which provides error detection in read operations. The checksum is computed as follows: a) The accumulator and carry are initially cleared; b) Each byte of the header and data fields is added to the accumulator with carry. In write operations, the computed checksum is written immediately following the data field. In read operations, the checksum is re-computed from the read data and is compared with the checksum byte which is read. If they do not comoare, a read error has occurred.

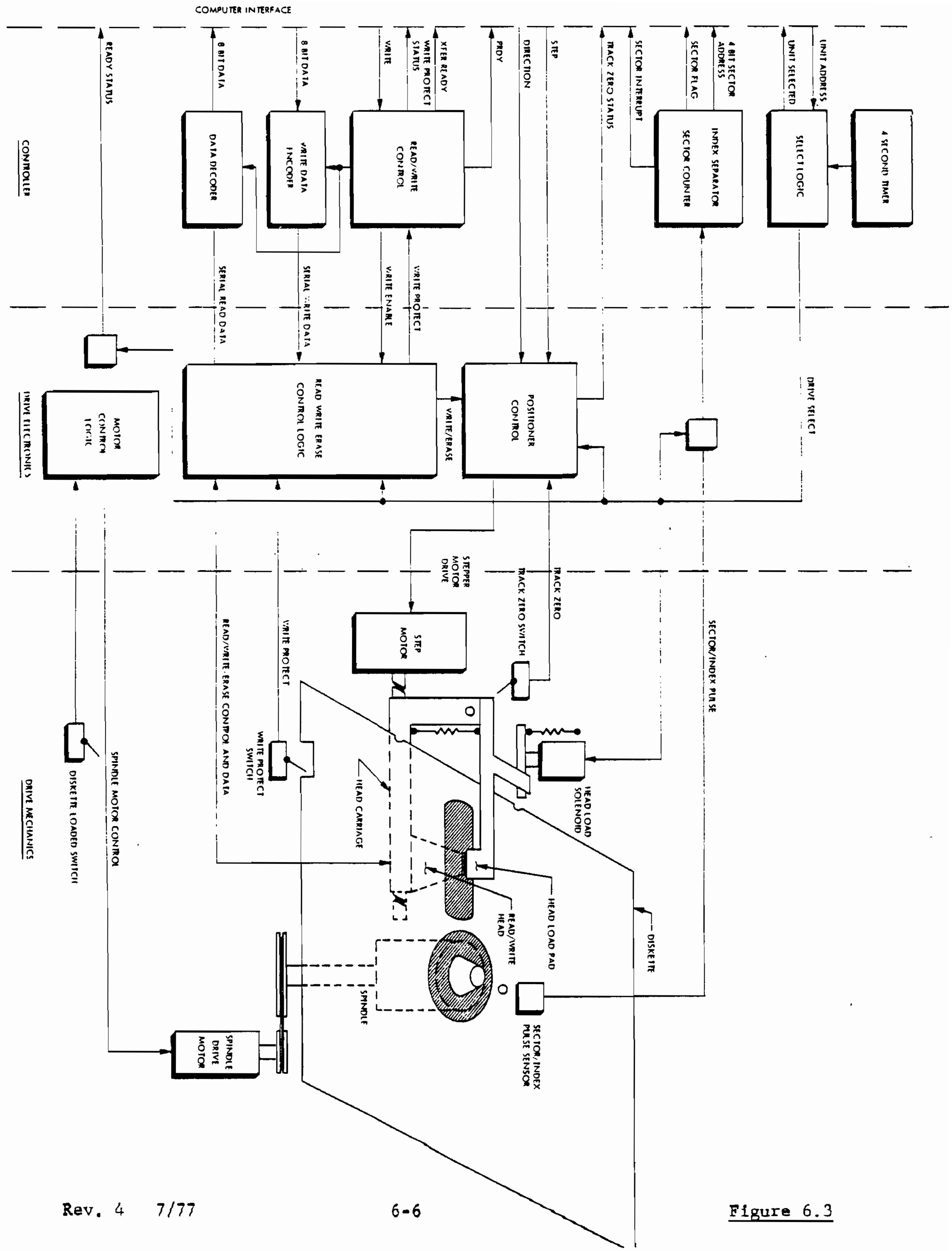

COMPUTER INTERFACE
CONTROLLER
DRIVE ELECTRONICS
DRIVE MECHANICS
READY STATUS
8 BIT DATA
8 BIT DATA
WRITE
WRITE PROTECT STATUS
XFER READY
PRDY
DIRECTION
STEP
TRACK ZERO STATUS
SECTOR INTERRUPT
SECTOR FLAG
4 BIT SECTOR ADDRESS
UNIT SELECTED
UNIT ADDRESS
DATA DECODER
WRITE DATA ENCODER
READ/WRITE CONTROL
INDEX SEPARATOR SECTOR COUNTER
SELECT LOGIC
4 SECOND TIMER
SERIAL READ DATA
SERIAL WRITE DATA
WRITE ENABLE
WRITE PROTECT
DRIVE SELECT
MOTOR CONTROL LOGIC
READ WRITE ERASE CONTROL LOGIC
WRITE/ERASE
POSITIONER CONTROL
STEPPER MOTOR DRIVE
TRACK ZERO SWITCH
TRACK ZERO
SECTOR/INDEX PULSE
STEP MOTOR
READ/WRITE ERASE CONTROL AND DATA
WRITE PROTECT
WRITE PROTECT SWITCH
HEAD CARRIAGE
HEAD LOAD SOLENOID
HEAD LOAD PAD
READ/WRITE HEAD
DISKETTE
SPINDLE
SECTOR/INDEX PULSE SENSOR
SPINDLE MOTOR CONTROL
DISKETTE LOADED SWITCH
SPINDLE DRIVE MOTOR

Figure 6.3

6) Postamble: The rest of a sector from the checksum to the next sector hole is filled with zero data bits. The length of the postamble allows for the mechanical tolerance in the placement of sector holes on the disk and tolerance for disk speed and write clock variations.

6.2 HARDWARE FUNDAMENTALS

Figure 6.3 is a block diagram of the Micropolis flexible disk subsystem. The components of the subsystem may be grouped as: spindle drive control; sector logic; position control logic; read/write logic; select and head load logic.

1) Spindle Drive Control: The disk drive spindle motor is controlled by a micro-switch that senses when the diskette is inserted and loaded, or unloaded. When the diskette is loaded, the disk is accelerated to a speed of 3ØØ RPM. After an appropriate delay to allow the speed to stabilize, the drive is ready to accept commands. If the drive is selected by the controller, the drive will indicate this state by asserting ready status.

2) Sector Logic: When the disk is rotating, the sector/index hole sensor provides the controller with an electrical pulse corresponding to each hole punched in the disk. The controller separates the sector and index pulses and counts the sector pulses, thereby providing the programmer with the 4 bit address of the sector currently passing under the read/write head. A flag bit in the status register is provided to indicate when the sector address is valid and when a read or write operation may be initiated.

3) Position Control Logic: The read/write head is mounted on a carriage which is moved from track to track by a stepper motor-driven lead screw. Positioning is accomplished by specifying the desired direction (in or out) and issuing a step command. Control logic in the drive electronics generates all the signals necessary to cause the motor to move a track in the desired direction. When a drive is first selected, such as at power on, the track position of the drive is indeterminate. Before read or write operations may be performed, the positioner must be recalibrated as follows: when the carriage is positioned at track Ø, a microswitch associated with the positioning mechanism is made. The state of this "track Ø" switch is provided as a status bit. Recalibration consists of examining the track Ø status and if it is not true, issuing a command to step out. After an appropriate delay to allow the command to be executed, the process is repeated. Once the positioner has been calibrated, the software must keep track of the current position.

4) Read/Write Logic: Data is transferred between the computer and the controller on a byte-by-byte basis. For write operations, the controller generates the preamble and then converts 8-bit byte data from the computer to the serial data which is recorded on the disk. When the computer stops supplying data, the controller automatically writes zero data to the rest of the sector until a sector pulse is sensed. For read operations, the controller converts the serial data stream coming from the disk to 8-bit bytes and automatically detects the sync byte to determine when valid data is available.

The controller generates a "transfer ready" status flag which indicates that the controller is ready to accept data in a write operation, or that data is available in a read operation.

The controller is accessed using a technique called "memory-mapped I/O". This means that the controller command, status and data registers are treated as memory addresses and that controller read/write commands are actually memory reference instructions. When the controller data register is accessed in a read or write operation, the controller forces the computer to wait until the controller is ready to transfer data. From the computer's point of view, the controller appears to be slow memory.

The read/write control logic in the drive electronics provides the conversion between the serial digital data at the controller interface and the serial data signals at the read/write head. Whenever the drive is performing a write operation, the positioner control and read logic is disabled and the appropriate signals are generated to drive the read/write and erase heads. The erase head used in flexible disk drives is a "trim" erase head. Old data written on a sector is implicitly erased by being written over by new data. However, any slight track positioning errors could cause sufficient remnant old data to be left in the space between tracks to cause data reliability problems. To eliminate this error source, an erase head which erases the disk a small distance on either side of the newly written data is provided. This erase head is located a small distance behind the read/write head and cleans up the inter-track gap after data is written.

When a write operation is terminated by the occurrence of a sector pulse, the erase head is left on a sufficient amount of time for the last data written to be trimmed. Since the position control and read logic will be inhibited until the write operation is complete (including the erase), a new operation must not be attempted for at least one millisecond after the termination of a write operation.

The drive contains a microswitch which senses the write protect cutout in the diskette jacket. When the write protect tab is installed, the write/erase control logic is inhibited. The state of the write protect switch is available as a status bit.

5) Select and Head Load Logic: The controller will support up to 4 disk drive units connected in a "daisy chain" configuration. The drive electronics in each unit are conditioned by the drive select such that only one drive at a time will respond to, or provide, signals on the controller/drive interface. When a drive is not selected, the spring-loaded pressure pad which holds the disk in contact with the read/write head is moved away so that there is no contact and the head is "unloaded". When the drive is selected, a solenoid is energized, which allows the load pad to contact the disk so read or write operations may be performed. The controller contains a 4-second timer which automatically deselects all units if the controller has not been accessed for four seconds.

6.3 CONTROLLER REGISTERS

The disk controller occupies a 1K byte block of memory from F4ØØH to F7FFH. The first half (F4ØØH to F5FFH) is reserved for on-board bootstrap ROM. The controller command, status and data registers start at address F6ØØH and are defined as follows:

1) Output Registers

Command Register

F6ØØH or
F6Ø1H

7	6	5	4	3	2	1	0
COMMAND CODE						MOD	

MOD = Command Modifier

The commands available are:

Code	Command	Modifier
ØØ1	Select drive	Contains drive unit address (Ø-3)

Ø1Ø	Set interrupt enable (controls sector pulse interrupt)	Ø1 = enable interrupt
		ØØ = disable interrupt

Ø11	Step 1 track	ØØ = step out
		Ø1 = step in

1ØØ	Enable write	Not used
1Ø1	Reset controller	Not used

Write Data Register

F6Ø2H — If the write data register is referenced when the transfer flag is set during a write operation, the controller expects a data byte to be on the S1ØØ buss data lines. The PRDY line will be held false until the controller has accepted the data, then the PRDY line will be set true for 1 bit time (4 usec). (See the status register description for the definition of the transfer flag.)

2) Input Registers

Sector Register

F6ØØH

7	6	5	4	3	2	1	Ø
SCTR. FLG.	INT. FLG.			SECTOR ADDRESS			

Bits	Definition
0-3	Sector Address: Address of the sector currently passing under the read/write head of the selected drive.
4,5	Reserved.
6	Sector Interrupt Flag: Indicates an interrupt request has been generated by a sector pulse. Flag is reset by issuing a reset or an interrupt disable command.
7	Sector Flag: Indicates the sector address is valid and that a read or write operation may be performed. Flag is true for 30 usec at the start of each sector. All data transfers must be initiated within 100 u seconds of the flag going true.

Status Register

F6Ø1H

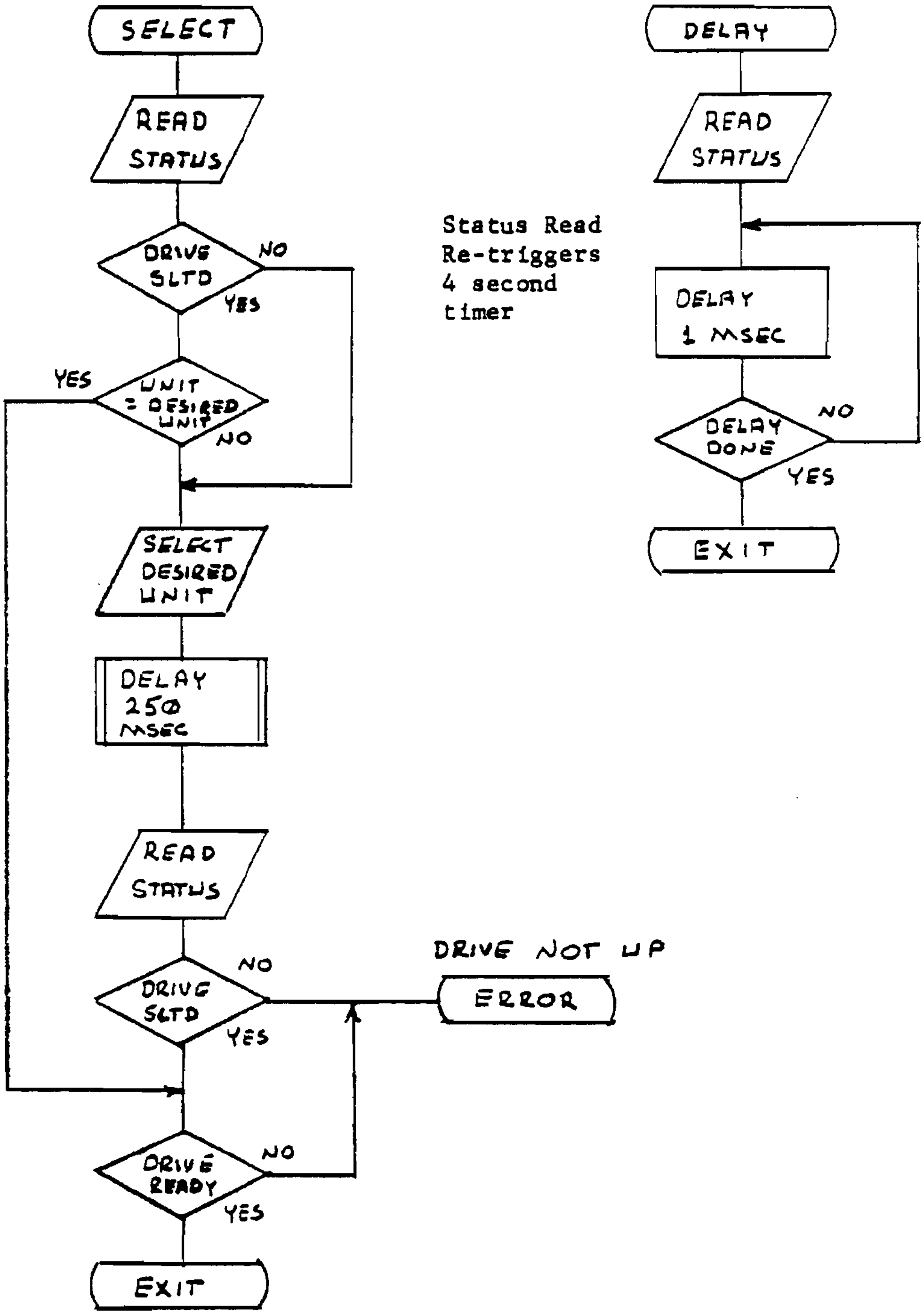
7	6	5	4	3	2	1	Ø
XFER. FLG.	PINTE	READY	WPT	TKØ	SLTD	UNIT	ADDR

Bits	Definition
Ø-1	Unit Address: Address of the currently selected drive. Address is valid only if SLTD is true.
2	SLTD: Unit selected. This flag is low true, i.e., Ø = Selected 1 = Not selected SLTD is true if a drive has been selected and the 4-second timer has not expired. SLTD is low true so that the software may detect when the controller is not installed (non-existent memory references yield ØFFH).
3	TKØ: Track Ø status from selected drive.
4	WPT: Write protected status from selected drive.
5	READY: Ready status from the selected drive. When true, indicates the drive is ready to perform commands.
6	PINTE: PINTE status from the S1ØØ BUSS.
7	XFER FLAG: Transfer flag. In write operations, indicates that the controller is ready to accept data from the computer. In read operations, indicates the controller has data available to the computer. When the software detects the transfer flag has set, all data transfers are performed by accessing the controller data register, which automatically synchronizes the transfer by use of the PRDY line.

Read Data Register

F6Ø2H If the read data register is accessed when the transfer flag is set during a read operation, the controller will hold the PRDY line false until a byte of data is available. The controller will then place the data on the S1ØØ BUSS data lines and set PRDY true for 1 bit time (4 usec). The data will only be available for this 1 bit time period.

Figure 6.4



DRIVE SELECT LOGIC

N MILLISECOND TIMER

Status Read Re-triggers 4 second timer

6.4 DISK OPERATIONS

The following paragraphs describe in detail the steps involved in performing each of the operations required to operate the Micropolis flexible disk drive subsystem.

6.4.1 Select a Drive

A drive must be selected prıor to any status read, step or data transfer operation. Selection must be performed for each operation since the 4 second timer may have deselected a unit since it was last accessed. The important considerations in selecting a drive are:

1) When the drive is selected, the head will be loaded. A minimum of 75 milliseconds must be allowed for the head to load and settle.

2) The sector counter is located in the controller. When a drive is selected, a minimum of 250 milliseconds must be allowed for the sector counter to synchronize to the drive.

Figure 6.4 is a flowchart of the select operation.

NOTE that all delays are generated by a software timing loop subroutine. A read status command is included to re-trigger the 4 second timer every time the delay routine is entered.

6.4.2 Position the Head

A drive must be selected before a step command can be issued to cause the head to move 1 track. One step command of the appropriate direction (in or out) must be issued for each track moved. A minimum delay of 30 milliseconds must be allowed between each step command. (Note a step in moves the head toward the center of the disk and therefore to a higher track number.) Typical logic to implement a 1 track step is illustrated in Figure 6.5.

After the head is positioned to the desired track, an extra delay must be allowed for the head to settle before read/write operations are attempted. The complete process for an N track move is illustrated in Figure 6.6.

6.4.3 Restore to Track Ø

When a drive is first selected, the position of the read/write head is indeterminate. Prior to performing disk data transfers, the positioner must be "recalibrated" which consists of stepping the head out until tne track Ø switch is made. If the drive already indicates track Ø status when first selected, the head is stepped in 8 tracks, then out to ensure a good track Ø position. Once calibrated, the software must keep track of the current head position for each drive. The restore logic recommended is illustrated in Figure 6.7.

Figure 6.5

STEP 1 TRACK

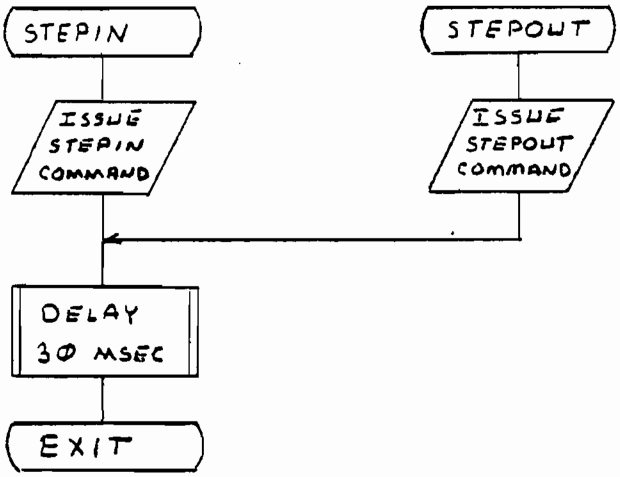


Figure 6.6

POSITION N TRACKS

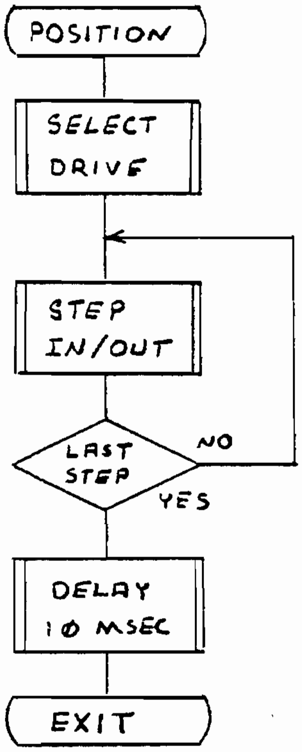
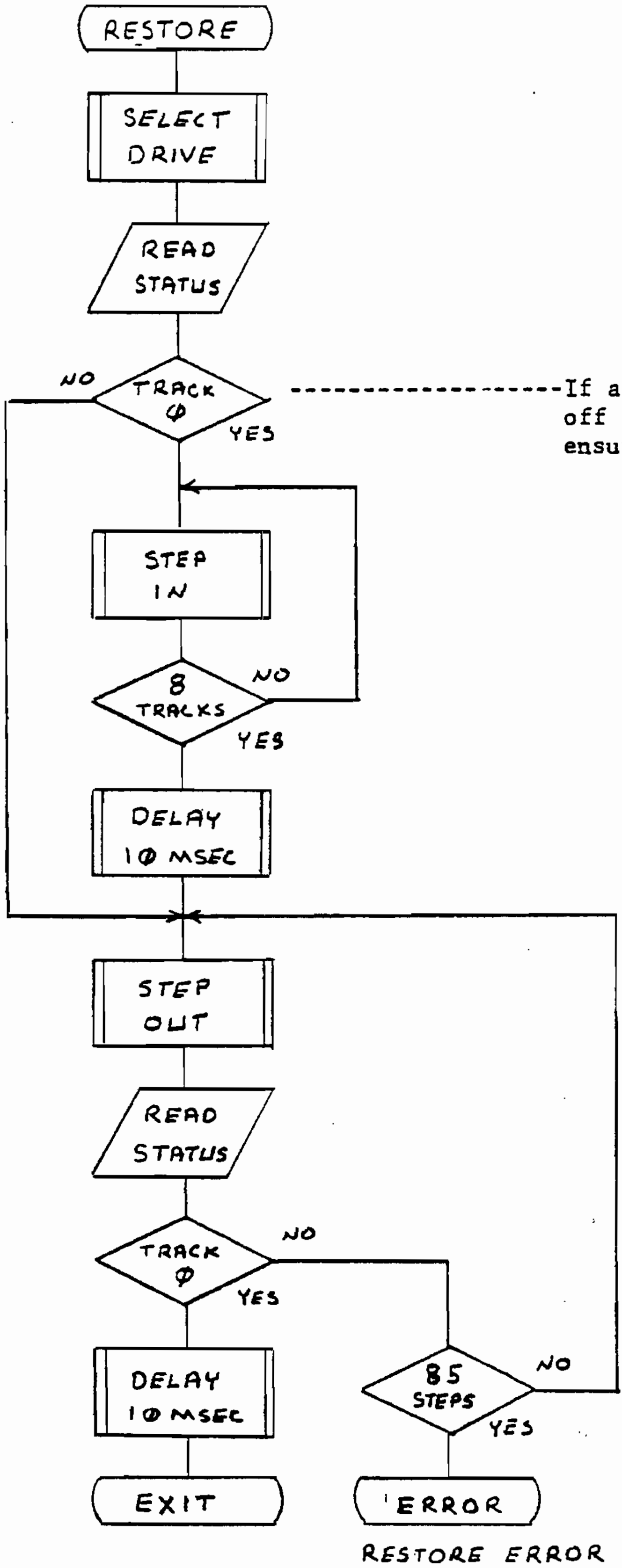


Figure 6.7 RESTORE TO TRACK Ø



If already at track Ø, move off 8 tracks then restore to ensure a good position.

