mits

PROGRAMMING SYSTEM II.

MITS Programming System II
(Rev 3.Ø)

TABLE OF CONTENTS

I. GLOSSARY

I. Glossary

Machine instruction - Binary byte(s) that execute to perform a defined computer function.

Assembly (source) code - Symbolic labels, opcodes, and operands that are ordered in succession to define a logical procedure which can be assembled to produce executable machine instructions.

Opcodes - Defined symbols that assemble directly as 1 to 3 bytes of machine instruction. The symbols are meaningful descriptors of the machine function to be performed during program execution.

Label - A user defined symbol that corresponds to the storage address of the following opcode. Labels are used to define points for transfer of program execution which normally proceeds in a sequential manner.

Operands - Symbolic references to registers, labels or constants that are used to completely define the function specified by the opcode.

Pseudo-opcodes - Mnemonics that direct the assembly of the source code. They can allocate memory, define constants or affect control of the assembly procedure.

Execution storage - The physical memory space where an assembled program can execute. Absolute assembly generates machine instructions that will only execute correctly in memory space that was defined during assembly(defined by ORG pseudo op).

Program storage - The physical memory where program machine code is stored during assembly. The program will not necessarily execute correctly at this location unless assembly defined the program storage to be the same as execution storage(no ORR psuedo op given).

Debug - The process of testing a program to remove logic errors(bugs) by analyzing its execution(performance).

Patch - Correcting a program by changing machine instructions during debugging.

Symbolism used in Manual

<CR> - Type a carriage return.
<LF> - Type a line feed.
<Control Z> - Type a Control Z not the individual characters.
<Escape> - Type an escape(TTY key usually has ESC on it).
<Tab> - Type a tab(Control I).

Anything enclosed in square brackets(i.e. [ ]) is optional.
A Q following a number indicates the number is octal.

II. SYSTEM MONITOR

II. System Monitor

The system monitor has been designed to load and execute absolute programs, have a flexible I/O system for supporting all MITS peripherals, allow handlers for non-standard peripherals to be added, and has limited debugging capability.

Their are three tables within the monitor that make this flexibility possible. The names of all programs that have been read in is stored in the program name table(PTL), all open I/O symbolic names, flags, and other information are contained in the I/O table, and the hardware table which contains addresses of the device handlers.

Hardware Table

This table has room for 5 entries, 4 of which are defined for standard MITS I/O devices. The four default device names and uses are:

TY - Console terminal
AC - Audio cassette
EB - Edit buffer read
TR - Mits high speed paper tape reader

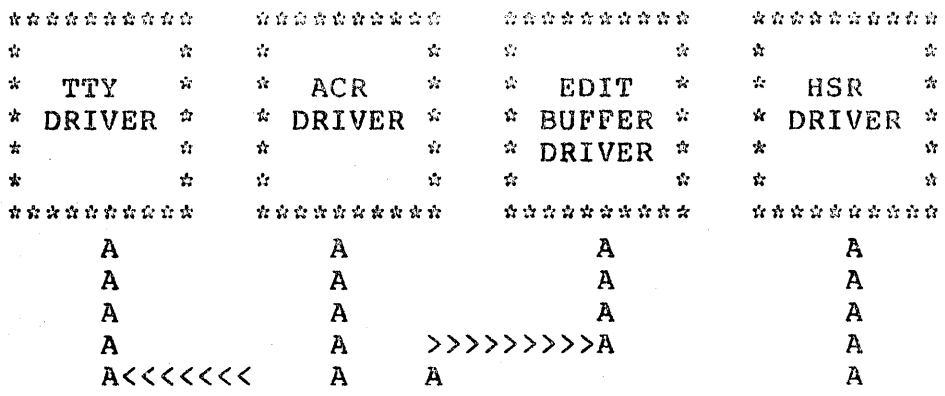
The exact structure of this table and instructions on how to modify it is given in Appendix D.

I/O Table

The I/O table has room for 7 symbolic device names to be open simultanously. The five names used by PKG II programs are automatically open, leaving room for 2 names to be set up for user programs if needed.