If 85 step out commands have been given and track Ø has not been reached, something is wrong.

6.4.4 Write Operation

Figure 6.8 illustrates the logic necessary to perform a sector write operation. The program illustrated requires a 268 byte memory buffer with the first two bytes set to the track and sector address. The sync byte and checksum are generated in the program. The steps involved in writing a sector are:

1) Move the data to the write buffer.

2) Select the drive.

3) Wait for sector flag. When the flag goes true compare the sector address with the desired sector address. When the desired sector is found, issue an enable write command.

4) The enable write command causes the controller to generate the preamble. Wait for transfer ready flag to indicate the controller is ready to receive data. The software must then write the sync byte. The timing of the software loop which tests for XFER ready and then outputs the sync byte is extremely critical. The sync byte must be on the S1ØØ buss data lines within 32 usec after XFER ready sets. The following code satisfies the timing requirements:

   (HL = F6Ø1H and A = Ø when this loop is entered)

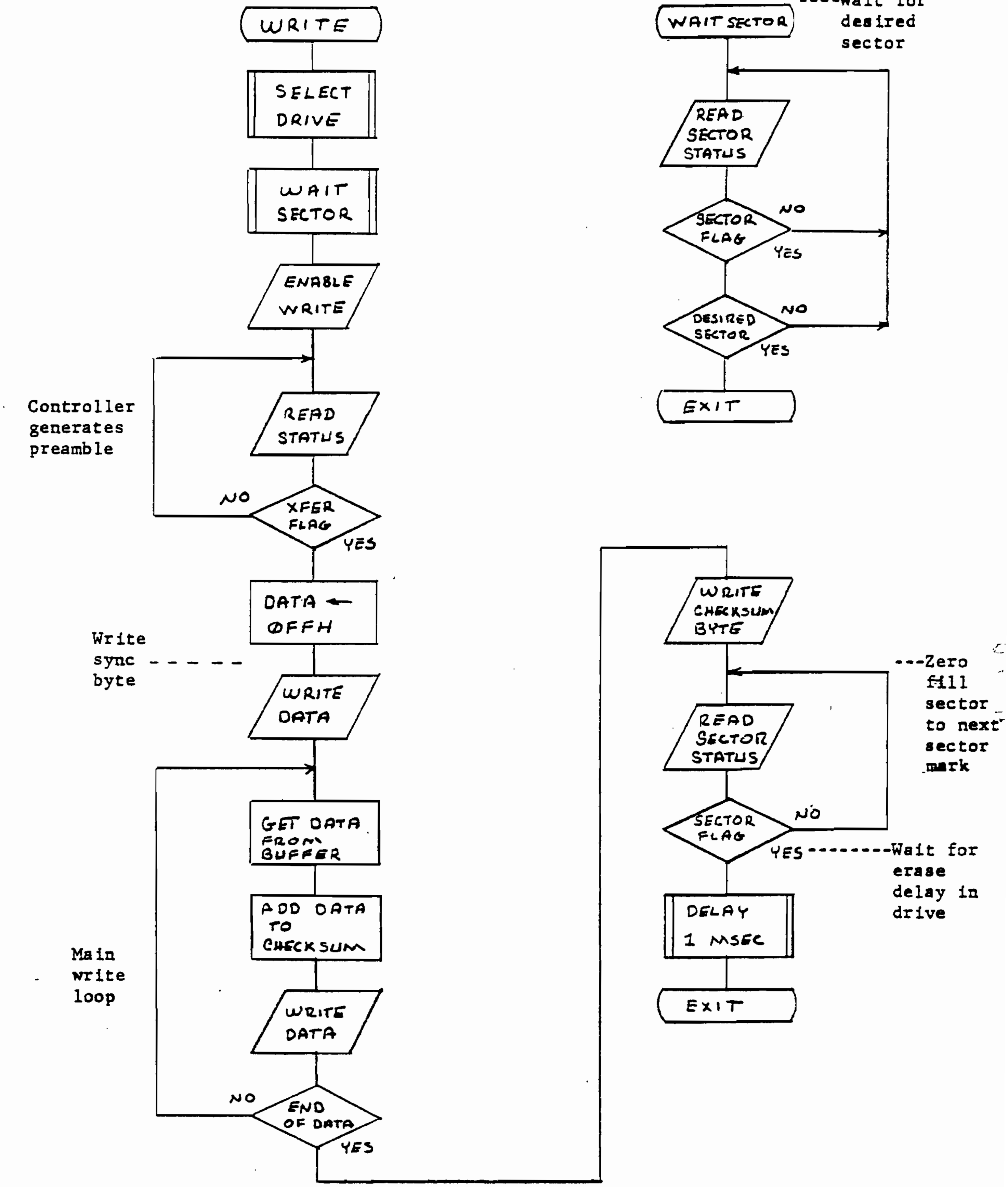
```
*Wait for XFER ready flag

WAIT  ORA M
      JP WAIT
*INSERT SYNC BYTE
      INX  H
      MVI M, ØFFH
```

5) Each successive data byte must be made available within 32 useconds of the previous byte. When the data register is accessed, the controller will hold PRDY false until it accepts the data and then allow PRDY to go true for 1 bit time. The timing constraints on the write loop are therefore a maximum loop time of 32 useconds and a minimum loop time of 1 bit time (4 useconds). These figures do not include any margin for clock tolerance, so the actual design goals should be about 28 and 6 useconds for a conservative design.

6) When the checksum has been written, stop accessing the controller write register. The controller will automatically zero fill the rest of the sector.

7) After the checksum is written, the program waits for the next sector flag. At this time the controller terminates the write operation and the erase delay in the drive starts. The 1 millisecond software delay allows sufficient time for the erase delay to expire so that step and read functions are again enabled.

Figure 6.8 SECTOR WRITE



Controller generates preamble

Write sync byte

Main write loop

----Wait for desired sector

---Zero fill sector to next sector mark

--------Wait for erase delay in drive

6.4.5 Read Operation

Figure 6.9 illustrates the logic necessary to perform a sector read operation. The program illustrated requires a 268 byte read buffer. The track/sector ID will be read into the first two bytes of the buffer and when the operation is complete, will be compared against the desired track/sector address. The steps involved in reading a sector are:

1) Select the drive.

2) Wait for the sector flag. When the sector flag is true, compare the sector address with the desired sector.

3) When the desired sector is found, wait for the transfer flag to set to indicate disk data is available. Note that no command is necessary to start a read operation, but you must always wait for a sector flag to indicate the start of the read.

4) When the transfer flag is set, the sync byte will be available in 25-28 useconds. The sync byte will only be available for 3-4 useconds so the timing of the loop which checks for the transfer ready flag is critical. The following code satisfies the timing requirements:

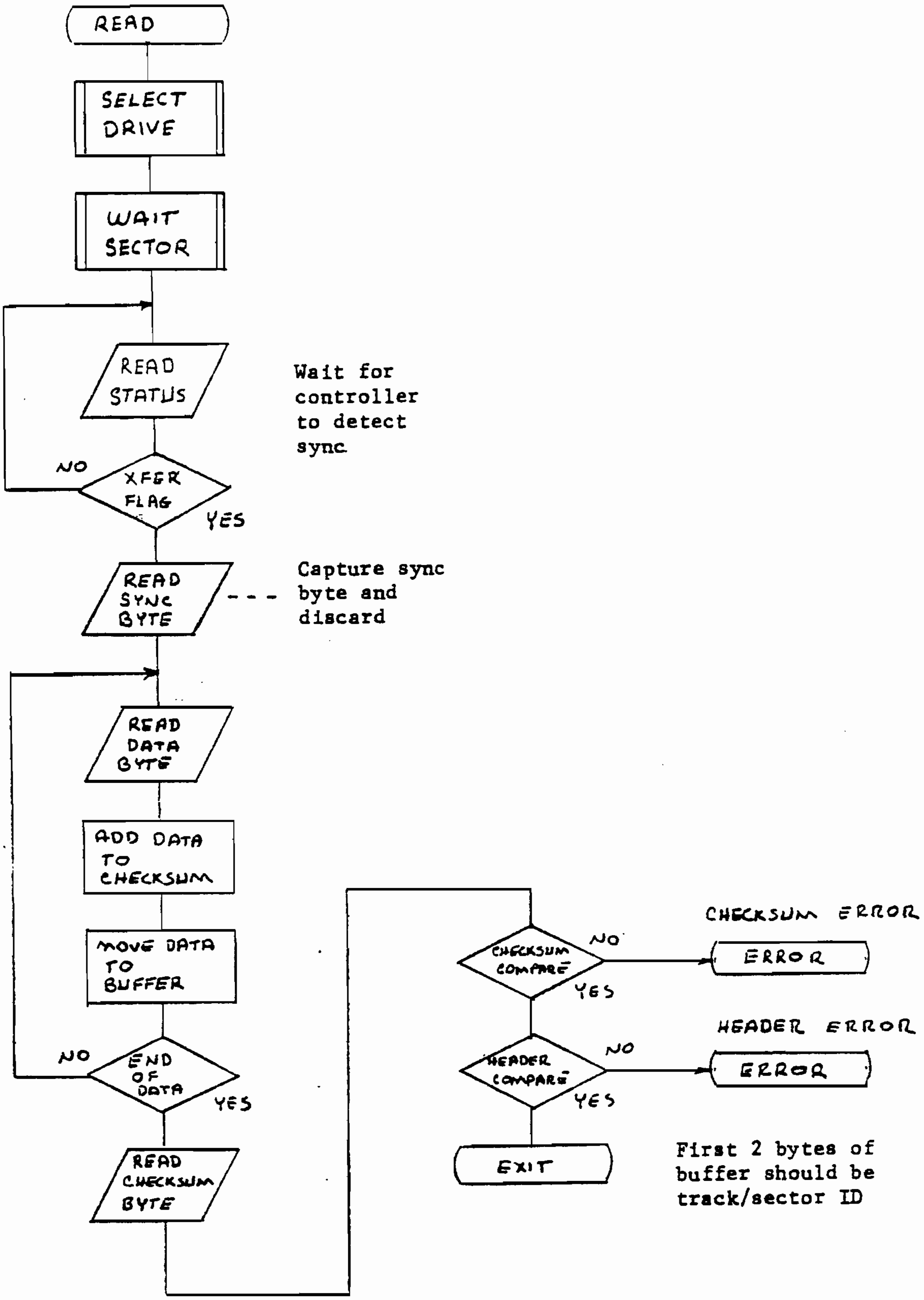
   (HL = F6Ø1H and A = Ø when this loop is entered)

   ```
   * Wait for XFER RDY flag

   WAIT    ORA M
           JP WAIT
   *GOBBLE SYNC BYTE
           INX H
           MOV A,M
   ```

5) Each successive data byte will be available within approximately 25 useconds and will be available for about 3 useconds. When the controller data register is accessed, the controller will hold PRDY false until the data is ready, then will place the data on the S1ØØ buss data lines and allow PRDY to go true for 1 bit time. Once the software has read a byte, it must not access the data register again until this bit time has expired. The timing constraints on the read loop are therefore a maximum loop time of 25 useconds and a minimum loop time of 5-6 useconds. These figures reflect a conservative margin to allow for timing variations in the disk read data.

6) The last byte to be read from the disk is the checksum. The checksum read should be compared with the re-computed checksum, to determine if a read error has occurred.

Figure 6.9 SECTOR READ



Wait for controller to detect sync

Capture sync byte and discard

First 2 bytes of buffer should be track/sector ID

7) If no checksum error is detected, the first two bytes read should be compared with the desired track and sector addresses to ensure the correct sector was read.

6.5 ERROR HANDLING

An important consideration which may not be ignored in the design of a flexible disk driver is the handling of errors which occur. Magnetic storage devices in general are subject to errors. The succeptability of the diskette to damage or contamination due to handling makes error handling particularly important in flexible disk systems. Most errors are of a temporary nature and will be invisible to the system with a properly designed driver.

Most errors can be attributed to one or more of the following sources:

1) Transient Electrical Noise

2) Media Contamination - Particles of foreign substances may become lodged between the head and the recording surface of the disk and cause data errors.

3) Head Positioning - The read write head may be positioned to the wrong track if the specified step rate is exceeded or may be marginally positioned if a drive is misadjusted.

4) Disk Centering - Due to the flexible material of which the disk is constructed, or in the event the disk is damaged or distorted due to mis-handling, it is possible that a diskette may be improperly clamped to the spindle in the disk drive.

The following procedures are recommended to perform proper error handling in disk read/write operations:

Read Operations

1) Step the positioner to the desired track.

2) Perform the read operation as described in Section 6.9.5. If a header or checksum error occurs, re-read the sector up to 5 times.

3) If the 5 retrys were unsuccessful, step the positioner off one track and then back to the desired track. Repeat Step 2. If still unsuccessful, step the positioner off one track in the other direction and then back. Repeat Step 2.

4) Perform the restep procedure given in Step 3 up to 4 times. If still unsuccessful, deselect the unit and wait about 200 milliseconds for the head to unload. Reselect the unit, restore to track Ø, and re-seek to the desired track. Repeat Steps 2 and 3.

5) Perform the reselect function given in Step 4 up to 3 times. If still unsuccessful, abort the operation with a permanent I/O error.

Write Operation

1) Step the positioner to the desired track.

2) Read the sector immediately preceding the desired sector. Any errors which occur should be handled in the manner described for normal read operations. This operation ensures the head is properly positioned to the right track and the sector counter is synchronized with the disk.

3) Write the desired sector as described in Section 6.4.4.

4) Read the sector just written to ensure the data was recorded properly. If an error occurs, repeat Steps 2, 3, and 4 up to 5 times.

5) If unsuccessful, perform the restep operation as described for the read operation and repeat Steps 2, 3, and 4.

6) If 4 restep operations are unsuccessful, perform the reselect operation as described for the read operation.

7) If 3 reselect operations are unsuccessful, abort the operation with a permanent I/O error.

If a permanent I/O error occurs, the disk may be improperly centered, there may be a defect in or damage to the recording surface of the disk, or the disk may have been written on a marginal drive.

The "restep" procedure described takes advantage of the hysteresis present in all positioning systems. Friction in the positioner causes the head position to deviate slightly from the nominal track position. This position will be different when the head is stepped to a track from different directions. In normal operations, this slight position error is well within the tolerance limits for proper operations. However, if errors are encountered in reading a disk which was written on another drive that is marginally aligned, the slight difference may be enough to recover the data.

The "reselect" procedure serves to dislodge any foreign particles and to recalibrate the positioner, should it be positioned to the wrong track.

6.6 DISK DRIVER

As a comprehensive example of all the principles presented in this section, a sample disk driver is presented here. This driver provides the facilities to seek to a track, seek and read a sector, seek and write a sector, and seek and verify a sector. This verify operation is a special case of a sector read but only the header bytes are transferred into the buffer. This allows the use of a single disk buffer to perform write operations, which consist of a header check prior to write, writing the sector, and a read-after-write check.

The power-on recalibration is transparent. The driver maintains a table containing the current track address of each drive connected to the controller. The user's power on initialize software must set the entries in this table to ØFFH. The first time a drive is accessed, the driver will recognize this flag and recalibrate the positioner on the drive before performing the specified operation.

When the driver is called, the HL register must point to a parameter block (referred to as a disk control block) which specifies the operation to be performed. When the driver returns, the condition code will reflect the status of the operation. (See the listing for details.)

The DCB is structured as follows:

ADDRESS	7	6	5	4	3	2	1	Ø
DCB + Ø							FN CODE	
DCB + 1	ID FLAG	RAW FLAG					UNIT ADDR.	
DCB + 2	SECTOR ADDRESS							
DCB + 3	TRACK ADDRESS							
DCB + 4	BUFFER ADDRESS						LSB	
DCB + 5	BUFFER ADDRESS						MSB	

The DCB entries are described as follows:

FN CODE Function code
Ø = Seek only
1 = Seek and read sector
2 = Seek and write sector
3 = Seek and verify sector

ID FLAG Pre-Write Header (ID) Check Flag
Ø = Perform check
1 = Inhibit check

RAW FLAG Read-After-Write Check Flag
Ø = Perform check
1 = Inhibit check

UNIT ADDR. Drive Unit Address
Ø - 3

Sector and Track Address are the address of the sector which is to be written or read and the address of the track upon which the sector resides. The driver will seek as necessary to move the head to the desired track.

The Buffer Address is a 16 bit memory address stored in standard 8080 low/high format. This must be the address of a 268 byte read/write buffer. The first two bytes of the buffer are reserved for the header.

To perform a write operation, move the data to the read/write buffer, set up the DCB, and call the driver.

To perform a read operation, set up the DCB and call the driver. When the operation is complete, the data from the desired sector will be in the read buffer.

```
****************************************
*                                      *
*      DISK DRIVER FOR MICROPOLIS      *
*      FLEXIBLE DISK SUBSYSTEM         *
*                                      *
*  COPYRIGHT MICROPOLIS CORPORATION    *
*      8 JUNE 1977                     *
*                                      *
****************************************
*
*
* 1)    CALLING SEQUENCE:
*
*       LXI  H,UDCB     POINT HL TO USER
*       CALL DSKIO      DCB & PERFORM
*       JNZ  ERROR      OPERATION
*
*       UDCB IS THE USER'S DISK CONTROL
*       BLOCK WHICH DEFINES THE OPERATION
*       TO BE PERFORMED AND IS STRUCTURED
*       AS FOLLOWS:
*
*       UDCB+Ø FUNCTION CODE
*            Ø  SEEK TRACK ONLY
*            1  SEEK AND READ SECTOR
*            2  SEEK AND WRITE SECTOR
*            3  SEEK AND VERIFY SECTOR
*
*       WRITE OPERATIONS CONSIST OF:
*       1) VERIFY THE TRACK/SECTOR ID
*          IN THE SECTOR IMMEDIATELY
*          PRECEEDING THE DESIRED SECTOR
*       2) PERFORM THE WRITE OPERATION
*       3) THE SECTOR WRITTEN IS THEN
*          VERIFIED BY A READ-AFTER-WRITE
*          CHECKSUM READ
*       NOTE:THE ID CHECK AND READ AFTER
*       WRITE CHECKS CAN BE OVERRIDDEN
*       BY CONTROL FLAGS IN UDCB+1
*       FOR WRITING ON UNFORMATTED DISKS
*
*       UDCB+1  CONTROL FLAGS/UNIT SELECT
*           BIT   FUNCTION
*            Ø-1  UNIT ADDRESS
*            6    READ-AFTER-WRITE CHECK
*                 CONTROL:Ø=PERFORM,
*                 1=INHIBIT
*            7    PRE-WRITE ID CHECK
*                 CONTROL: Ø=PERFORM,
*                 1=INHIBIT
*       UDCB+2   SECTOR ADDRESS (Ø-15)
*       UDCB+3   TRACK ADDRESS (Ø-76)(34)
*       UDCB+4&5 BUFFER ADDRESS
*            BUFFER ADDRESS IS THE START
*            ADDRESS OF THE READ/WRITE
*            BUFFER TO BE USED IN
*            PERFORMING THE OPERATION.
```

```
           *          ALL OPERATIONS
           *          REQUIRE A 268 BYTE BUFFER
           *          ORGANIZED AS FOLLOWS:
           *          BYTE Ø -- TRACK ID
           *          BYTE 1 -- SECTOR ID
           *          BYTE 2-267 -- DATA
           *
           *          BYTES Ø AND 1 ARE FILLED
           *          IN AS NECESSARY BY THE
           *          DRIVER
           *
           * 2) THE DISK I/O DRIVER RETURNS WITH
           *    THE CONDITION CODE SET TO Z IF
           *    THE OPERATION WAS SUCCESSFUL AND
           *    NZ IF AN ERROR OCCURRED.  THE
           *    A REGISTER WILL CONTAIN AN ERROR
           *    CODE AS FOLLOWS:
           *      1 -- PERMANENT I/O ERROR - AN
           *           UNRECOVERABLE DISK ERROR
           *           OCCURRED
           *      2 -- PARAMETER ERROR - ONE OF THE
           *           PARAMETERS IN THE DCB IS
           *           INVALID
           *      3 -- DRIVE NOT UP - THE SELECTED
           *           DRIVE IS NOT READY
           *      4 -- WRITE PROTECT - THE SELECTED
           *           DRIVE IS WRITE PROTECTED AND
           *           A WRITE OPERATION WAS
           *           SPECIFIED
           * 3) INITIALIZATION REQUIREMENTS:
           *
           *      1) THE DRIVER CONTAINS A TABLE
           *      LABLED "TRACK" WHICH CONTAINS
           *      THE CURRENT TRACK POSITION FOR
           *      EACH DRIVE CONNEXTED TO THE
           *      CONTROLLER.  EACH ENTRY MUST BE
           *      INITIALIZED TO FFH TO CAUSE THE
           *      TRACK POSITION OF EACH DRIVE TO
           *      BE RE-CALIBRATED THE FIRST TIME
           *      IT IS ACCESSED
           *
           *      2) THE PARAMETER LABELED "TRKMX"
           *      MUST BE SET TO THE HIGHEST
           *      TRACK ADDRESS WHICH IS 76 FOR
           *      MOD II SUBSYSTEMS AND 34 FOR
           *      MOD I SUBSYSTEMS
           *
           *      3) THE 16 BIT PARAMETER LABELED
           *      "DADR"MUST BE SET TO THE ADDRESS
           *      OF THE DISK CONTROLLER WHICH IS
           *      THE BOOT PROM ADDRESS+2ØØH
           *
           *
           *
ØØØ                   ORG  X'4ØØ'
           *
4ØØ F3     DSKIO      DI
```

```
Ø4Ø1 C5             PUSH B         SAVE REGISTERS
Ø4Ø2 D5             PUSH D
Ø4Ø3 E5             PUSH H
Ø4Ø4 21ØØØØ         LXI  H,Ø       SAVE STACK POINTER
Ø4Ø7 39             DAD  SP
Ø4Ø8 22Ø8Ø7         SHLD STACK
Ø4ØB E1             POP  H         GET POINTER TO
Ø4ØC E5             PUSH H         USER'S DCB
Ø4ØD 11F5Ø6         LXI  D,DCB     COPY USER DCB TO
Ø41Ø Ø6Ø6           MVI  B,DCBLEN  INTERNAL DCB
Ø412 7E      DSØ1Ø  MOV  A,M
Ø413 12             STAX D
Ø414 23             INX  H
Ø415 13             INX  D
Ø416 Ø5             DCR  B
Ø417 C212Ø4         JNZ  DSØ1Ø
            *
            *       VALIDATE DCB PARAMETERS
            *
Ø41A 21F5Ø6         LXI  H,DCB     FUNCTION MUST BE
Ø41D 7E             MOV  A,M       3 OR LESS
Ø41E FEØ4           CPI  4
Ø42Ø D2D2Ø5         JNC  PARMER    PARAMETER ERROR
Ø423 23             INX  H
Ø424 7E             MOV  A,M       UNIT ADDRESS MUST
Ø425 E63F           ANI  X'3F'     BE LESS THAN 4
Ø427 FEØ4           CPI  4
Ø429 D2D2Ø5         JNC  PARMER
Ø42C 23             INX  H
Ø42D 7E             MOV  A,M       SECTOR MUST BE
Ø42E FE1Ø           CPI  16        15 OR LESS
Ø43Ø D2D2Ø5         JNC  PARMER
Ø433 23             INX  H
Ø434 3AFBØ6         LDA  TRKMX     TRACK MUST BE LESS
Ø437 96             SUB  M         THAN OR EQUAL TO
Ø438 FAD2Ø5         JM   PARMER    MAX TRACK
            *
            *       ENSURE DRIVE IS OPERATIONAL
            *
Ø43B CDE4Ø5         CALL SLCT
            *
            *       SEEK TO DESIRED TRACK
            *
Ø43E CDD5Ø4         CALL SEEK
            *
            *       GET FUNCTION PARAMETER FROM DCB
            *       AND PERFORM ANY OTHER REQUIRED
            *       FUNCTION
            *
Ø441 3AF5Ø6         LDA  DCBFN     DONE IF FUNCT=
Ø444 B7             ORA  A         SEEK ONLY(Ø)
Ø445 CACCØ4         JZ   DS1ØØ     DONE
            *
            *       PERFORM READ/WRITE FUNCTION
            *
            *
            *       RETRY CONTROL FOR READ/WRITE
```

```
                  *      OPERATIONS:
                  *      A 3 LEVEL RETRY STRUCTURE IS
                  *      PROVIDED AS FOLLOWS:
                  *      1 -- IF AN ERROR OCCURS,UP TO 5
                  *      RETRYS OF THE OFFENDING OPERATION
                  *      WILL BE PERFORMED
                  *      2-- IF THE LEVEL 1 RETRYS ARE NOT
                  *      SUCCESSFUL,THE POSITIONER WILL
                  *      BE STEPPED OFF TRACK AND BACK
                  *      AND THE LEVEL 1 RETRYS WILL BE
                  *      PERFORMED. THE LEVEL 2 RETRYS
                  *      WILL BE PERFORMED UP TO 4 TIMES
                  *      3 -- IF THE LEVEL 2 RETRY
                  *      PROCEDURE IS NOT SUCCESSFUL,THE
                  *      UNIT WILL BE DESELECTED TO UNLOAD
                  *      THE HEAD THEN THE UNIT WILL BE
                  *      RESELECTED,THE POSITIONER WILL
                  *      BE RECALIBRATED AND MOVED BACK
                  *      TO THE DESIRED TRACK AND THE
                  *      LEVEL 1 AND 2 RETRY PROCEDURES
                  *      WILL BE PERFORMED. THIS WILL BE
                  *      DONE UP TO 3 TIMES.IF NOT
                  *      SUCCESSFUL,A PERMANENT I/O
                  *      ERROR WILL RESULT
                  *
Ø448 3EØ3   DSØ2Ø MVI  A,3         PRESET RETRY
Ø44A 32Ø6Ø7       STA  L3RTRY      COUNTERS
Ø44D 3EØ4   DSØ3Ø MVI  A,4
Ø44F 32Ø5Ø7       STA  L2RTRY
Ø452 3EØ5   DSØ4Ø MVI  A,5
Ø454 32Ø4Ø7       STA  L1RTRY
                  *
                  *      SELECT DESIRED FUNCTION AND
                  *      PERFORM
                  *
Ø457 2AF9Ø6 DSØ5Ø LHLD DCBAD       PRESET BUFFER
Ø45A 22ØØØ7       SHLD BUFADR      ADDRESS
Ø45D 3AF5Ø6       LDA  DCBFN       GET FUNCTION
Ø46Ø 3D           DCR  A
Ø461 C26AØ4       JNZ  DSØ6Ø
                  *
                  *      READ SECTOR
                  *
Ø464 CD81Ø6       CALL READAL      READ SECTOR
Ø467 C3A2Ø4       JMP  DSØ9Ø       CHECK FOR ERROR
Ø46A 3D     DSØ6Ø DCR  A
Ø46B C297Ø4       JNZ  DSØ8Ø
                  *
                  *      WRITE SECTOR
                  *
Ø46E 3AF6Ø6       LDA  DCBUN       IF HEADER CHECK
Ø471 E68Ø         ANI  HCI         INHIBIT SET GO
Ø473 C283Ø4       JNZ  DSØ7Ø       WRITE
Ø476 3AF7Ø6       LDA  DCBSC       BACKSPACE SECTOR
Ø479 3D           DCR  A           COUNT MOD 16
Ø47A E6ØF         ANI  X'ØF'
Ø47C 47           MOV  B,A
```

```
Ø47D CDB1Ø6        CALL READCK    DO PRE-WRITE HDR
Ø48Ø C2A2Ø4        JNZ  DSØ9Ø     CHECK - ABORT ERR
Ø483 CD2FØ6 DSØ7Ø  CALL WSECT     GO WRITE
Ø486 3AF7Ø6        LDA  DCBSC     DO RAW CHECKSUM
Ø489 47            MOV  B,A       READ CHECK
Ø48A 3AF6Ø6        LDA  DCBUN     UNLESS INHIBITED
Ø48D E64Ø          ANI  RAFI
Ø48F EE4Ø          XRI  RAFI
Ø491 C4B1Ø6        CNZ  READCK
Ø494 C3A2Ø4        JMP  DSØ9Ø     GO CHECK FOR ERR
Ø497 3D     DSØ8Ø  DCR  A
Ø498 C2D2Ø5        JNZ  PARMER    TRAP-JUST IN CASE
            *
            *      VERIFY SECTOR
            *
Ø49B 3AF7Ø6        LDA  DCBSC
Ø49E 47            MOV  B,A
Ø49F CDB1Ø6        CALL READCK    DO CHECKSUM READ
            *
            *      CHECK FOR ERROR
            *
Ø4A2 CACCØ4 DSØ9Ø  JZ   DS1ØØ     NO ERROR-EXIT
Ø4A5 3AØ4Ø7        LDA  L1RTRY    LEVEL 1 -- RETRY
Ø4A8 3D            DCR  A         UP TO 5 TIMES
Ø4A9 32Ø4Ø7        STA  L1RTRY
Ø4AC C257Ø4        JNZ  DSØ5Ø
            *
            *      RETRIED 5 TIMES - STEP OFF TRACK
            *      AND BACK AND REPEAT
            *
Ø4AF CD36Ø5        CALL RESTEP
Ø4B2 3AØ5Ø7        LDA  L2RTRY    PERFORM UP TO 4
Ø4B5 3D            DCR  A         TIMES
Ø4B6 32Ø5Ø7        STA  L2RTRY
Ø4B9 C252Ø4        JNZ  DSØ4Ø
            *
            *      STEPPED OFF 4 TIMES - DESELECT
            *      DRIVE TO UNLOAD HEAD THEN
            *      SELECT,RESTORE AND RE-SEEK
            *
Ø4BC CD63Ø5        CALL RESLCT
Ø4BF 3AØ6Ø7        LDA  L3RTRY    PERFORM UP TO 3
Ø4C2 3D            DCR  A         TIMES
Ø4C3 32Ø6Ø7        STA  L3RTRY
Ø4C6 C24DØ4        JNZ  DSØ3Ø
            *
            *      UNSUCCESSFUL -- ABORT WITH
            *      PERMANENT I/O ERROR
            *
Ø4C9 C3CCØ5        JMP  PERMER
            *
            *      END OF OPERATION
            *
Ø4CC 2AØ8Ø7 DS1ØØ  LHLD STACK     RESTORE STACK PTR
Ø4CF F9            SPHL
Ø4DØ E1            POP  H         RESTORE REGISTERS
Ø4D1 D1            POP  D
```

```
Ø4D2 C1              POP   B
Ø4D3 ØØ      EIADR   NOP              SPACE FOR EI
Ø4D4 C9              RET
             *
             *
             *       SEEK TO DESIRED TRACK
             *
Ø4D5 CDE4Ø5  SEEK    CALL  SLCT       ENSURE DRIVE SLTD
Ø4D8 E5              PUSH  H          AND READY
Ø4D9 CDBDØ5          CALL  LDTRK      POINT HL TO TRACK
Ø4DC 3EFF            MVI   A,X'FF'    SEE IF DRIVE HAS
Ø4DE BE              CMP   M          BEEN INITIALIZED
Ø4DF C2E5Ø4          JNZ   SEEK1      YES-CONTINUE
Ø4E2 CD79Ø5          CALL  RESTOR     CALIBRATE POSITION
Ø4E5 3AF8Ø6  SEEK1   LDA   DCBTK      GET TRACK FROM DCB
Ø4E8 4F              MOV   C,A        SAVE IN C
Ø4E9 96              SUB   M          ALREADY AT TRACK?
Ø4EA CAØ4Ø5          JZ    SEEKR      YES-RETURN
             *
             *       NOT AT TRACK -- ISSUE THE
             *       APPROPRIATE NUMBER OF STEPS TO
             *       MOVE TO THE DESIRED TRACK
             *
Ø4ED FAFAØ4          JM    SEKOUT
Ø4FØ CDØ7Ø5  SEKIN   CALL  STEPIN
Ø4F3 3D              DCR   A
Ø4F4 C2FØØ4          JNZ   SEKIN
Ø4F7 C3Ø1Ø5          JMP   SEEKR1
Ø4FA CD1DØ5  SEKOUT  CALL  STPOUT
Ø4FD 3C              INR   A
Ø4FE C2FAØ4          JNZ   SEKOUT
Ø5Ø1 CD2DØ5  SEEKR1  CALL  SETTLE     WAIT HEAD SETTLE
Ø5Ø4 71      SEEKR   MOV   M,C        STORE TRACK
Ø5Ø5 E1              POP   H
Ø5Ø6 C9              RET
             *
             *       STEP POSITIONER IN 1 TRACK
             *
Ø5Ø7 F5      STEPIN  PUSH  PSW
Ø5Ø8 D5              PUSH  D
Ø5Ø9 E5              PUSH  H
Ø5ØA AF              XRA   A          SET DIRECTION FLAG
Ø5ØB 32Ø7Ø7          STA   DIRCTN
Ø5ØE 2AØ2Ø7          LHLD  DADR       STEP IN  ONE TRK
Ø511 3661            MVI   M,STEP+1
Ø513 111EØØ  STP1    LXI   D,3Ø       WAIT STEP TIME
Ø516 CD17Ø6          CALL  TIMER
Ø519 E1              POP   H
Ø51A D1              POP   D
Ø51B F1              POP   PSW
Ø51C C9              RET

             *
             *       STEP POSITIONER OUT 1 TRACK
             *
Ø51D F5      STPOUT  PUSH  PSW
Ø51E D5              PUSH  D
```

```
Ø51F E5             PUSH H
Ø52Ø 3EFF           MVI  A,X'FF'  SET DIRECTION FLAG
Ø522 32Ø7Ø7         STA  DIRCTN
Ø525 2AØ2Ø7         LHLD DADR
Ø528 366Ø           MVI  M,STEP    STEP OUT ONE TRK
Ø52A C313Ø5         JMP  STP1      GO WAIT STEP TIME
            *
            *
            *      WAIT HEAD SETTLE TIME
            *
Ø52D D5     SETTLE  PUSH D
Ø52E 11ØAØØ         LXI  D,1Ø      1Ø MILLISECONDS
Ø531 CD17Ø6         CALL TIMER
Ø534 D1             POP  D
Ø535 C9             RET
            *
            * STEP OFF TRACK ONE AND BACK TO CORRECT
            *  POSSIBLE MARGINAL TRACK POSITION
            *  OF DRIVE WHICH WROTE THE DISK
            * IF TRACK Ø SUBSTITUTE RESTOR
            *
Ø536 CDBDØ5 RESTEP  CALL LDTRK     GET CRNT TRK ADDR
Ø539 7E             MOV  A,M       GET CRNT TRK
Ø53A B7             ORA  A
Ø53B C242Ø5         JNZ  RSTPA
Ø53E CD79Ø5         CALL RESTOR    USE RESTOR IF TK Ø
Ø541 C9             RET
Ø542 3AØ7Ø7 RSTPA   LDA  DIRCTN
Ø545 B7             ORA  A
Ø546 C256Ø5         JNZ  RSTPB
Ø549 CDØ7Ø5         CALL STEPIN
Ø54C CD2DØ5         CALL SETTLE
Ø54F CD1DØ5         CALL STPOUT
Ø552 CD2DØ5         CALL SETTLE
Ø555 C9             RET
Ø556 CD1DØ5 RSTPB   CALL STPOUT
Ø559 CD2DØ5         CALL SETTLE
Ø55C CDØ7Ø5         CALL STEPIN
Ø55F CD2DØ5         CALL SETTLE
Ø562 C9             RET
            *
            * RETRY ROUTINE TO RESTORE TO Ø THEN
            * LIFT HEAD, LOWER HEAD AND RESEEK
            *
Ø563 E5     RESLCT  PUSH H
Ø564 2AØ2Ø7         LHLD DADR
Ø567 36AØ           MVI  M,RESET   RESET CONTROLLER
Ø569 11C8ØØ         LXI  D,2ØØ
Ø56C CD17Ø6         CALL TIMER
Ø56F CDE4Ø5         CALL SLCT      RESELECT,LOWR HEAD
Ø572 E1             POP  H
Ø573 CD79Ø5         CALL RESTOR
Ø576 C3D5Ø4         JMP  SEEK      GO RE-SEEK
            *
            *      RESTORE POSITIONER TO TRACK Ø
            *      POSITIONER MUST BE STEPPED OUT
            *      UNTIL THE TRACK Ø SWITCH IS MADE
```

```
              *       TO CALIBRATE TRACK POSITION
              *
 79 E5        RESTOR PUSH H
 7A C5               PUSH B
57B CDBDØ5           CALL LDTRK       POINT HL TO TRACK
57E 36FF             MVI  M,X'FF'     PRESET TO BAD TRK
58Ø CD88Ø5           CALL RESTR1      RESTORE TO TK Ø
583 36ØØ             MVI  M,Ø         SET TRACK=Ø
585 C1               POP  B
586 E1               POP  H
587 C9               RET
              *
              *       RESTORE TO TK Ø
              *
588 E5        RESTR1 PUSH H
589 CDE4Ø5           CALL SLCT        ENSURE UNIT SLCTD
58C D5               PUSH D           AND READY
58D C5               PUSH B
58E 2AØ2Ø7           LHLD DADR        POINT TO STATUS
591 23               INX  H           BYTE
592 7E               MOV  A,M         ALREADY AT
593 E6Ø8             ANI  TKØ         TRACK Ø ?
595 CAA4Ø5           JZ   REST3       NO - PRESS ON
              *
              * ALREADY AT TRACK Ø - STEP
              * IN 8 TIMES THEN RESTORE
              * TO ENSURE GOOD POSITION
              *
Ø598 3EØ8            MVI  A,8
Ø59A CDØ7Ø5   REST2  CALL STEPIN      STEP IN 8
Ø59D 3D              DCR  A           TRACKS
Ø59E C29AØ5          JNZ  REST2
Ø5A1 CD2DØ5          CALL SETTLE      WAIT SETTLE TIME
              *
              * STEP OUT UNTIL TRACK Ø SWITCH
              * IS ACTUATED OR UNTIL 85 STEPS
              * HAVE BEEN ISSUED SO THAT WE
              * DONT BANG AGAINST THE STOP
              * FOREVER IF TKØ SWITCH IS
              * BROKEN
              *
Ø5A4 ØE55     REST3  MVI  C,85        LOAD MAX STEPCNT
Ø5A6 7E       REST3A MOV  A,M         TRACK Ø?
Ø5A7 E6Ø8            ANI  TKØ
Ø5A9 C2B6Ø5          JNZ  REST4       YES- PRESS  ON
Ø5AC CD1DØ5          CALL STPOUT      STEP OUT ONE TK
Ø5AF ØD              DCR  C           MAX STEPS ?
Ø5BØ C2A6Ø5          JNZ  REST3A      NO - TRY AGAIN
              *
              * MAXIMUM NUMBER OF STEPS HAVE
              * BEEN ISSUED - ERROR ABORT
              *
Ø5B3 C3CCØ5          JMP  PERMER
              *
              *FOUND TRACK Ø - WAIT
              * SETTLE TIME THEN EXIT
              *
```

```
Ø5B6 CD2DØ5 REST4  CALL SETTLE     WAIT HEAD SETTLE
Ø5B9 C1            POP  B
Ø5BA D1            POP  D
Ø5BB E1            POP  H
Ø5BC C9            RET
                   *
                   * LOAD ADDRESS OF CURRENT TRACK ON
                   * CURRENT UNIT INTO HL
                   *
Ø5BD D5     LDTRK  PUSH D
Ø5BE 3AF6Ø6        LDA  DCBUN
Ø5C1 E6Ø3          ANI  Ø3         MASK OUT UNIT
Ø5C3 5F            MOV  E,A
Ø5C4 16ØØ          MVI  D,Ø
Ø5C6 21FCØ6        LXI  H,TRACK    POINT HL INTO
Ø5C9 19            DAD  D          TRACK TABLE
Ø5CA D1            POP  D
Ø5CB C9            RET
                   *
                   *
                   *
                   *
                   *  ERROR EXITS
                   *
Ø5CC 3EØ1   PERMER MVI  A,1
Ø5CE B7            ORA  A
Ø5CF C3CCØ4        JMP  DS1ØØ
Ø5D2 3EØ2   PARMER MVI  A,2
Ø5D4 B7            ORA  A
Ø5D5 C3CCØ4        JMP  DS1ØØ
Ø5D8 3EØ3   DRIVER MVI  A,3
Ø5DA B7            ORA  A
Ø5DB C3CCØ4        JMP  DS1ØØ
Ø5DE 3EØ4   PROTER MVI  A,4
Ø5EØ B7            ORA  A
Ø5E1 C3CCØ4        JMP  DS1ØØ
                   *
                   *
                   *
                   ***************************************
                   *      REGISTER DEFINITIONS AND       *
                   *      FLAG EQUATES FOR MICROPOLIS    *
                   *      FLEXIBLE DISK CONTROLLER B     *
                   ***************************************
                   *
                   *
                   *
F4ØØ               BPROM  EQU  X'F4ØØ'
F6ØØ               DIADR  EQU  BPROM+X'Ø2ØØ'
                   *
                   *      DATA REGISTERS
                   *
F6Ø2               WDATA  EQU  DIADR+X'Ø2'
F6Ø2               RDATA  EQU  WDATA
                   *
                   *      STATUS REGISTERS
                   *
```

```
F6ØØ        DSECTR EQU  DIADR
            *    Ø-3    SECTOR COUNT
            *      4    SPARE
            *      5    SPARE
            *      6    SCTR INTERRUPT FLAG
            *      7    SECTOR FLAG
            *
            *      FLAG BITS
            *
ØØ4Ø        SIFLG  EQU  X'4Ø'
ØØ8Ø        SFLG   EQU  X'8Ø'
ØØ2Ø        DTMR   EQU  X'2Ø'
            *
            *
F6Ø1        DSTAT  EQU  DIADR+1
            *    Ø-1    UNIT ADDRESS
            *      2    UNIT SELECTED (LOW TRUE)
            *      3    TRACK Ø
            *      4    WRITE PROTECT
            *      5    DISK READY
            *      6    PINTE
            *      7    TRANSFER FLAG
            *
            *      FLAG BITS
            *
ØØ8Ø        TFLG   EQU  X'8Ø'
ØØ4Ø        INTE   EQU  X'4Ø'
ØØ2Ø        RDY    EQU  X'2Ø'
ØØ1Ø        WPT    EQU  X'1Ø'
ØØØ8        TKØ    EQU  X'Ø8'
ØØØ4        USLT   EQU  X'Ø4'
            *
            *
            *      COMMAND REGISTER
            *
F6ØØ        DCMND  EQU  DIADR
            *(ALSO WILL RESPOND TO DISK+1)
            *
            *    Ø-1    COMMAND MODIFIER
            *    5-7    COMMAND
            *
            *      COMMANDS
            *
ØØ2Ø        SLUN   EQU  X'2Ø'     SELECT UNIT
            *      MODIFIER CONTAINS UNIT ADDRESS
ØØ4Ø        SINT   EQU  X'4Ø'     SET INTERRUPT
            *      MODIFIER =1 ENABLE INTERRUPT
            *               =Ø DISABLE INTERRUPT
ØØ6Ø        STEP   EQU  X'6Ø'     STEP CARRIAGE
            *      MODIFIER =ØØ STEP OUT
            *               =Ø1 STEP IN
ØØ8Ø        WTCMD  EQU  X'8Ø'     ENABLE WRITE
            *      NO MODIFIER USED
ØØAØ        RESET  EQU  X'AØ'     RESET CONTROLLER
            *      NO MODIFIER USED
            *
            *
```

```
                  *
ØØ86              SCLEN  EQU  134        SECTOR LNGTH/2
                  *
                  *
                  *      SELECT DRIVE SPECIFIED
                  *      BY UNIT ADDRESS IN DCB
                  *
Ø5E4 D5           SLCT   PUSH D
Ø5E5 C5                  PUSH B
Ø5E6 E5                  PUSH H
Ø5E7 2AØ2Ø7              LHLD DADR       GET CONTROLLER ADR
Ø5EA 3AF6Ø6              LDA  DCBUN      GET UNIT ADR FROM
Ø5ED E6Ø3                ANI  X'Ø3'      DCB
Ø5EF 47                  MOV  B,A        AND SAVE
Ø5FØ 23                  INX  H          POINT TO STATUS
Ø5F1 7E                  MOV  A,M        AND READ
Ø5F2 4F                  MOV  C,A        SAVE STATUS
Ø5F3 E6Ø7                ANI  X'Ø7'      MASK USLD & ADDR
Ø5F5 A8                  XRA  B          DESIRED UNIT PREV
                  *      NOTE-THIS TEST WILL FAIL IF
                  *      CONTROLLER IS NOT PLUGGED IN
Ø5F6 79                  MOV  A,C        SELECTED?
Ø5F7 CAØCØ6              JZ   SLØ1Ø      YES-CHECK RDY
Ø5FA 78                  MOV  A,B        GET UNIT ADDRESS
Ø5FB F62Ø                ORI  SLUN       BUILD COMMAND
Ø5FD 77                  MOV  M,A        OUTPUT COMMAND
                  *                      WAIT 25Ø MSEC FOR
Ø5FE 11FAØØ              LXI  D,25Ø      SECTOR CNTR TO
Ø6Ø1 CD17Ø6              CALL TIMER      GET IN SYNC
Ø6Ø4 7E                  MOV  A,M        GET STATUS
Ø6Ø5 E6Ø7                ANI  X'Ø7'      SELECTED NOW?
Ø6Ø7 A8                  XRA  B
Ø6Ø8 7E                  MOV  A,M        GET STATUS AGAIN
Ø6Ø9 C21ØØ6              JNZ  SLØ2Ø      ERROR IF NOT SLTD
Ø6ØC E62Ø         SLØ1Ø  ANI  RDY        ENSURE UNIT IS
Ø6ØE EE2Ø                XRI  RDY        READY
Ø61Ø E1           SLØ2Ø  POP  H
Ø611 C1                  POP  B
Ø612 D1                  POP  D
Ø613 C8                  RZ              RETURN IF OK
                  *      DRIVE NOT UP ERROR
Ø614 C3D8Ø5              JMP  DRIVER
                  *
                  *
                  *      1 MILLISECOND TIMER
                  *      DE=(DELAY) TIME IN MSEC
                  *
                  *      A IS DESTROYED
                  *
Ø617 C5           TIMER  PUSH B
Ø618 E5                  PUSH H
Ø619 2AØ2Ø7              LHLD DADR
Ø61C 7E                  MOV  A,M        RE-TRIGGER 4
Ø61D Ø66Ø                MVI  B,96       SECOND TIMER
Ø61F 78           TIØ1Ø  MOV  A,B        COUNT
Ø62Ø D6Ø1                SUI  1          DELAY LOOP=1.ØØ8
Ø622 B7                  ORA  A          MSEC @5ØØ NSEC
```

```
0623 C22006          JNZ  TI010+1
              *
              *      1MSEC EXPIRED - DECREMENT DELAY
              *      MULTIPLIER & CHECK FOR DONE
              *
0626 1B              DCX  D
0627 7B              MOV  A,E
0628 B2              ORA  D
0629 C21F06          JNZ  TI010
062C E1              POP  H
062D C1              POP  B
062E C9              RET
              *
              *      WRITE 1 SECTOR
              *
              *
062F CDE405   WSECT  CALL SLCT       ENSURE UNIT SLD
0632 3AF706          LDA  DCBSC      AND READY
0635 47              MOV  B,A
0636 C5              PUSH B
0637 0E86            MVI  C,SCLEN    C <- BYTCT/2
0639 2A0207          LHLD DADR       GET CONTROLLER ADR
063C E5              PUSH H
063D 23              INX  H          READ STATUS
063E 7E              MOV  A,M        ABORT IF
063F E610            ANI  WPT        WRITE PROTECTED
0641 C2DE05          JNZ  PROTER
0644 2A0007          LHLD BUFADR     GET BUFFER ADDR
0647 E5              PUSH H
0648 D1              POP  D          MOVE TO DE
0649 3AF806          LDA  DCBTK      MOVE TRACK AND
064C 77              MOV  M,A        SECTOR ID TO WRITE
064D 23              INX  H          BUFFER
064E 70              MOV  M,B
064F 2A0207          LHLD DADR       GET CONTROLLER ADR
0652 CDE906          CALL GETSEC     WAIT FOR SECTOR
              *
              *      FOUND DESIRED SECTOR-
              *      ENABLE WRITE
              *
0655 3680            MVI  M,WTCMD
0657 23              INX  H
              *
              *      WAIT FOR TRANSFER FLAG
              *
0658 B6       WS010  ORA  M
0659 F25806          JP   WS010
              *
              *      INSERT SYNC BYTE
              *
065C 23              INX  H
065D 36FF            MVI  M,X'FF'
              *
065F AF              XRA  A          CLEAR CARRY
0660 EB              XCHG
0661 0600            MVI  B,0        AND CHECKSUM
              *
```

```
            *      WRITE HEADER & DATA FIELD
            *
Ø663 7E     WSØ2Ø  MOV  A,M       GET BYTE FROM MEM
Ø664 12            STAX D         WRITE TO DISK
Ø665 88            ADC  B         ADD TO CKSUM
Ø666 47            MOV  B,A       SAVE CKSUM
Ø667 23            INX  H         NEXT BYTE
Ø668 7E            MOV  A,M       -ETC-
Ø669 12            STAX D
Ø66A 88            ADC  B
Ø66B 47            MOV  B,A
Ø66C 23            INX  H
Ø66D ØD            DCR  C
Ø66E C263Ø6        JNZ  WSØ2Ø
            *
            *      END OF DATA - INSERT CHECKSUM
            *
Ø671 78            MOV  A,B
Ø672 12            STAX D
            *
            *      WAIT END OF SECTOR
            *
Ø673 E1            POP  H
Ø674 AF            XRA  A
Ø675 B6     WSØ3Ø  ORA  M         WAIT SCTR FLAG
Ø676 F275Ø6        JP   WSØ3Ø
Ø679 11Ø1ØØ        LXI  D,1       WAIT 1 MSEC FOR
Ø67C CD17Ø6        CALL TIMER     ERASE DELAY
Ø67F C1            POP  B
Ø68Ø C9            RET
            *
            *
            *      READ 1 SECTOR
            *      VERIFY CHECKSUM AND HEADER
            *
            *      RETURNS Z=OK
            *             NZ=ERROR
            *
Ø681 CDE4Ø5 READAL CALL SLCT      ENSURE UNIT IS
            *                     RDY + SLTD
Ø684 3AF7Ø6        LDA  DCBSC     GET SECTOR ADDR
Ø687 47            MOV  E,A       FROM DCB
Ø688 C5            PUSH B
Ø689 ØE86          MVI  C,SCLEN   C <- BYTCT/2
Ø68B CDD6Ø6        CALL WTSYNC    WAIT DESIRED
            *                     SECTOR & STRIP
            *                     SYNC BYTE
            *
            *      FOUND DESIRED SECTOR - READ
            *
Ø68E EB            XCHG
Ø68F Ø6ØØ          MVI  B,Ø       CLR CHECKSUM
            *
            *      READ LOOP
            *
Ø691 1A     RDA1Ø  LDAX D         READ FROM DISK
Ø692 77            MOV  M,A       MOVE TO BUFFER
```

```
Ø693 23              INX  H            NEXT LOC
Ø694 88              ADC  B            ADD TO CHECKSUM
Ø695 47              MOV  B,A          AND SAVE
Ø696 1A              LDAX D            NEXT READ
Ø697 77              MOV  M,A          -ETC-
Ø698 23              INX  H
Ø699 88              ADC  B
Ø69A 47              MOV  B,A
Ø69B ØD              DCR  C            END OF DATA?
Ø69C C291Ø6          JNZ  RDA1Ø        NO-LOOP
               *
               *     END OF DATA-READ CHECKSUM
               *
Ø69F 1A              LDAX D
Ø6AØ B8        RDAØ2Ø CMP B            COMPARE WITH
Ø6A1 C1              POP  B            COMPUTED CHECKSUM
Ø6A2 CØ              RNZ               RETURN IF ERROR
               *
               *     CHECKSUM OK-VERIFY HEADER
               *
Ø6A3 2AØØØ7          LHLD BUFADR       POINT DE TO READ
Ø6A6 EB              XCHG              BUFFER
Ø6A7 CDBDØ5          CALL LDTRK        POINT TO CURRENT
Ø6AA 1A              LDAX D            TRACK AND COMPARE
Ø6AB BE              CMP  M            WITH TRACK ID READ
Ø6AC CØ              RNZ
Ø6AD 13              INX  D
Ø6AE 1A              LDAX D            COMPARE SECTOR ID
Ø6AF B8              CMP  B            WITH DESIRED SCTR
Ø6BØ C9              RET
               *
               *     VERIFY SECTOR
               *
               *     READ THROUGH SECTOR WITHOUT
               *     MOVING DATA INTO MEMORY AND
               *     VERIFY TRACK AND SECTOR ID
               *     AND CHECKSUM
               *
               *     ONLY TRACK AND SECTOR ID ARE READ
               *     INTO MEMORY AND CHECKSUM IS
               *     VERIFIED
               *
               *     SECTOR IS SPECIFIED BY B REG
               *
               *     RETURNS Z=OK
               *             NZ=ERROR
               *
Ø6B1 C5        READCK PUSH B           SAVE SECTOR
Ø6B2 CDE4Ø5          CALL SLCT         ENSURE SLTD&RDY
Ø6B5 ØE85            MVI  C,SCLEN-1    C <- BYTCT/2-1
Ø6B7 CDD6Ø6          CALL WTSYNC       WAIT SECTOR & STRP
               *                       OFF SYNC BYTE
Ø6BA Ø6ØØ            MVI  B,Ø          CLR CHECKSUM
Ø6BC 7E              MOV  A,M          READ TRACK ID
Ø6BD 12              STAX D            SAVE IN BUFFR
Ø6BE 88              ADC  B            ADD TO CHECKSUM
36BF 47              MOV  B,A          AND SAVE
```

```
Ø6CØ 13                 INX  D
Ø6C1 7E                 MOV  A,M       READ SCTR ID
Ø6C2 12                 STAX D         AND SAVE
Ø6C3 88                 ADC  B
Ø6C4 47                 MOV  B,A
Ø6C5 ØØ                 NOP
            *
            *      READ THROUGH REMAINDER OF SECTOR
            *      TO COMPUTE & VERIFY CHECKSUM
            *
Ø6C6 7E     RDCK1Ø MOV  A,M       READ FROM DISK
Ø6C7 88                 ADC  B         ADD TO CHECKSUM
Ø6C8 47                 MOV  B,A       SAVE CKSUM
Ø6C9 ØØ                 NOP
Ø6CA ØØ                 NOP
Ø6CB 7E                 MOV  A,M       -ETC-
Ø6CC 88                 ADC  B
Ø6CD 47                 MOV  B,A
Ø6CE ØD                 DCR  C
Ø6CF C2C6Ø6             JNZ  RDCK1Ø
            *
            *      END OF DATA - READ CHECKSUM
            *
Ø6D2 7E                 MOV  A,M
Ø6D3 C3AØØ6             JMP  RDAØ2Ø    GO CHECK HDR &
            *                          CHECKSUM
            *
            *
            *      WAIT FOR DESIRED SECTOR
            *      TO COME AROUND AND STRIP OFF
            *      SYNC BYTE FOR READ ROUTINES
            *
Ø6D6 2AØØØ7 WTSYNC LHLD BUFADR    GET BUFFER ADDRESS
Ø6D9 EB                 XCHG
Ø6DA 2AØ2Ø7             LHLD DADR      AND CONTROLLER ADR
Ø6DD CDE9Ø6             CALL GETSEC    WAIT FOR SECTOR
Ø6EØ 23                 INX  H
Ø6E1 B6     WTSØ1Ø ORA  M         WAIT FOR XFER RDY
Ø6E2 F2E1Ø6             JP   WTSØ1Ø    FLAG
Ø6E5 23                 INX  H         OK-READ IN SYNC
Ø6E6 7E                 MOV  A,M       BYTE - - THROW IT
Ø6E7 AF                 XRA  A         AWAY,CLEAR CARRY
Ø6E8 C9                 RET            AND GO READ
            *
            *      WAIT FOR DESIRED SECTOR TO COME
            *      AROUND
            *
Ø6E9 7E     GETSEC MOV  A,M       WAIT FOR SCTR FLAG
Ø6EA B7                 ORA  A
Ø6EB F2E9Ø6             JP   GETSEC
Ø6EE E6ØF               ANI  X'ØF'     OK -IS THIS THE
Ø6FØ A8                 XRA  B         ONE WE WANT?
Ø6F1 C2E9Ø6             JNZ  GETSEC    NO-WAIT
Ø6F4 C9                 RET            PRESS ON
            *
            *      RAM STORAGE REQUIRED FOR DRIVER
            *
```

```
              *
              *       INTERNAL DISK CONTROL BLOCK
              *
06F5          DCB    EQU   *
06F5          DCBFN  DS    1
06F6          DCBUN  DS    1
06F7          DCBSC  DS    1
06F8          DCBTK  DS    1
06F9          DCBAD  DS    2
0006          DCBLEN EQU   *-DCB
              *
              *
0080          HCI    EQU   X'80'       HEADER CHECK INH
0040          RAFI   EQU   X'40'       RAW CHECK INHIBIT
06FB 4C       TRKMX  DC    76          MOD 2
              *
              *
              *       CURRENT TRACK TABLE
              *       MUST BE INITIALIZED TO FF
              *       AT POWER ON TO CAUSE DISK TO
              *       BE RESTORED TO TRACK 0
              *       THE FIRST TIME IT IS ACCESSED TO
              *       CALIBRATE TRACK POSITION
              *
06FC FF       TRACK  DC    X'FF'
06FD FF              DC    X'FF'
06FE FF              DC    X'FF'
06FF FF              DC    X'FF'
              *
              *
0700          BUFADR DS    2           CURRENT BUFFER ADR
              *
              *
              *
0702 00F6     DADR   DC    B(DIADR)    DISK CTLR ADDR
              *
              *       RETRY COUNTERS
0704          L1RTRY DS    1
0705          L2RTRY DS    1
0706          L3RTRY DS    1
              *
0707          DIRCTN DS    1
0708          STACK  DS    2           SAVED SP
              *
              *
              *
070A                 END   *-*
```

APPENDIX A - BASIC ERROR MESSAGES

ARGUMENT - Argument in a function reference is the wrong data type or missing.

ARRAY INDEXING ERROR - A reference to an array element contains an invalid index. May also be caused if an attempt is made to reference an array element before the array is defined in a DIM statement.

CONVERSION ERROR - Attempt to assign a real value to an integer variable and the converted value is too large.

DIGIT BEYOND RADIX - A number specified in radix format includes a digit which is invalid for the specified radix.

DISK FULL - An attempt was made to allocate another track for a file and no free tracks remain.

DRIVE NOT UP - The desired disk unit does not have a diskette loaded, is not up to speed, or has a malfunction which prevents it from accepting commands.

DUPLICATE NAME - An attempt was made to OPEN a file name which already exists as a new file.

END-FILE - The end-of-file was encountered in a disk file read.

EXTRA INPUT IGNORED - The response to an INPUT statement contained more values than were needed to satisfy the variable list and the extra values were ignored.

FILE ALREADY OPEN - File number specified in an OPEN statement already has a file opened to it.

FILE NOT FOUND - File name specified in a disk I/O command does not exist on the specified diskette.

FILE NOT OPEN - File number specified in a disk I/O statement does not have a file name opened to it.

FILE TYPE ERROR - The attributes of the referenced file are inconsistent with the requirements of the statement or command that referenced it.

ILLEGAL IMMEDIATE - An attempt was made to use a statement as a direct command, but the statement is only valid within a BASIC program.

INPUT OVERFLOW - A program line greater than 250 characters in length was entered - the entire program line is cancelled.

INSUFFICIENT INPUT - The response to an INPUT statement contained insufficient values to satisfy the variable list.

INTERRUPT - Execution of a program was interrupted by entry of a CNTL/C key at the terminal.

INVALID DISK FILE NAME - Disk file name specified is not a valid disk file name.

LOAD OVERRUN - The length of the BASIC program being loaded exceeds the memory space currently available to BASIC.

LOG OF NEG # - Attempt was made to pass a negative or zero value to the LOG or LN function.

MEMORY OVERFLOW - Insufficient memory exists for execution of the program.

MISSING FOR - A NEXT statement was encountered prior to execution of a FOR statement specifying the loop variable.

NOT A FILE # - File number specified in a disk I/O statement is not one of the digits 0 - 9.

NOT A LOAD FILE - Attempt to load a data format disk file.

NOT A RECORD # - The value following the RECORD option in a GET or PUT statement is not a valid record number.

NOTHING TO RETURN TO - A RETURN statement was encountered prior to executing a GOSUB statement.

NUMBER OUT OF RANGE - The value of an expression referenced is illegal. Refer to the description of the statement in error for the range of valid values.

OVERFLOW - Numeric overflow - Result of an operation is too large to be contained in a variable.

OUTPUT OVERFLOW - A PRINT or PUT statement has attempted to create an output line (record) greater than 25Ø characters in length. This exceeds the maximum internal buffer capacity. The line (record) is not output.

PARM ERR - Disk I/O Parameter error - usually caused by setting the sequential GET/PUT pointers to an invalid value.

PERM FILE - An attempt was made to SCRATCH a permanent file.

PERM I/O ERROR - A disk I/O error occurred which was not recoverable in the disk I/O retry logic.

PRECISION ERROR - A numeric function or the ↑ operator was referenced with RSIZE greater than 10.

READY - The BASIC interpreter is ready for entry of commands or program lines at the terminal.

RAN OUT OF DATA - A READ statement depleted the data list before satisfying the variable list. A GET statement encountered the end of the current record without satisfying the variable list.

SIZES ERROR - One of the parameters of a SIZES statement is invalid or there are already variables allocated when the statement is encountered.

SQRT OF NEG # - Attempt to pass a negative number to the SQR function.

STACK OVERFLOW - The statement in error contains an expression which is too complex. Break the expression into multiple expressions which are less complex.

STMT # NOT FOUND - The statement in error tried to transfer control to a program line number which does not exist.

SYNTAX - The statement in error is not recognizable or contains an invalid structure such as unequal right and left parentheses.

TYPE ERROR - Attempt to assign a value of the wrong data type to a variable.

WRITE PROTECT - An attempt was made to write on a file with a write protect attribute or the diskette on which the file resides has a write protect tab installed.

UNDERFLOW - Numeric underflow - The result of an operation is too small to be assigned to a variable.

X↑Y INDETERMINATE - Attempt to take a fractional power of a negative number or Ø or to raise Ø to a negative or Ø power, which are undefined operations.

ZERO DIVIDE - Attempt to divide by zero which is an undefined operation.

APPENDIX B - BASIC UTILITY

B.Ø DESCRIPTION

The MDOS System diskette included with each system contains a BASIC utility program.

The functions provided are:

1) Initializing a diskette: This must be done before a newly purchased diskette can be used by MDOS or M.BASIC to store data or programs. The INIT command in MDOS may be used instead. It has the same effect.

2) Examining and modifying memory: Used to examine, and change if desired, the contents of any location in memory. The P command in the Extended Systems Monitor is similar.

3) Saving BASIC: Writes a copy of M.BASIC plus the RES module onto a diskette. Used for creating a BASIC-only system diskette.

B.1 CALLING THE UTILITY

1) Make sure you have mounted in drive Ø an MDOS system diskette, or BASIC-only diskette with both M.BASIC and the BASIC Utility on it.

2) Use normal operating procedures to get M.BASIC in control, indicated by the READY prompt.

3) Enter the command LOAD "UTILITY" (return).

4) When the system responds with READY, enter RUN (return). The Utility will sign on with:

```
BASIC UTILITY PROGRAM-VERSION X.X
ENTER KEY TO SELECT DESIRED FUNCTION

F        FORMAT DISK
M        MEM EXAM/MODIFY
S        SAVE BASIC
E        EXIT

FUNCTION?
```

5) To select a function, enter the associated letter, followed by a return.

6) After completing a function, the program will request another command. Enter E to return to M.BASIC.

7) If the program is for some reason unable to complete a function, it may return to the M.BASIC executive. To get back to the Utility, begin again at step 3.

B.2 INITIALIZING A DISKETTE - FUNCTION F

The Utility refers to this as the FORMAT DISK function. Initialization consists of writing track and sector address information in each sector of the data area of the diskette and writing an empty Directory on the Directory track.

Since initialization essentially erases a diskette, DO NOT initialize the System diskettes included with your system.

1) In response to F (return), the Utility will output:

   SPECIFY UNIT NUMBER?

2) Enter the number of the drive to be used (Ø to 3) and press return. The program responds with:

   INSERT BLANK DISKETTE IN UNIT X.
   ARE YOU READY?

   If you wish to get out of this function, press (return), otherwise, continue.

3) Load the diskette you wish to initialize into the specified drive.

4) Enter Y (return).

The Utility will initialize the diskette. This takes about 7Ø seconds.

When completed, the Utility will request the next function command.

B.3 MEMORY EXAM/MODIFY - FUNCTION M

In response to M (return), the Utility will output:

ENTER ADDRESS?

Type the hexadecimal representation of the desired memory address followed by a carriage return. The Utility will print the hexadecimal value of the contents of the desired memory location, followed by a question mark (?). Enter one of the following responses:

1) If a hexadecimal number from Ø - FF followed by a carriage return is entered, the contents of the memory location just displayed are set to the value entered. The contents of the next sequential memory location are then displayed and the Utility prompts for the next response.

2) If a carriage return only is entered, the contents of the next sequential memory location are displayed and the Utility prompts for the next response.

3) If a colon (:) followed by a carriage return is entered, the Utility prompts for the entry of a new address to display/modify as described above.

4) If an exclamation mark (!) followed by a carriage return is entered, the Utility exits the memory modify/display function and prompts for a new function select.

B.4 SAVE BASIC - FUNCTION S

1) In response to S (return), the Utility will output:

   ARE YOU READY?

   If you want to get out of this function, press (return), otherwise, continue.

2) Mount the diskette on which you wish to store M. BASIC in drive Ø. (The diskette MUST be newly initialized. If it is not, do section B.2 above, first.)

3) Enter Y (return).

4) The Utility will save M. BASIC on the diskette, and set its attributes to permanent and write-protected. When completed, the Utility will request the next function command.

5) If you wish to copy the BASIC Utility onto the BASIC-only diskette, exit from the Utility by entering E as the next function. After the BASIC prompt READY, enter SAVE "N:UTILITY" (return).

6) To copy any assembly language utility, such as DISKCOPY, onto the BASIC-only diskette, use the FILECOPY command in MDOS.

APPENDIX C - ACCESSING DISKCOPY FROM BASIC

DISKCOPY is a special overlay utility that writes an absolute binary copy of one disk onto another. The utility overlays MDOS or BASIC. It uses all available memory during the copying process. The more memory in a system the faster the copying process. On average it takes about two minutes to copy and verify all 315k bytes of a MOD II disk.

NOTE 1: Previous versions of DISKCOPY will not run with BASIC 3.Ø and DISKCOPY 3.Ø will not run with earlier versions of Micropolis BASIC.

NOTE 2: In multiple drive systems DISKCOPY can be copied onto another disk by using the FILECOPY utility under MDOS (Section 4.7).

The DISKCOPY utility is invoked from BASIC by using the LINK command.

```
LINK "[unit:]DISKCOPY"
```

a sign-on message is output:

```
MICROPOLIS DISKCOPY VS X.X - COPYRIGHT 1978
SPECIFY UNIT # FOR ORIGINAL (SOURCE) DISKETTE
?
```

DISKCOPY waits until the unit number is entered. When a number between Ø and 3 is entered it prompts:

```
SPECIFY UNIT # FOR DESTINATION DISKETTE
?
```

and waits until the unit number (Ø to 3) is entered. It then prompts:

```
PUT DISKETTES IN SPECIFIED UNITS
TYPE Y WHEN READY
?
```

and waits for a Y. A note of CAUTION, we strongly recommend placing a write protect tab on the original (source) diskette. It is possible to put the wrong diskette in the wrong drive or type the wrong unit numbers. If your original does not have a write protect tab and you make an error, the original can be overwritten. The write protect tab provides a physical interlock which disables the write electronics.

When a Y is typed DISKCOPY will start the copying process. During copying, the process can be temporarily halted between read source and write destination cycles by typing a control S. The process is restarted by typing any other key except a control C.

The control C will cancel the entry or copy process and prompt:

```
CANCELLED
MORE ?
```

If a Y is typed DISKCOPY starts from the top asking for the unit numbers again. If an N is typed DISKCOPY prompts:

```
PUT SYSTEM DISKETTE IN UNIT Ø
TYPE Y WHEN READY
?
```

When a Y is typed the disk in unit Ø is rebooted. If it's an MDOS diskette MDOS is booted. If the disk in unit Ø is a BASIC only disk or some other bootable system, it will be booted in and sign on. DISKCOPY is overlayed by the incoming system and is no longer in memory.

When the disk has been copied and verified correctly DISKCOPY outputs:

```
GOOD COPY
MORE ?
```

If the copy cannot be completed or does not verify correctly DISKCOPY outputs:

```
PERM I/O ERROR ON DESTINATION DISKETTE
```

or

```
PERM I/O ERROR ON SOURCE DISKETTE
```

indicating where the error occurred.

It is possible for single drive systems to make use of the DISKCOPY utility to copy from one disk to another. In this case it is imperative that the original diskette be write protected with a write protect tab. The procedure involves specifying the same unit number for both source and destination disks. Immediately after typing a Y in response to the TYPE Y WHEN READY prompt, type a control S. The DISKCOPY program will read as many tracks from the source disk as can be contained in main memory and then pause. When the select indicator light goes out, remove the source diskette and insert the destination diskette. Press the return key and as soon as the select indicator light comes on type a control S again. When the select indicator light goes out again the data from the source disk has been written to the destination disk and one complete cycle is finished. This process is repeated, swaping the source and destination disks in and out until the entire disk is copied. After the last data is written onto the destination disk, the program goes directly into a verifying process and will not pause until this is over. When the source is placed back into the drive and the return key is pressed the system will prompt: GOOD COPY or output an error message as discussed above. At this point the copy is complete.

APPENDIX D - SUMMARY OF MDOS ERROR MESSAGES

D.1 MDOS EXECUTIVE AND SHARED SUBROUTINES

BAD FILE #

The file number specified is greater than 8.

BAD RECORD #

The record number specified is greater than exists in the specified file.

CANCELLED

A control C was typed at the console, canceling an operation.

COMMAND NOT FOUND

The word typed as a command name, or implicit command (file name) does not exist. The command was spelled incorrectly or the file name was not found on the specified disk.

DISK FULL

An attempt was made to allocate an additional track to a file, and no free tracks exist. The file is closed and the message is output. Some data may have been successfully written to the file before additional track space was needed.

DRIVE NOT UP

The disk unit specified is not loaded.

DUPLICATE NAME

The file name already exists on the unit specified. All files on a disk must have unique names.

END-FILE

The end of the file has been reached during a disk read.

FILE NOT FOUND

The file name specified does not exist on the unit specified.

FILE NOT OPEN

The file with the specified number has not been opened.

INDEX PAST EOR

The index position is beyond the end of the record.

LOAD ADDRESS ERROR

The address specified with a file to be loaded into memory would cause the file to overwrite the operating system.

PARM ERR

A parameter is out of range for a particular command, to big or to small. This is different than a syntax error caused by a parameter beyond the maximum input range.

PERM FILE

The file specified with a SCRATCH command or with the @SCRATCH subroutine has an attribute with bit 1 set high indicating a permanent file.

PERM I/O ERR

A disk I/O error occurred which was not recoverable by the disk I/O retry logic.

READ ONLY FILE

The specified file has an attribute with bit Ø set high. This inhibits rewriting of the file.

SYNTAX ERROR

The syntax of a command is wrong. This may be due to incorrect spelling, or parameters beyond the maximum input ranges; 1Ø characters for ASCII and four hex digits for numeric.

SYSTEM VERSION ERROR

An attempt was made to run a system program on the wrong version of the system.

WRITE PROTECT

The unit specified with a SAVE command or a subroutine that writes to the disk has a disk in it with a write protect tab in place.

WRONG FILE TYPE

The file type does not correspond to the type of operation that is to be performed.

D.2 EDITOR

FILEBUFFER OVERFLOW

This message occurs whenever there is less than 256 bytes of buffer space remaining in the edit buffer. Input can continue until the buffer is completely full, but the message will be repeated after each carriage return. The file should be written to disk and a new file started. If a file is loaded from disk and is too large to reside in the buffer, this message is output and the load is aborted. No data is loaded. This is most likely to occur in conjunction with the APPEND command. If an APPEND causes an overfollow, it is aborted and the files that were in the buffer prior to the command are not changed.

FILE ON DISK NOT UPDATED, PROCEED?

The current working file in the editor buffer has not been saved or resaved to disk. If you want to continue without updating the disk then type a Y in response, otherwise type an N.

FILE NOT NAMED

A name has not been given to the current editor file prior to trying to save it onto a disk.

LINE NOT FOUND

A line number which does not exist in the current text file was specified in an EDIT command.

LINE NUMBER OVERFLOW

The editor command RENUM specified an increment that caused the line number to exceed 9999 decimal. The file is only partially renumbered and care should be taken to do an additional RENUM with a smaller increment to assure that the file is properly numbered prior to doing any editing on the file.

STRING NOT FOUND

The SEARCH MASK specified with a SEARCH or CHANGE command in the editor does not exist in the text.

D.3 ASSEMBLER

See Section 4.5.3.

APPENDIX E - RES.I/O SOURCE LISTING

```
Addr B1 B2 B3 B4 E Line Label          Opcd   Operand

0000               0010 *
0000               0020 * I/O source file for Micropolis RES module
0000               0030 * on Vector MZ, version 4.1
0000               0040 *
0000               0050 * by Neale Brassell,
0000               0060 * 2/79
0000               0070 * Vector Graphic Inc.
0000               0080 *
0000               0090 * first, general system equates from SYSQ
0000               0100 *
0000    04EC    =  0110 @CONSOLEADDR   EQU    04ECH
0000    04F0    =  0120 @CIOTABLE      EQU    04F0H
0000    0502    =  0130 @LIOTABLE      EQU    0502H
0000    078D    =  0140 @CDIN          EQU    078DH
0000    0792    =  0150 @CDOUT         EQU    0792H
0000    0797    =  0160 @CDBRK         EQU    0797H
0000    07E5    =  0170 @LDOUT         EQU    07E5H
0000    07EA    =  0180 @LDATN         EQU    07EAH
0000    04EA    =  0190 @D1PORT        EQU    04EAH
0000    04E7    =  0200 RES            EQU    04E7H
0000               0210 *
0000               0220 * now, general equates
0000               0230 *
0000    000D    =  0240 CR             EQU    0DH
0000    000A    =  0250 LF             EQU    0AH
0000    0008    =  0260 BS             EQU    08H
0000    0003    =  0270 CNTC           EQU    03H
0000    0013    =  0280 CNTS           EQU    13H
0000    0015    =  0290 CNTU           EQU    15H
0000    0018    =  0300 CNTX           EQU    18H
0000    007F    =  0310 DEL            EQU    7FH
0000    005F    =  0320 USCORE         EQU    5FH
0000               0330 *
0000    0010    =  0340 CANCELLED      EQU    16
0000               0350 *
0000    C0DC    =  0360 MIN            EQU    0C0DCH
0000    C098    =  0370 MOUT           EQU    0C098H
0000               0380 *
0000               0390 * Get printer etc. from user, and compute ports
0000               0400 *
0000    0000    =  0410 DIAB           REQ    'Diablo (1=Yes, 0=No):'
0000    0000    =  0420 CENT           REQ    'Centronics (1=Yes, 0=No):'
0000    0000    =  0430 DECW           REQ    'Decwriter, TTY, etc (1=Yes, 0=No):'
0000    0000    =  0440 OTHR           REQ    'Any other printer (1=Yes, 0=No):'
0000    0000    =  0450 BASE           REQ    'Bitstreamer base address:'
0000    0000    =  0460 ANY            EQU    DIAB!CENT!DECW!OTHR
0000               0470 *
0000    0003    =  0480 SSTAT          EQU    BASE+3        ;serial status
0000    0002    =  0490 SDATA          EQU    BASE+2        ;serial data
0000    0000    =  0500 PSTAT          EQU    BASE          ;parallel 0
0000    0001    =  0510 PDATA          EQU    BASE+1        ;parallel 1
0000               0520 *
0000               0530 * Ok! first, the vectors to the i/o tables
0000               0540 *
0000               0550                ORG    @CONSOLEADDR
04EC               0560 *
```

```
Addr B1 B2 B3 B4 E Line Label          Opcd   Operand

04EC F0 04          0570                DW     @CIOTABLE
04EE 02 05          0580                DW     @LIOTABLE
04F0                0590 *
04F0                0600 * the console i/o table
04F0                0610 *
04F0                0620                ORG    @CIOTABLE
04F0                0630 *
04F0 14 05          0640                DW     CIN             ;logical input
04F2 2E 05          0650                DW     COUT            ;logical output
04F4 77 05          0660                DW     CBRK            ;logigal break check
04F6 F8 05          0670                DW     CDIN            ;physical input
04F8 00 06          0680                DW     CDOUT           ;physical output
04FA 04 06          0690                DW     CDBRK           ;physical break check
04FC 0F 06          0700                DW     CDINIT          ;physical initialization
04FE                0710 *
04FE 00             0720 WRAPFLAG       DB     0               ;wraparound flag
04FF 01             0730 NULLCT         DB     1               ;null count (+1)
0500 4F             0740 WIDTH          DB     79              ;width (-1)
0501 03             0750 CURSOR         DB     3               ;cursor position
0502                0760 *
0502                0770 * next, the list i/o table
0502                0780 *
0502                0790                ORG    @LIOTABLE
0502                0800 *
0502 00 00          0810                DW     0               ;placeholder for input
0504 8E 05          0820                DW     LOUT            ;logical output
0506 EA 05          0830                DW     LATN            ;logical attention check
0508 00 00          0840                DW     0               ;placeholder for input
050A 27 06          0850                DW     LDOUT           ;physical output
050C 11 06          0860                DW     LDATN           ;physical attention check
050E 13 06          0870                DW     LDINIT          ;physical initialization
0510                0880 *
0510 00             0890 PWRAPFLAG      DB     0               ;wraparound flag
0511 01             0900 PNULLCT        DB     1               ;null count (+1)
0512 83             0910 PWIDTH         DB     131             ;width (-1)
0513 01             0920 PCURSOR        DB     1               ;line position
0514                0930 *
0514                0940 * now for the logical i/o routines
0514                0950 *
0514                0960 * {CIN} logical console input
0514                0970 *
0514 CD 8D 07       0980 CIN            CALL   @CDIN           ;get character
0517 78             0990                MOV    A,B
0518 FE 03          1000                CPI    CNTC            ;^C?
051A C8             1010                RZ                     ;return if so
051B FE 15          1020                CPI    CNTU            ;^U?
051D C2 22 05       1030                JNZ    $+5
0520 06 18          1040                MVI    B,CNTX          ;xlate ^U into ^X
0522 FE 5F          1050                CPI    USCORE          ;underscore?
0524 CA 2A 05       1060                JZ     BSPCE
0527 EE 7F          1070                XRI    DEL             ;DEL?
0529 C0             1080                RNZ
052A 06 08          1090 BSPCE          MVI    B,BS            ;make backspace
052C 3C             1100                INR    A               ;force NZ
052D C9             1110                RET
052E                1120 *
```

```
Addr B1 B2 B3 B4 E Line Label           Opcd   Operand

052E               1130 * {COUT} logical console output
052E               1140 *
052E ED 5B FE 04   1150 COUT            LDED   WRAPFLAG
0532 2A 00 05      1160                 LHLD   WIDTH         ;get wrap, null, width, cursor
0535 78            1170                 MOV    A,B           ;get character
0536 FE 0A         1180                 CPI    LF            ;linefeed?
0538 CA 92 07      1190                 JZ     @CDOUT        ;output, ignor if so
053B FE 0D         1200                 CPI    CR            ;return?
053D CA 5F 05      1210                 JZ     CROUT         ;handle special
0540 FE 18         1220                 CPI    CNTX          ;^X character?
0542 CA 6F 05      1230                 JZ     CNTXOUT       ;handle special also
0545 FE 08         1240                 CPI    BS
0547 C2 4D 05      1250                 JNZ    COUT1         ;print if not BS
054A 25            1260                 DCR    H
054B 25            1270                 DCR    H             ;adjust cursor counter
054C 00            1280                 NOP                  ;(space for patch)
054D CD 92 07      1290 COUT1           CALL   @CDOUT        ;print character
0550 7B            1300 WRAP            MOV    A,E           ;get wrap flag
0551 B7            1310                 ORA    A
0552 C0            1320                 RNZ                  ;return if no wrap
0553 7C            1330                 MOV    A,H           ;get cursor
0554 BD            1340                 CMP    L             ;end of line?
0555 C2 69 05      1350                 JNZ    DONE          ;done if not
0558 06 0D         1360 CCRLF           MVI    B,CR
055A CD 92 07      1370                 CALL   @CDOUT        ;print LF
055D 06 0A         1380                 MVI    B,LF
055F CD 92 07      1390 CROUT           CALL   @CDOUT        ;and CR
0562 06 00         1400                 MVI    B,0           ;make a null
0564 15            1410                 DCR    D             ;decrement counter
0565 C2 5F 05      1420                 JNZ    CROUT         ;loop
0568 AF            1430                 XRA    A
0569 3C            1440 DONE            INR    A             ;increment cursor ptr
056A 32 01 05      1450                 STA    CURSOR        ;save
056D B7            1460                 ORA    A
056E C9            1470                 RET                  ;return
056F 06 5C         1480 CNTXOUT         MVI    B,'\'         ;print \ instead of ^X
0571 CD 92 07      1490                 CALL   @CDOUT
0574 C3 58 05      1500                 JMP    CCRLF         ;go print CRLF
0577               1510 *
0577               1520 * {CBRK} logical console break check
0577               1530 *
0577 CD 97 07      1540 CBRK            CALL   @CDBRK
057A C0            1550                 RNZ                  ;return if no char
057B 78            1560                 MOV    A,B           ;get char
057C FE 13         1570                 CPI    CNTS          ;^S?
057E C2 89 05      1580                 JNZ    CANC
0581 CD 8D 07      1590 PAUSE           CALL   @CDIN         ;get char
0584 FE 13         1600                 CPI    CNTS          ;another ^S?
0586 CA 81 05      1610                 JZ     PAUSE
0589 FE 03         1620 CANC            CPI    CNTC          ;^C?
058B 3E 10         1630                 MVI    A,CANCELLED   ;error code, just in case
058D C9            1640                 RET                  ;return
058E               1650 *
058E               1660 * {LOUT} logical list output
058E               1670 *
058E ED 5B 10 05   1680 LOUT            LDED   PWRAPFLAG     ;get wrap, nulls
```

```
Addr B1 B2 B3 B4 E Line Label          Opcd   Operand

0592 2A 12 05      1690                LHLD   PWIDTH         ;and width, cursor
0595 78            1700                MOV    A,B
0596 FE 0A         1710                CPI    LF             ;linefeed?
0598 C2 A2 05      1720                JNZ    LOUT0
059B CD E5 07      1730                CALL   @LDOUT         ;print directly if LF
059E DA EE 05      1740                JC     ATT            ;handle if ATTN
05A1 C9            1750                RET
05A2 FE 0D         1760 LOUT0          CPI    CR             ;return?
05A4 CA CC 05      1770                JZ     LCROUT
05A7 FE 18         1780                CPI    CNTX           ;^X character?
05A9 CA DF 05      1790                JZ     LCNTXOUT
05AC FE 08         1800                CPI    BS             ;backspace?
05AE C2 B4 05      1810                JNZ    LOUT1
05B1 25            1820                DCR    H              ;adjust cursor
05B2 25            1830                DCR    H
05B3 00            1840                NOP                   ;(spot for patch)
05B4 CD E5 07      1850 LOUT1          CALL   @LDOUT         ;print character
05B7 DA EE 05      1860                JC     ATT            ;handle if ATTN
05BA 7B            1870 LWRAP          MOV    A,E            ;wraparound?
05BB B7            1880                ORA    A
05BC C0            1890                RNZ                   ;return if not
05BD 7C            1900                MOV    A,H            ;get cursor
05BE BD            1910                CMP    L              ;too far right?
05BF C2 D9 05      1920                JNZ    LDONE
05C2 06 0D         1930 LCRLF          MVI    B,CR
05C4 CD E5 07      1940                CALL   @LDOUT         ;print LF
05C7 DA EE 05      1950                JC     ATT            ;check ATTN
05CA 06 0A         1960                MVI    B,LF
05CC CD E5 07      1970 LCROUT         CALL   @LDOUT         ;print CR
05CF DA EE 05      1980                JC     ATT
05D2 06 00         1990                MVI    B,0            ;create a null
05D4 15            2000                DCR    D              ;count
05D5 C2 CC 05      2010                JNZ    LCROUT         ;print nulls
05D8 AF            2020                XRA    A
05D9 3C            2030 LDONE          INR    A              ;inc cursor
05DA 32 13 05      2040                STA    PCURSOR        ;save it
05DD B7            2050                ORA    A
05DE C9            2060                RET                   ;return
05DF 06 5C         2070 LCNTXOUT       MVI    B,'\'          ;xlate here, too
05E1 CD E5 07      2080                CALL   @LDOUT         ;print
05E4 D2 C2 05      2090                JNC    LCRLF          ;handle CRLF if no ATTN
05E7 C3 EE 05      2100                JMP    ATT            ;go to ATTN routine
05EA               2110 *
05EA               2120 * {LATN} list logical attention check
05EA               2130 *
05EA CD EA 07      2140 LATN           CALL   @LDATN         ;do it
05ED D0            2150                RNC                   ;done if NC
05EE 21 EA 04      2160 ATT            LXI    H,@D1PORT      ;on ATTN,
05F1 3E 01         2170                MVI    A,1            ; reset
05F3 77            2180                MOV    M,A            ; assignments
05F4 3C            2190                INR    A              ; to their
05F5 23            2200                INX    H              ; defaults,
05F6 77            2210                MOV    M,A            ; and indicate
05F7 C9            2220                RET                   ; an error.
05F8               2230 *
```

```
Addr B1 B2 B3 B4 E Line Label          Opcd   Operand

05F8                 2250 *
05F8                 2260 * now for the physical i/o drivers
05F8                 2270 *
05F8                 2280 * {CDIN} physical console input
05F8                 2290 *
05F8 CD DC C0        2300 CDIN          CALL   MIN            ;get stat/char
05FB CA F8 05        2310               JZ     CDIN           ;none yet
05FE 47              2320               MOV    B,A            ;satisfy requirements
05FF C9              2330               RET                   ;that's that
0600                 2340 *
0600                 2350 * {CDOUT} physical console output
0600                 2360 *
0600 78              2370 CDOUT         MOV    A,B            ;get character
0601 C3 98 C0        2380               JMP    MOUT           ;go print it
0604                 2390 *
0604                 2400 * {CDBRK} physical console break check
0604                 2410 *
0604 CD DC C0        2420 CDBRK         CALL   MIN            ;get stat/char
0607 CA 0D 06        2430               JZ     CB1            ;no char
060A 47              2440               MOV    B,A            ;save char
060B AF              2450               XRA    A              ;set Z
060C C9              2460               RET                   ;return
060D 3C              2470 CB1           INR    A              ;clear Z
060E C9              2480               RET                   ;and return
060F                 2490 *
060F                 2500 * {CDINIT} physical console initialization
060F                 2510 *
060F AF              2520 CDINIT        XRA    A              ;clear CY
0610 C9              2530               RET                   ;console is always init'ed
0611                 2540 *
```

```
Addr B1 B2 B3 B4 E Line Label         Opcd   Operand

0611               2560 *
0611               2570 * Now for the physical list routines.
0611               2580 *
0611               2590 * {LDATN} physical list ATTN check
0611               2600 *
0611 AF            2610 LDATN         XRA    A             ;none of our devices
0612 C9            2620               RET                  ; have this feature
0613               2630 *
0613               2640 * {LDINIT} physical list initialization
0613               2650 *
0613 AF            2660 LDINIT        XRA    A             ;send nulls
0614 D3 03         2670               OUT    SSTAT
0616 D3 03         2680               OUT    SSTAT
0618 D3 03         2690               OUT    SSTAT
061A 3E 40         2700               MVI    A,40H         ;send reset
061C D3 03         2710               OUT    SSTAT
061E 3E CE         2720               MVI    A,0CEH        ;send mode
0620 D3 03         2730               OUT    SSTAT
0622 3E 27         2740               MVI    A,27H         ;send command
0624 D3 03         2750               OUT    SSTAT
0626 C9            2760               RET                  ;return
0627               2770 *
0627               2780 * {LDOUT} physical list output
0627               2790 *
0627 CD EA 07      2800 LDOUT         CALL   @LDATN        ;formality
062A D8            2810               RC
062B               2820 * -----
062B               2830               IFT    DECW          ;if TTY, Decwriter, etc.
062B               2840               PRT    'General selected'
062B               2850 *
062B               2860 L01           IN     SSTAT         ;get status
062B               2870               RAR
062B               2880               JNC    L01           ;wait till ready
062B               2890               MOV    A,B
062B               2900               OUT    SDATA         ;output data
062B               2910               XRA    A             ;clear C
062B               2920               RET                  ;return
062B               2930 *
062B               2940               ENDIF
062B               2950 * -----
062B               2960               IFT    DIAB          ;if Diablo
062B               2970               PRT    'Diablo selected'
062B               2980 *
062B               2990 L01           IN     SSTAT         ;get status
062B               3000               RAR
062B               3010               JNC    L01           ;wait till ready
062B               3020               MOV    A,B
062B               3030               OUT    SDATA         ;output character
062B               3040               CPI    LF            ;linefeed?
062B               3050               JNZ    XARET         ;return if not
062B               3060               MVI    B,CNTC        ;send ETX char
062B               3070               CALL   LDOUT
062B               3080 L02           IN     SSTAT         ;get return status
062B               3090               ANI    2
062B               3100               JZ     L02           ;wait till reply ready
062B               3110               IN     SDATA         ;get reply
```

```
Addr B1 B2 B3 B4 E Line Label          Opcd   Operand

062B                3120               MVI    B,LF           ;restore LF
062B                3130 XARET         XRA    A              ;zap carry flag
062B                3140               RET                   ;return
062B                3150 *
062B                3160               ENDIF
062B                3170 * -----
062B                3180               IFT    CENT           ;if Centronics
062B                3190               PRT    'Centronics selected'
062B                3200 *
062B                3210 L01           IN     PDATA          ;get status
062B                3220               RAR
062B                3230               JC     L01            ;wait till not busy
062B                3240               MOV    A,B
062B                3250               ORI    128            ;strobe on
062B                3260               OUT    PDATA
062B                3270               ANI    127            ;strobe off
062B                3280               OUT    PDATA
062B                3290               ORI    128            ;strobe on
062B                3300               OUT    PDATA
062B                3310               XRA    A              ;clear C flag
062B                3320               RET                   ;return
062B                3330 *
062B                3340               ENDIF
062B                3350 * -----
062B                3360               IFF    ANY            ;if no printer at all
062B                3370               PRT    'No printer'
062B                3380 *
062B C3 92 07       3390 L01           JMP    @CDOUT         ;dummy routine
062E                3400 *
062E                3410               ENDIF
062E                3420 * -----
062E                3430 *
062E                3440               IFT    OTHR           ;special driver
062E                3450               PRT    'Special printer'
062E                3460 *
062E                3470 L01           RET                   ;user must write special driver
062E                3480 *
062E                3490               ENDIF
062E                3500 * -----
062E                3510 *
062E                3520               PRT    'End = ',$
062E                3530 *
062E                3540               END    RES
```

APPENDIX F - MICROPOLIS DISK BOOTSTRAP

The Micropolis Disk Bootstrap Program resides in PROM on the controller B board, occupying the first 512 bytes of the controller address space. The bootstrap is involved by starting program execution at the base address of the controller. An address-independent relocator determines the controller base address and moves the bootstrap code from PROM to low RAM system memory where it is executed. The Bootstrap Program selects drive unit Ø and reads the contents of sector Ø of track Ø (the System Loader Program) into memory. Sector Ø must be formatted as described in Section 6.1.2 and must be organized as follows:

Byte Ø	Track ID
Byte 1	Sector ID
Byte 2-11	(Ignored)
Byte 12-265	System Loader Program
Byte 266-267	Load Address

Sector Ø is read into RAM at the system loader origin specified by bytes 266 and 267. After a successful read, the bootstrap transfers control to load address +12. The DE register pair will contain the controller base address.

The Bootstrap Program requires approximately 1K of RAM memory from address 9ØH.

```
            ****************************************
            *                                      *
            *      MICROPOLIS DISK BOOTSTRAP       *
            *                                      *
            *      VERSION 2 -- RELOCATABLE        *
            *      BOOTSTRAP - OPERATES WITH       *
            *      CONTROLLER STRAPPED FOR ANY     *
            *      LOCATION FROM C000H-FC00H       *
            *                                      *
            *      PROM PART NUMBERS:              *
            *           HIGH   800003-01-4C        *
            *           LOW    800003-02-2C        *
            *                                      *
            *      RELEASE 1.0                     *
            *   COPYRIGHT MICROPOLIS CORPORATION   *
            *      OCTOBER 11 1977                 *
            *                                      *
            ****************************************
            *
            ****************************************
            *      REGISTER DEFINITIONS AND        *
            *      FLAG EQUATES FOR MICROPOLIS     *
            *      FLEXIBLE DISK CONTROLLER B      *
            ****************************************
            *
            *
            *
F400        BPROM  EQU  X'F400'
            *      DEFINITIONS GIVEN FOR STANDARD
            *      ADDRESS OF F400H -- CONTROLLER
            *      MAY ACTUALLY BE STRAPPED FOR
            *      ANY 1K BOUNDARY FROM C000H -FC00H
            *
F600        DISK   EQU  BPROM+X'0200'
            *
            *      DATA REGISTERS
            *
F602        WDATA  EQU  DISK+X'02'
F602        RDATA  EQU  WDATA
            *
            *      STATUS REGISTERS
            *
F600        DSECTR EQU  DISK
            *    0-3    SECTOR COUNT
            *      4    SPARE
            *      5    SPARE
            *      6    SCTR INTERRUPT FLAG
            *      7    SECTOR FLAG
            *
            *      FLAG BITS
            *
0040        SIFLG  EQU  X'40'
0080        SFLG   EQU  X'80'
0020        DTMR   EQU  X'20'
            *
            *
F601        DSTAT  EQU  DISK+1
```

```
            *    Ø-1    UNIT ADDRESS
            *      2    UNIT SELECTED (LOW TRUE)
            *      3    TRACK Ø
            *      4    WRITE PROTECT
            *      5    DISK READY
            *      6    PINTE
            *      7    TRANSFER FLAG
            *
            *      FLAG BITS
            *
ØØ8Ø        TFLG   EQU  X'8Ø'
ØØ4Ø        INTE   EQU  X'4Ø'
ØØ2Ø        RDY    EQU  X'2Ø'
ØØ1Ø        WPT    EQU  X'1Ø'
ØØØ8        TKØ    EQU  X'Ø8'
ØØØ4        USLT   EQU  X'Ø4'
            *
            *
            *      COMMAND REGISTER
            *
F6ØØ        DCMND  EQU  DISK
            *(ALSO WILL RESPOND TO DISK+1)
            *
            *    Ø-1    COMMAND MODIFIER
            *    5-7    COMMAND
            *
            *      COMMANDS
            *
ØØ2Ø        SLUN   EQU  X'2Ø'     SELECT UNIT
            *      MODIFIER CONTAINS UNIT ADDRESS
ØØ4Ø        SINT   EQU  X'4Ø'     SET INTERRUPT
            *      MODIFIER =1 ENABLE INTERRUPT
            *               =Ø DISABLE INTERRUPT
ØØ6Ø        STEP   EQU  X'6Ø'     STEP CARRIAGE
            *      MODIFIER =ØØ STEP OUT
            *               =Ø1 STEP IN
ØØ8Ø        WRITE  EQU  X'8Ø'     ENABLE WRITE
            *      NO MODIFIER USED
ØØAØ        RESET  EQU  X'AØ'     RESET CONTROLLER
            *      NO MODIFIER USED
            *
            *
            *      DISK PARAMETERS
            *
ØØØF        SDLY   EQU  15        STEP+SETTLE TIME
            *                     DIVIDED BY 2.6775
ØØ86        BYTCT  EQU  134       BYTCT/2
            *
            *
            ****************************************
            *                                      *
            *      PROM-RESIDENT BOOTSTRAP         *
            *                                      *
            ****************************************
            *
            *      BOOTSTRAP REQUIRES AT LEAST 1K
            *      OF RAM MEMORY FROM 9ØH
```

```
                   *
                   *      RELOCATES FROM PROM INTO RAM THEN
                   *      BOOTSTRAP LOADS SECTOR ZERØ OF
                   *      TRACK ZERO INTO RAM AND STARTS
                   *      THE PROGRAM LOADED
                   *
                   *      SECTOR ZERØ IS ORGANIZED AS
                   *      FOLLOWS:
                   *      BYTES Ø-1       HEADER
                   *      BYTES 2-265     USER PROGRAM
                   *      BYTES 266-267   RAM ADDRESS
                   *
                   *      BOOTSTRAP WILL READ SECTOR ZERO
                   *      INTO RAM STARTING AT THE
                   *      ADDRESS SPECIFIED BY BYTES
                   *      266 & 267 AND WILL START
                   *      THE PROGRAM AT RAM ADDRESS +12
                   *
                   *
                   *
ØØAØ               CTORG  EQU  X'AØ'       CONTROLLER BASE
                   *                       ADDRESS SAVED HERE
                   *
ØØØØ                      ORG  CTORG-X'35' CTORG+2-RLCLEN)
                   *
                   *      RELOCATOR -- MOVES BOOTSTRAP INTO
                   *      RAM AND STARTS BOOTSTRAP
                   *
ØØ6B F3            RELOC  DI
ØØ6C 21A2ØØ               LXI  H,CTORG+2 STUFF A RETURN IN
ØØ6F F9                   SPHL           RAM AND CALL IT TO
ØØ7Ø 36C9                 MVI  M,X'C9'   DETERMINE ADDRESS
ØØ72 CDA2ØØ               CALL CTORG+2   OF CONTROLLER
ØØ75 EB                   XCHG           SAVE RAM ADDR
ØØ76 2AAØØØ               LHLD CTORG     GET ADDRESS WHICH
ØØ79 2EØØ                 MVI  L,Ø       WAS PUSHED ON STAC
ØØ7B E5                   PUSH H         MSB IS CTLR ADDR
ØØ7C Ø11DØØ               LXI  B,BTDSP1  BUILD MOVE LOOP
ØØ7F Ø9                   DAD  B         ADDRESS
ØØ8Ø E5                   PUSH H         STUFF ON STACK
ØØ81 E1                   POP  H         ADJUST SP
ØØ82 ØE1A                 MVI  C,BTDSP2  BUMP HL TO START
ØØ84 Ø9                   DAD  B         OF BOOT CODE
ØØ85 Ø6BD                 MVI  B,BTLEN
ØØ87 EB                   XCHG
ØØ88 3B            REØ1Ø  DCX  SP        ADJUST SP TO POINT
ØØ89 3B                   DCX  SP        TO REØ1Ø ON STACK
ØØ8A 1A                   LDAX D         MOVE BYTE FROM
ØØ8B 77                   MOV  M,A       PROM TO RAM
                   *
                   *      COMPARE MEMORY WITH A REG --
                   *      IF DIFFERENT THEN DESTINATION
                   *      RAM IS BAD OR IS PROM --
                   *      RELOCATOR WILL LOOP IN MOVE
                   *      LOOP UNTIL SUCCESSFUL
                   *
ØØ8C BE                   CMP  M         GOOD MOVE?
```

```
008D C0             RNZ            NO-LOOP
008E 23             INX  H
008F 13             INX  D
0090 05             DCR  B         DONE?
0091 C0             RNZ            NO-LOOP
0092 E1             POP  H         YES-CLEAN UP STACK
0093 2AA000         LHLD CTORG     BUILD CONTROLLER
0096 110002         LXI  D,X'200'  ADDRESS FROM BASE
0099 19             DAD  D
009A 22A200         SHLD DADR      AND SAVE
009D 36A0           MVI  M,RESET   RESET CONTROLLER
009F C3D400         JMP  SL010     AND GO START BOOT
            *
001D        BTDSP1 EQU  RE010-RELOC
001A        BTDSP2 EQU  *-RE010
0037        RLCLEN EQU  *-RELOC
            *
00A2        BOOT   EQU  *
00A2        DADR   DS   2
00A4        LDRST  DS   2
            *
            *
            *
            *      READ 1 SECTOR
            *
            *
            *      B=SECTOR
            *      C=BYTECOUNT /2
            *      DE=READ BUFFER
            *
            *      A,HL ARE DESTROYED
            *
            *      RETURNS Z=OK
            *              NZ=ERROR
            *
            *
            *      WAIT FOR DESIRED SECTOR
            *
00A6 2AA200 RDSEC  LHLD DADR
00A9 7E            MOV  A,M        WAIT SCTR FLAG
00AA E680          ANI  SFLG
00AC CAA900        JZ   RDSEC+3
00AF 7E            MOV  A,M        OK-IS THIS THE
00B0 E60F          ANI  X'0F'      DESIRED SCTR?
00B2 A8            XRA  B
00B3 C2A900        JNZ  RDSEC+3    NO-WAIT
            *
            *      FOUND DESIRED SECTOR GO READ
            *
00B6 23            INX  H
            *
            *
00B7 B6     RD005  ORA  M          WAIT FOR TRANSFER
            *                      FLAG
00B8 F2B700        JP   RD005
            *
            *      TRANSFER FLAG SET-STRIP
```

```
                 *       SYNC BYTE
                 *
ØØBB 23                  INX  H
ØØBC 7E                  MOV  A,M       READ SYNC BYTE
ØØBD AF                  XRA  A         CLEAR CARRY
ØØBE EB                  XCHG
ØØBF Ø6ØØ                MVI  B,Ø       AND CHECKSUM
ØØC1 ØØ                  NOP
ØØC2 ØØ                  NOP
                 *
                 *       READ LOOP
                 *
ØØC3 1A          RDØ1Ø   LDAX D         READ FROM DISK
ØØC4 77                  MOV  M,A       MOVE TO BUFFER
ØØC5 23                  INX  H         NEXT LOC
ØØC6 88                  ADC  B         ADD TO CHECKSUM
ØØC7 47                  MOV  B,A       AND SAVE
ØØC8 1A                  LDAX D         NEXT READ
ØØC9 77                  MOV  M,A       -ETC-
ØØCA 23                  INX  H
ØØCB 88                  ADC  B
ØØCC 47                  MOV  B,A
ØØCD ØD                  DCR  C         END OF DATA?
ØØCE C2C3ØØ              JNZ  RDØ1Ø     NO-LOOP
                 *
                 *       END OF DATA-READ CHECKSUM
                 *
ØØD1 1A                  LDAX D
ØØD2 B8                  CMP  B         COMPARE WITH
ØØD3 C9                  RET            COMPUTED CHECKSUM
                 *
                 *
                 *
                 *
                 *
                 *
                 *       SELECT DRIVE Ø
                 *
                 *
ØØD4 2AA2ØØ      SLØ1Ø   LHLD DADR      SELECT DRIVE
ØØD7 362Ø                MVI  M,SLUN
ØØD9 23                  INX  H
ØØDA 7E                  MOV  A,M
ØØDB 2B                  DCX  H
ØØDC E624                ANI  RDY+USLT  CHECK SLTD & RDY
ØØDE EE2Ø                XRI  RDY       WAIT UNTIL OK
ØØEØ C2D4ØØ              JNZ  SLØ1Ø     TO PROCEED
                 *
                 *                      WAIT 25Ø MSEC
ØØE3 ØE5E                MVI  C,94      FOR SECTOR CNTR
ØØE5 CD49Ø1              CALL TIMER     TO SYNC
ØØE8 23          SLØ2Ø   INX  H
ØØE9 7E                  MOV  A,M       READ STATUS AGAIN
ØØEA 2B                  DCX  H
ØØEB E624                ANI  RDY+USLT  TO ENSURE STILL
ØØED EE2Ø                XRI  RDY       OK TO PROCEED
ØØEF C2D4ØØ              JNZ  SLØ1Ø     NO-TRY AGAIN
```

```
                    *
                    *       RESTORE DRIVE TO TRACK 0
                    *
00F2 23             CZERO   INX  H           READ STATUS
00F3 7E                     MOV  A,M
00F4 E608                   ANI  TK0         TRACK 0?
00F6 2B                     DCX  H
00F7 CA0701                 JZ   CZ030       NO-PRESS ON
                    *
                    *       IF ALREADY AT TRACK ZERO
                    *       STEP IN THEN BACK OUT
                    *       TO ENSURE A GOOD POSITION
                    *
00FA 0608                   MVI  B,8         STEP IN 8 TKS
00FC 3661           CZ010   MVI  M,STEP+1    STEP IN
00FE 0E0F                   MVI  C,SDLY      DELAY SEEK +
0100 CD4901                 CALL TIMER       SETTLE TIME
0103 05             CZ020   DCR  B
0104 C2FC00                 JNZ  CZ010       LOOP UNTIL IN
                    *
0107 23             CZ030   INX  H           READ STATUS
0108 7E                     MOV  A,M         TRACK 0?
0109 E608                   ANI  TK0
010B 2B                     DCX  H
010C C21901                 JNZ  RSZERO      YES-PRESS ON
010F 3660                   MVI  M,STEP      NO-STEP OUT
0111 0E0F                   MVI  C,SDLY      DELAY
0113 CD4901                 CALL TIMER       THEN TEST AGAIN
0116 C30701                 JMP  CZ030
                    *
                    *       READ THROUGH SECTOR ZERO
                    *       ONE TIME TO FIND RAM ADDRESS
                    *       THEN READ PROGRAM IN & START
                    *
0119 215F21         RSZERO  LXI  H,BTBUF
011C CD3701                 CALL RZER0       READ SCTR ZERO-
011F C2D400                 JNZ  SL010       RESEEK IF HDR BAD
0122 2A6902                 LHLD BTBUF+266 GET PGM ADDRESS
0125 22A400                 SHLD LDRST       GO LOAD PGM
0128 CD3701                 CALL RZER0
012B C2D400                 JNZ  SL010       RESEEK IF HDR BAD
012E 2AA400                 LHLD LDRST       COMPUTE START
0131 110C00                 LXI  D,12        ADDRESS AND GO
0134 19                     DAD  D           START PROGRAM
0135 D1                     POP  D           (CTLR CRG STILL
0136 E9                     PCHL             ON STACK)
                    *
0137 E5             RZER0   PUSH H           SAVE RAM ADDRESS
0138 EB                     XCHG             DE<-ADDRESS
0139 018600                 LXI  B.BYTCT
013C CDA600                 CALL RDSEC       READ IN SECTOR 0
013F E1                     POP  H
0140 C23701                 JNZ  RZER0       RETRY IF CKSUM ERR
0143 E5                     PUSH H
0144 7E                     MOV  A,M         CHECK HEADER
0145 23                     INX  H
0146 B6                     ORA  M
```

APPENDIX G - "FEATURES" PROGRAM TO OPTIONALLY SHORTEN BASIC

M.BASIC contains features which are very useful during program development but unnecessary when running debugged production programs. It is possible to selectively delete some or all of these features. When these features are removed the program buffer (user's program space) is enlarged. Without removing them, the program buffer begins at 5D86 (Hex) whereas when all the features which can be removed are removed, the program buffer begins at 57ØØ. This is the same place it did in version 3.Ø of M.BASIC.

A special assembly languge program called FEATURES is supplied to selectively remove features from BASIC. The three features which can be removed are MERGE, RENUM, and EDIT. The procedure is as follows:

1) Load BASIC fron an MDOS system diskette or from a BASIC-only diskette. This must be BASIC version 4.Ø.

2) Type LINK "FEATURES" then depress (return).

3) The program will then begin by displaying:

```
BASIC V.S. 4.Ø FEATURES PROGRAM

ENTER NUMBER OF DESIRED FUNCTION (CONTROL-C TO EXIT)

1-REMOVE MERGE
2-REMOVE RENUM AND MERGE
3-REMOVE EDIT, RENUM AND MERGE

?
```

4) Select the desired function and enter its number. You have only the 3 choices given. The program will begin executing as soon as you touch one of the number keys. If you want to return to BASIC rather than executing the program, depress control-C (hold CTRL key down while depressing the letter C) instead of one of the numbers.

5) When the selected features are removed, the system is returned to BASIC automatically.

NOTE: If you run the FEATURES program using a disk whose BASIC is already shortened and if you select any of the features which had been removed, then the program will set the beginning of the program buffer back to where it was originally, as if the feature had not been removed, but the feature itself will not be added back on. Thus, the program buffer will be shrunk, but you will not have the feature. In short, be careful that you do not try to remove a feature that has already been removed.

The shortened BASIC created by the FEATURES program may be saved ona newly initialized diskette for use as a BASIC-only diskette. Follow the procedure in Appendix B before you exit from BASIC, in order to do this.

The shortened BASIC can also be saved on your Personalized MDOS System Diskette, or a copy of it. To do this, type the following lines after BASIC's "READY" prompt, with the desired system disk in drive Ø (each line is followed by depressing return):

```
OPEN 1 "BASIC":ATTRS(1)=Ø
SCRATCH "BASIC"
SAVE "BASIC" 16R1572, 16R5DFF
ATTRS(1)=16RF:CLOSE 1
```

Following the last line, your system diskette has a copy of the shortened version of BASIC, which will be used everytime you enter the command BASIC. You can use the DISKCOPY command in MDOS to copy this sytem diskette.

If you do not save your shortened BASIC in one of these ways, then since it only exists in the system's memory, it will be lost when you turn the power off or return to MDOS. Until then, you can use it for programming in BASIC.

APPENDIX H - INTERFACING TO A CENTRONICS PRINTER

Centronics Printer

VECTOR GRAPHIC PRINTER INTERFACE

General

The Vector Graphic Printer Interface provides the means to connect a Centronics line printer such as the 700 series of printers or equivalent to the Vector MZ or other Vector Graphic microcomputers. The interface is designed to utilize the Vector Graphic Bit Streamer I/O board parallel ports via connection to one input port and one output port.

The software driver program monitors the BUSY signal from the printer and when the printer is not BUSY (BUSY=0) the program may transfer a character of data at which time the printer BUSY signal goes true thus holding off data transmission until the printer is once again ready to accept data.

I/O PORT BIT ASSIGNMENTS

PORT 01 OUTPUT

BIT	7	6	5	4	3	2	1	0
	STROBE	DATA 6	DATA 5	DATA 4	DATA 3	DATA 2	DATA 1	DATA 0

PORT 01 INPUT

BIT	7	6	5	4	3	2	1	0
	—	—	—	—	—	—	—	BUSY

INTERFACE PARTS LIST

1 ea	Serial I/O cable (Bit Streamer to Vector MZ backpanel.
1 ea	Printer cable (Vector MZ backpanel to printer)
1 ea	6 pin Molex connector.

INSTALLATION INSTRUCTIONS

CAUTION - Power must be off before proceeding with installation.

1. Bit Streamer I/O Board

   a) Cut the circuit trace at J3-19.
   b) Add a short jumper wire from J3-19 to J2-17.
   c) Add the 6 pin Molex connector on the circuit or back side of the board as shown in Figure 1.
   d) Install the Bit Streamer in a chassis slot near the back panel of the computer chassis.
   e) Plug in the 24 pin dip plug (part of the I/O cable) into J3 of the Bit Streamer. If your computer does not have this cable (Vector P/N IO-1327) one must be obtained.

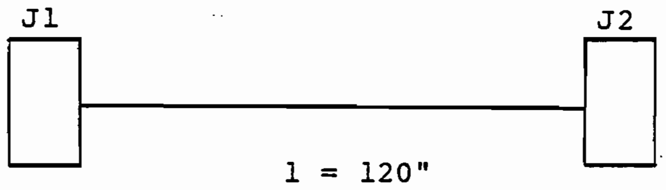
2. Serial I/O Cable

   a) Install the serial I/O cable in the Vector MZ with the 25 pin connector attached in an available cutout on the rear panel and connect the 6 pin Molex plug to the Bit Streamer as shown in Figure 1. This now becomes the connector to use with your terminal (Hazeltine, etc).

CABLE WIRE LIST AND DIAGRAM

VECTOR MZ/CENTRONICS I/O CABLE

J1 VECTOR MZ	J2 CENTRONICS	CENTRONICS SIGNAL NAME	COMPUTER SIGNAL NAME
6	11	BUSY	port 01 bit 0 IN
25	7	DATA 6	port 01 bit 5 OUT
24	6	DATA 5	port 01 bit 4 OUT
16	3	DATA 2	port 01 bit 1 OUT
15	4	DATA 3	port 01 bit 2 OUT
17	2	DATA 1	port 01 bit 0 OUT
12	8	DATA 7	port 01 bit 6 OUT
14	5	DATA 4	port 01 bit 3 OUT
11	1	STROBE	port 01 bit 7 OUT
7	16	GROUND	-



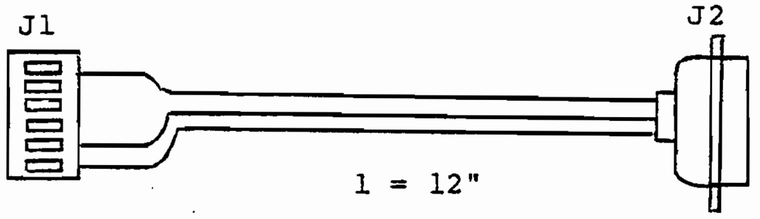
DB-25P

Amphenol 57-30360
or equiv.

CABLE WIRE LIST AND DIAGRAM

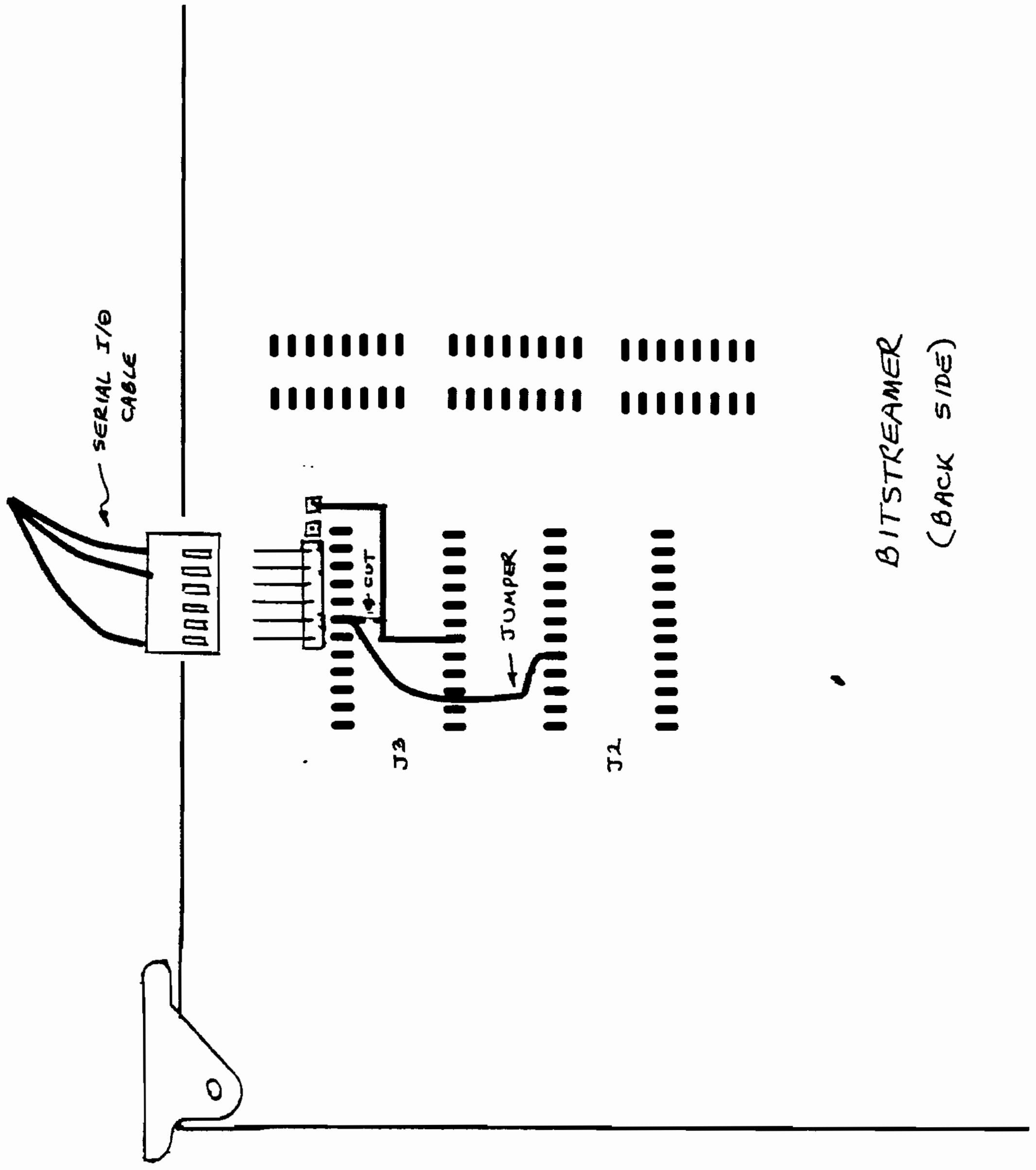
SERIAL I/O CABLE

J1 BIT STREAMER	J2 VECTOR MZ BACK PANEL	SIGNAL NAME
1	7	GROUND
5	3	TRANSMIT DATA
6	2	RECEIVE DATA



6 Pin Molex

DB-25S



BITSTREAMER (BACK SIDE)

FIGURE 1

APPENDIX I - TROUBLE SHOOTING IF MDOS DOES NOT LOAD

This section is applicable the first time you attempt to load MDOS using the Extended System Monitor B command.

1) If the disk drive select light does not go on in response to command B, check the connection between the mainframe and the console. If this is not the problem, then the system requires attention by the dealer or by Vector Graphic.

2) If the MDOS has not signed on within 2Ø seconds, but the disk drive select indicator light is still glowing, the bootstrap ROM has been unable to read the loader into memory from the diskette. Depress RESET. Check whether the correct diskette was inserted in the correct drive, that it is inserted facing correctly (label leftward or upward), and that it is fully inserted and fully mounted (snapped into place). If not the problem, inspect the diskette for obvious contamination or damage. Reload the diskette and begin again with the Monitor B command.

3) If the system has not signed on but the unit select indicator has extinguished, the loader may not have been able to read the rest of the system into memory. The probable cause is a malfunctioning memory chip. Use the Extended Systems Monitor command N to test memory. (See the Extended Systems Monitor manual.) If this test terminates at a value below CØØØH (i.e. 48K), it indicates malfunctioning memory: The ending address is the location of the malfunction. If N reveals no problem, then try command T, a more thorough memory test. Use the ending address given by command N, less 1, as the second address in the command T argument, and use ØØØØ as the first address. To use an Extended System Monitor command, depress RESET on the front panel of the mainframe. Then enter the command you want, after the Monitor prompt * appears.

4) If there is no problem with memory, the system requires attention by a service representative.

APPENDIX J - GAMES AND DISPLAYS ON THE MDOS SYSTEM DISKETTE

STARTREKG, CIVILWAR, and LUNAR are games written in BASIC. Get into BASIC, then enter:

PLOADG "<game name>" (return).

The games are self-explanatory, with the exception of STARTREKG. STARTREKG uses the classic set of rules familiar to all computer Startrek aficianados. For others, a little trial and error gets the player going.

FINANCE is a BASIC program for computing various interest and annuity problems. It is useful on a day-to-day basis for users working with investment problems. Its operation is self-explanatory. To start it, use the PLOADG command as with games, above.

FLASH7 is a demonstration of the graphics capability of the Flashwriter II board. Do not attempt to use it unless your system uses this board, indicated by 80 X 24 display on a video monitor or Mindless Terminal. Also, it will not work if the system is set up to run word-processing (i.e. it is a MEMORITE II system, or the Word Management System character generator PROM's have been installed on the Flashwriter II board.) It will only work if the system has the graphics character generator PROM's which are installed when MZ systems are manufacturerd.

To use FLASH7, mount an MDOS System diskette in drive 0. Get into the MDOS command mode (usually done by depressing B (return) after turning on or reseting the machine.) Then type FLASH7 (return). The program will begin executing, showing off the many features of the Flashwriter II board, including graphics, lack of glitches on screen, multiple cursors, reverse video, and so on. The program will execute indefinitely by repeating itself until halted by the operator with the RESET botton. This program is an excellent demo for dealers. (Dealers who want to demo Word Management System on the same system must forego it, however.)

The operator may interact with FLASH7 (unlike the earlier FLASH6) in various ways. First, touching the space bar at most times will freeze the screen, for closer examination. Another space bar will resume the demo. Second, the operator can cause the demo to jump directly to any of several points within its cycle, if that particular part of the demo is of special interest. This is accomplished by pressing one of the following letters at almost any time while the demo is operating:

letter	part of demo	letter	part of demo
C	Character Set	B	Introducing System B
R	Sphere	L	Higher Level Languages
G	Gettysburg Address	S	Bubble Sort
D	Darth Vader		

APPENDIX K - CHANGING MICROPOLIS BOOTSTRAP ROM AND DISK I/O ADDRESSES

The disk Bootstrap ROM and Disk Controller I/O addresses are located in the 1K block from the base address D8ØØ to DBFF.

The user may change this location by changing jumpers on the disk controller board. If this is done, however, the B command in the Extended Systems Monitor will no longer function, unless the new base address is F4ØØ. If not, in place of B, the operator must use the G command followed by the new base address.

No software changes are necessary. Disk I/O routines in the RES module automatically find the disk controller and Bootstrap addresses.

This is also true if the CP/M operating system is used. However, the MEMORITE and Word Management System word processing software, and the MZOS operating system, can only function with the disk controller and Bootstrap block beginning at the normal D8ØØ location.

Use the following procedure to change the location of the block:

1. Refer to figure K.1, locate the base address desired and determine the jumpers required.

2. Referring to figure K.2, locate the address jumper locations on the controller board. Vector Graphic ships the board with jumpers W1 and W4 installed.

3. Remove one or both of the installed jumpers and replace with jumpers required for the desired address. Use short lengths of wire, a 25-3Ø watt soldering iron, and resin-core solder. To avoid blowing LSI chips with static electricity, do not work in a carpeted room. Touch the contacts on the board edge with one hand before beginning to solder.

		ADDRESS BIT											
		JUMPER											
		A15	A14	A13	A12	A11	A10	A9	A8	JUMPER INSTALLED			
	BASE ADDRESS	N/A		W1	W2	W3	W4	N/A		W1	W2	W3	W4
STANDARD ADDRESS	C0 00 - C3FF	1	1	0	0	0	0	0	0	Y	Y	Y	Y
	C4 00 - C7FF	1	1	0	0	0	1	0	0	Y	Y	Y	N
	C8 00 - CBFF	1	1	0	0	1	0	0	0	Y	Y	N	Y
	CC 00 - CFFF	1	1	0	0	1	1	0	0	Y	Y	N	N
	D0 00 - D3FF	1	1	0	1	0	0	0	0	Y	N	Y	Y
	D4 00 - D7FF	1	1	0	1	0	1	0	0	Y	N	Y	N
	D8 00 - DBFF	1	1	0	1	1	0	0	0	Y	N	N	Y
	DC 00 - DFFF	1	1	0	1	1	1	0	0	Y	N	N	N
	E0 00 - E3FF	1	1	1	0	0	0	0	0	N	Y	Y	Y
	E4 00 - E7FF	1	1	1	0	0	1	0	0	N	Y	Y	N
	E8 00 - EBFF	1	1	1	0	1	0	0	0	N	Y	N	Y
	EC 00 - EFFF	1	1	1	0	1	1	0	0	N	Y	N	N
	F0 00 - F3FF	1	1	1	1	0	0	0	0	N	N	Y	Y
	F4 00 - F7FF	1	1	1	1	0	1	0	0	N	N	Y	N
	F8 00 - FBFF	1	1	1	1	1	0	0	0	N	N	N	Y
	FC 00 - FFFF	1	1	1	1	1	1	0	0	N	N	N	N

As an example, if you wish to use base address F400 install jumper at W3.

Figure K.1 Controller Base Address Jumper Configurations

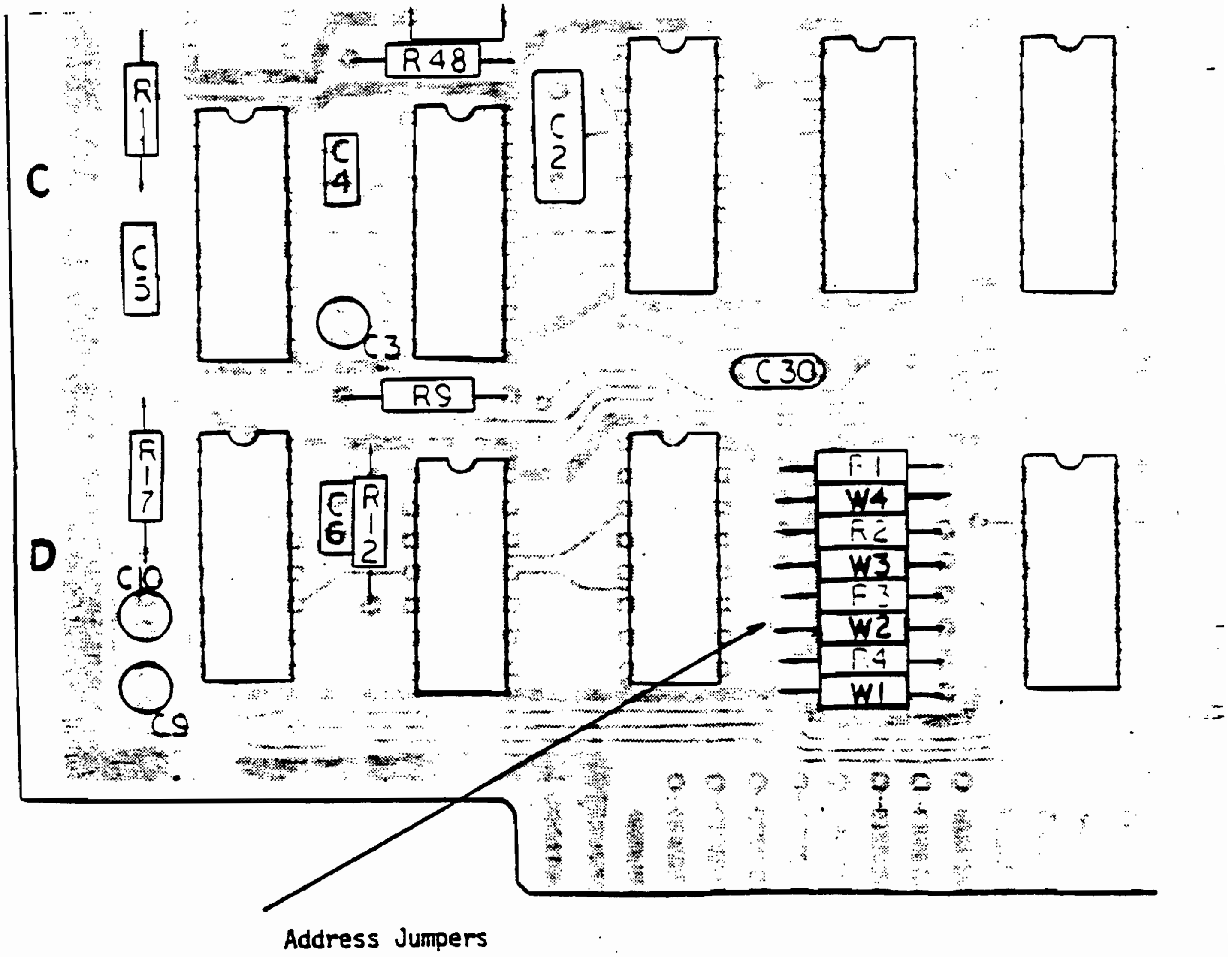


Figure K.2 Locating The Controller Address Jumpers

APPENDIX L - CHANGING CLOCK RATE TO 2 MHz

To operate the system at 2 MHz speeds, a jumper must be removed from the disk controller board, as follows:

1) Refer to figure L.1. Locate the ribbon cable edge connector and the resistors R25, R6 and R7.

2) Between R25 and R6 is a jumper location, W9. Remove the jumper there with a 25-3Ø watt soldering iron. To avoid blowing LSI chips with static electricity, do not work in a carpeted room. Touch the contacts on the board edge with one hand before beginning to solder.

A jumper must then be added to the Z-8Ø board at location "A". Location "A" will be found under the top row of chips, directly under the third chip from the left, U3. If necessary, refer to the figure found in the Z-8Ø Board User's Manual.

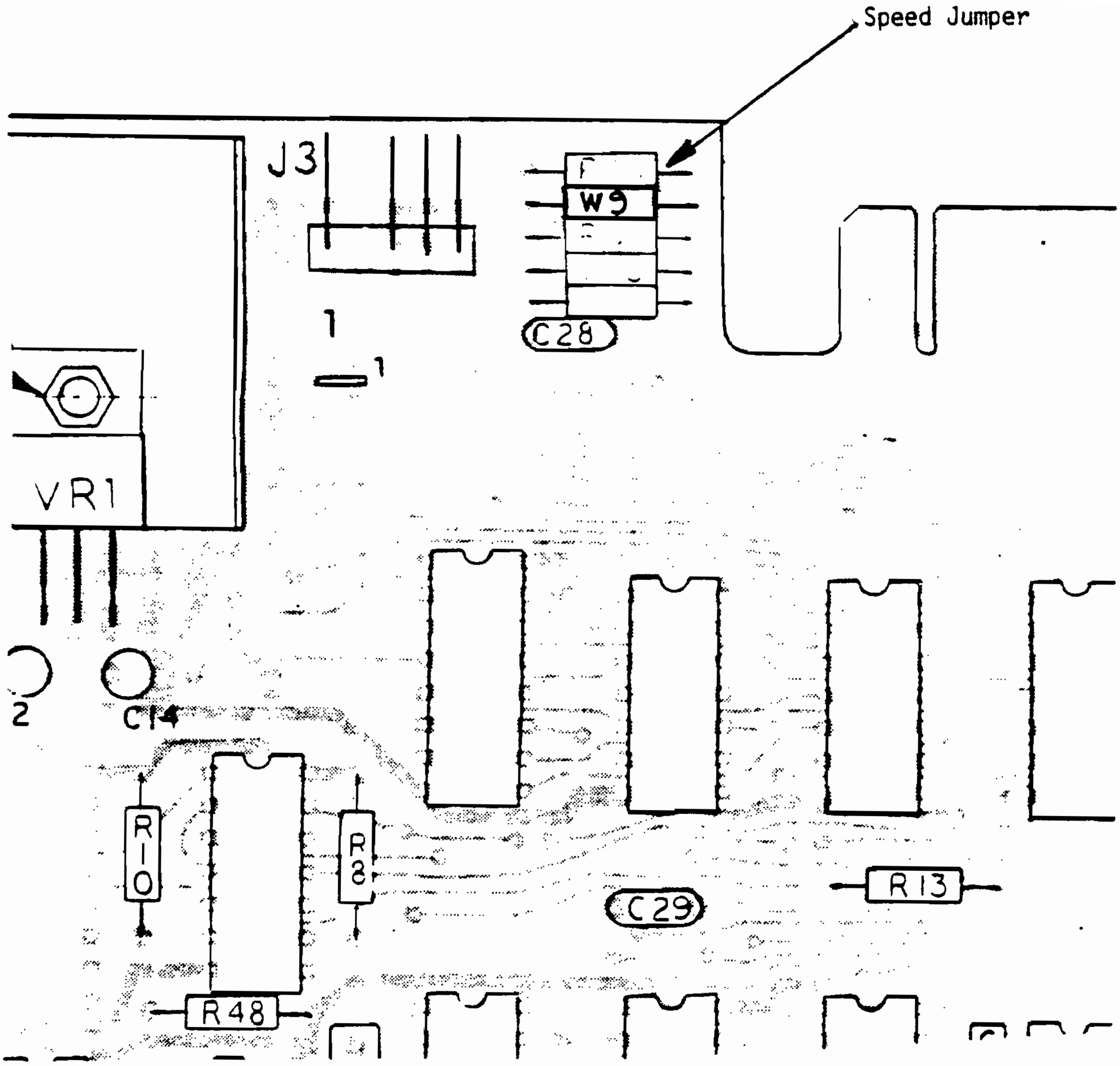


Figure L.1 Locating the controller processor speed jumper

APPENDIX M - WRITING A CONSOLE PHYSICAL I/O ROUTINE

For users wishing to replace the console physical driver in the Vector Graphic Extended Systems Monitor, this section describes the console I/O requirements of the RES module.

Your version should be written in place of the routines in RES.I/O found from lines 225Ø to 254Ø. RES.I/O is the source code for the I/O routines in the RES module. It will be found on your MDOS System Diskettes. The listing is in Appendix E.

If there are any other routines to rewrite, such as printer routines, do this before assembling RES.I/O. To assemble RES.I/O refer to Appendix O where the procedures are explained.

1) Lines 72Ø - 75Ø in the @CIOABLE can be changed if required.

2) The logical input, output and break check routines (CIN, COUT, and CBRK) should not have to be changed. They are tailored to support all MDOS and BASIC requirements.

3) The console physical input routine (CDIN) must have the following characteristics:

   a) It must return all registers except A & B unchanged.
   b) It can use the A register (destroy it).
   c) It must return an ASCII character including the parity bit if any, in the B register.
   d) It must return the carry flag clear (NC). The other status flags can be in any state.

4) The console physical output routine (CDOUT) must have the following characteristics:

   a) It must take an ASCII character in the B register.
   b) It must return all registers except A unchanged.
   c) It can use the A register (destroy it).
   d) It must return the carry flag clear (NC).
   e) The other status flags can be in any state.

5) The console physical break check routine (CDBRK) must have the following characteristics:

   a) It must check the console input status port to determine if a key has been pressed.
   b) If no key has been pressed it must return all registers except A unchanged and the zero flag clear (NZ).
   c) If a key has been pressed it must return the byte, in the B register. The A register can be used (destroyed). All other registers must be unchanged. The zero flag must be set (Z).
   d) The status flags other than zero can be in any state.

6) It will probably not be necessary to change the Physcial

Console Device Initialize routine (CDINIT).

APPENDIX N - WRITING A PRINTER PHYSICAL I/O ROUTINE

This Appendix is used when you want to write a custom version of the printer physical I/O routines in the RES module.

1) RES.I/O is an assembly language source code file found on the MDOS System Diskettes. In order to rewrite any part of the I/O routines in the RES module, rewrite the relevent portions of this source file, using the Line Editor in MDOS. Note that RES.I/O is not the source file for the entire RES module, but only the I/O portion of it.

2) Write the your printer driver routine beginning at line 3470 in the RES.I/O. Make sure the contents of lines 3520-3540 are at the end of your routine. The first line must use the label L01, not LDOUT. Do not over-write the other printer physical I/O routines in the Source code (only yours will be assembled, as you will see.) The parts of the new routine must have the following characteristics:

   a) The character to be output is passed to the physical output routine in the B register in ASCII.

   b) The physical output routine can use (destroy) the A register.

   c) All registers except A must be returned unchanged.

   d) Some printers can signal when paper is out, the motor is off, or they are out of ribbon. The system supports printers which can signal a PRINTER ATTENTION condition. If the printer needs attention, the physical output routine should return with the carry flag set (C). If your printer does not support a printer attention condition, then always return with the carry clear (NC). The other status flags can be returned in any state. LDATN, the routine which handles printer attention, must not destroy any registers except A.

3) Lines 890-920 in the @LIOTABLE can be changed if desired.

4) The present contents of lines 3520 - 3540 must be at the end of your routine, or it will not assemble.

5) Turn to Appendix 0 when you are ready to assembly and save the new RES module.

APPENDIX O - REASSEMBLING AND SAVING THE RES MODULE

Follow the procedure in this appendix after you have modified the RES.I/O source code using the Line Editor in MDOS. When you are done with this appendix, the RES module program will be modified on your MDOS System Diskette, and ready to use.

1) Mount Personalized MDOS System Diskette in Drive 0.

2) In MDOS, enter ZSM "RES.I/O" "CRES" "E" (return).

3) Four questions will appear on the screen one after the other. Your answers to these questions tell the assembler which printer driver to include in the assembled code. Your choices will be a standard Diablo protocol driver, a standard Centronics protocol driver, a standard Decwriter and Teletype protocol driver, or a driver you have written yourself according to the instructions in Appendix N. As each question appears, depress a 0 if you do not want that driver, or a 1 if you do. Answer 1 to only one of the questions, and 0 to the other three. If you did not write your own and are not sure which of the three standard drivers you need, review section 2.2 in Chapter 2 which includes examples of the different types of printers.

4) After the fourth question, another question will appear on the screen, asking "Bitstreamer base address?" The answer to this question is 0 if the Bitstreamer board is jumpered to respond to port #'s 0, 1, 2, and 3, and it is 4 if the Bitstreamer board is jumpered to respond to port #'s 4, 5, 6, and 7. Generally, the former is the case if you are using a serial terminal such as a Hazeltine, and the latter is the case if you are using a Flashwriter board to interface a memory-mapped terminal such as Vector Graphic's Mindless Terminal or a memory-mapped video monitor such as a Hitachi. (If for some reason you have chosen to jumper the Bitstreamer board for a different set of port #'s, then respond with the lowest # of the set you are using.)

5) After the last question, the object code will be assembled. At the end of the assembly , the message "END = XXXX" will appear. This value must be under 0700. If it is not, then the routines you have written are too long, and must be shortened.

6) At this point, with the code successfully assembled, the new I/O portion of the RES module is on disk as a temporary file called "CRES" but not yet overlayed over the entire RES module on the system diskette. To do this, enter TYPE "CRES" C (return), and then CRES (return). Finally, type SCRATCH "CRES" (return) to clear this workfile from the disk.

7) The complete RES module with all changes is now in memory, but not yet stored on disk. Debug it now. Proceed when it

is finalized.

8) To save the new RES module, follow the instructions in Section 2.2.0 of this manual.

10) NOTE: Do not overlay one of the pre-written printer drivers as instructed in Chapter 2, sections 2.2.1 and 2.2.2. Steps 3 and 4 above already installed the correct driver.

APPENDIX P - MAP OF I/O PORTS

On the following page you will find a chart which lists all the I/O ports that an 8080 or Z80 can address, in hexadecimal notation. An I/O port is accessed when the processor executes an IN xx or OUT xx instruction, where xx is the one of the port numbers in the chart. The port number will appear on the lower half of the address bus instead of a memory address, and either SINP or SOUT will be active high which tells memory NOT to react and tells I/O devices that it is their turn. Each I/O device and board has gating circuitry which detects when its own port number is on the bus. Usually, I/O devices have dip-switches or jumper pads with which you can assign any port number.

Next to some of the ports, you will find the names of commonly used boards which respond to those port numbers. Some of these boards are Vector Graphic's and some are not. In the case of the Vector Graphic boards, most of them can be assigned ANY port number, either by dip-switch or jumper. The numbers shown for these boards are those that Vector Graphic software expects. Use this information to avoid present and future conflict when you are assigning port numbers to hardware. You can also use this sheet as a worksheet if you are assigning a number of ports.

MAP OF PORTS

00	V.G. Flash-	V.G.	40	V.G. 16K bank select		80	C0	
01	Writers	Bit-	41			81	C1	
02		Streamer	42			82	C2	
03	V.G.	I	43			83	C3	
04	Bit-	Alternate	44			84	C4	
05	Streamer	Bit-	45			85	C5	
06	II	Streamer	46			86	C6	
07		I	47			87	C7	
08			48			88	C8	VDM (not V.G.)
09			49			89	C9	
0A			4A			8A	CA	
0B			4B			8B	CB	
0C			4C			8C	CC	
0D			4D			8D	CD	
0E			4E			8E	CE	
0F			4F			8F	CF	
10	A0		50			90	D0	
11	A1		51			91	D1	
12	A2	D+7A Board	52			92	D2	
13	A3	(not V.G.)	53			93	D3	
14	A4		54			94	D4	
15	A5		55			95	D5	
16	A6		56			96	D6	
17	A7		57			97	D7	
18			58			98	D8	
19			59			99	D9	
1A			5A			9A	DA	
1B			5B			9B	DB	
1C			5C			9C	DC	
1D			5D			9D	DD	
1E	On/Off	Dazzler	5E			9E	DE	
1F	Mode	(Not V.G.)	5F			9F	DF	
20			60			A0	E0	
21			61			A1	E1	
22			62			A2	E2	
23			63			A3	E3	
24			64			A4	E4	
25			65			A5	E5	
26			66			A6	E6	
27			67			A7	E7	
28			68			A8	E8	
29			69			A9	E9	
2A			6A			AA	EA	
2B			6B			AB	EB	
2C			6C	Status	Tarbell	AC	EC	
2D			6D	Data	Tape	AD	ED	
2E			6E	Status	(Not V.G.)	AE	EE	
2F			6F	Data		AF	EF	
30			70			B0	F0	
31			71			B1	F1	
32			72			B2	F2	
33			73			B3	F3	
34			74			B4	F4	
35			75			B5	F5	
36			76			B6	F6	V.G.
37			77			B7	F7	Joystick
48			78			B8	F8	Tarbell
39			79			B9	F9	Disk
3A			7A			BA	FA	(not V.G.)
3B			7B			BB	FB	
3C			7C			BC	FC	
3D			7D			BD	FD	
3E			7E	V.G. Video Digitizer		BE	FE	Imsai Memory (not V.G.
3F			7F			BF	FF	Front panel (not V.G.

APPENDIX Q - MEMORY DIAGNOSTICS

MDIAG

If you have some reason to suspect that the computer's main memory is malfunctioning, use the Memory Diagnostic program on the MDOS System Diskette. Simply turn the system on, mount the system diskette in drive 0 (the right-hand drive), type B following the Monitor prompt (*), type MDIAG following the MDOS prompt (>), then depress the RETURN key. The program will load into the scratch-pad area of memory (not part of main memory) and execute.

MDIAG tests the contiguous memory beginning at 0000. There are actually two tests going on at the same time. Each repetition ("pass") of the program fills the next 8K block of memory with random numbers, and then tests it for changes. At the same time, it also fills all of memory with a certain fill code, and then tests all of it for changes. A display appears showing the result of each repetition. The program waits a certain "delay time" after filling before it tests memory. After all 8K blocks of main memory have been tested, the delay time is increased, and the program repeats beginning with 0000.

The display shows for each repetition the TOP OF MEMORY (the lowest address which is not in main memory), ACTIVE BLOCK (the first address of the 8K block currently subject to the random number test), the PASS NUMBER (incremented after each repetition), the FILL CODE (the code used to fill all of main memory as the second part of the test), the DELAY TIME currently being used, the number of ERRORS READ, and an ERROR DUMP showing the last 10 errors encountered, giving the address which malfunctioned, the code written, and the code read.

MDIAG will run indefinitely, with ever increasing delay times, if allowed to. It is used at the factory to burn the systems in for long periods of time. To stop it, depress the RESET key.

Monitor T Command

The T memory test is part of the Extended Systems Monitor PROM which comes in the system. To activate it, depress the RESET key, then type T, followed by the beginning address (in hex) of the block you want to test, then the ending address of the block. For example, to test the 48K of main memory, type T 0000 BFFF. The program will begin executing immediately.

The program stores random numbers into memory, then tests to see if any have changed. If memory is perfect, you will see nothing on the screen. However, if anything changes, the program displays the address, the code written, and the code read back. Then it continues testing. It will go on until stopped by depressing the RESET key.

Comparing with MDIAG, the strengths of the "T" test are 1) it allows you to test portions of memory which are not contiguous beginning at 0000, for example an 8K block from E000 to FFFF, or the screen memory, normally from D000 to D7FF; 2) it displays ALL the errors, rather than the last 10, allowing you to pinpoint all malfunctioning locations, and 3) you can use it without disk drives, if needed.

The weaknesses are 1) it may not show up errors produced by dynamic memory over a delay time longer than T uses, whereas MDIAG increases the delay time to long enough intervals; and 2) you must know the ending address of memory. MDIAG is considered the better test for dynamic memories, which are used in the standard Vector Graphic systems.

Monitor N command

N is a non-destructive memory test. To activate it, depress the RESET key, then type N. It will make only one pass through memory, temporarily storing each byte, testing whether 00 and FF can be stored and recalled correctly, and then replacing the original contents. It does this until an error is found, whereupon it prints the address, the code written, and the code recalled, and then returns to the Monitor executive.

This program is most useful for determining how much main memory a given system has, because if no errors are found, it will print out the first address of ROM memory which is above main memory. The N test is not nearly as thorough as either the T test or MDIAG, and it only reports the first error found. However, it allows you to test memory without destroying any of the contents, unlike the others.

MAP

MAP is a utility which tells you whether RAM, ROM or no memory at all, is at each address in the system. This includes all special purpose memory such as video boards, scratch-pad, and so on. Use MAP if you are not sure what is in the system. If the system is standard, then the result should be the same as the map in Figure 1.2 (Chapter 1), with the PROMs appropriate for your configuration.

To run MAP, simply turn the system on, mount the system diskette in drive 0 (the right-hand drive), type B following the Monitor prompt (*), type MAP following the MDOS prompt (>), the depress the RETURN key. The progrm will load and execute. The resultant display is a matrix of memory that is fairly self-explanatory. You only have to know that the addresses increase from left to right in blocks of 100 Hex (256 bytes). You can run MAP with RAM holding data or program without losing anything; it is a non-destructive test, except for the area it uses itself, which is the scratch-pad area beginning from DC00 to DDFF.