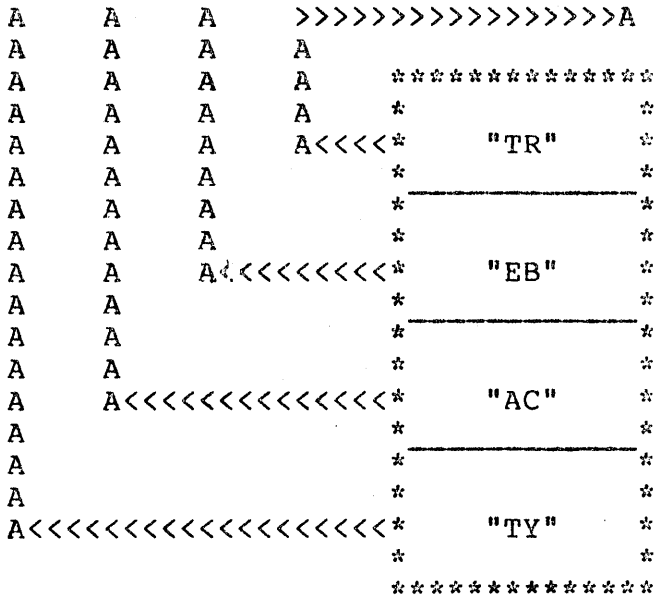
TTY - Monitor, Editor and Assembler command I/O device name
  Open for echoing,tabbing,and ASCII mode
LST - Editor, Debug, and Assembler list on LST
  Open for tabbing and ASCII mode.
FIL - file I/O for Editor and Assembler
  Open for echoing and ASCII mode.
ABS - program loading and file searching
  No options
ALT - used by Editor's alter command
  Open for tabbing

I/O DRIVERS
These drivers perform all monitor input/output (CHECK STATUS AND INPUT OR OUTPUT A CHARACTER).



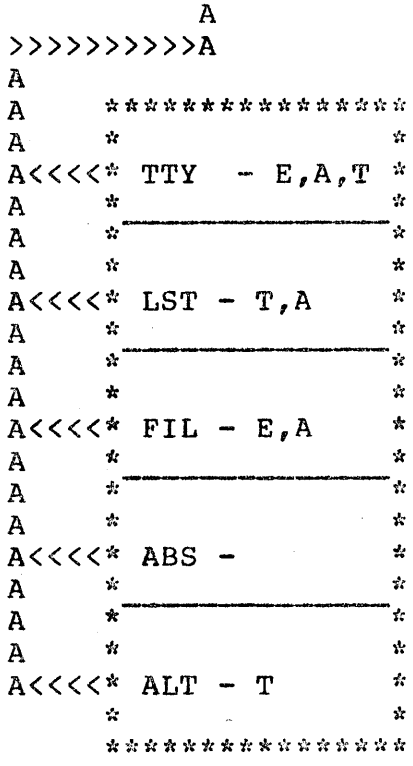
HARDWARE TABLE

This table contains the hardware driver names and pointers to the proper device drivers.



I/O TABLE

This table contains symbolic device names along with their flags and hardware table pointer, set by an OPN command. In the table shown at left the default flags and pointers are shown.



The block diagram of the I/O table shows all pointers from the symbolic device names going to the "TY" entry of the Hardware table. This is because all are open to "TY" when the monitor first comes up and can be changed at any time by giving an OPN command.

In order to support a non-standard I/O device, a driver would need to be written and the address of it patched into the hardware table as explained in appendix D. The device could then be used by all PKG II as well as user programs.

Monitor Command Format

1. Execute a program

   The Monitor signals that it is ready for a command by printing 2 blanks and a question mark. A program is executed by typing its 3 character name followed by a carriage return. If the program has already been loaded, it will start execution immediately. If it hasn't, it will be searched for and loaded from symbolic device ABS. When the program finishes loading it will automatically start executing.
   Example:
   If you want to load the Editor from your TTY type:
   ```
   ?OPN ABS,TY<CR>
   ?EDT<CR>
   ```
   The OPN command would only be needed if ABS was not open to the TY.
   To load the Editor from the ACR make sure the last OPN ABS command was as follows:
   ```
   ?OPN ABS,AC<CR>
   ```

2. Execution time options

   User programs can be passed execution options by the monitor if enclosed in parenthesis.
   ```
   ?EDT(R)<CR>
   ```
   When the program requested is branched to the D&E register pair contain the address of the first character following the monitor command. In the above example D&E would point at the open parenthesis. The B&C register pair contains the address of the monitor status word, which contains the length of the command line. In the above example the status word contains the number 6.

3. File searching

By typing a file name followed by a comma and a type designator, the monitor will search for the file on the device ABS is open to, and return after the file is skipped.

S - ASCII file
A - Absolute file

The main use of this command is to search for the last file on an audio cassette in order to write out a new one. All files on the the cassette should be of the same type as the file you are searching for.

```
?OPN ABS,AC<CR>
?AM2,A<CR>
```

This example would search for the absolute file "AM2" on the ACR. After finding the file, it would be skipped and control returned to the monitor.

Utility Programs

The monitor includes 9 utility programs:

- CLR - Deletes a program name from the PTL.
- OPN - Opens a symbolic device name to a physical device.
- CLS - Removes a symbolic device name from the I/O table.
- DEP - Used to change contents of memory locations.
- EXM - Used to print in octal the contents of memory.
- JMP - Causes the machine to start executing at any location.
- DMP - Dumps out memory in the checksum format.
- NUL - Sets the number of nulls to output after a <CR>.
- CNS - Console command

All numbers typed as parameters to these programs should be octal.

1. OPN

This program is used to assign different physical devices to a symbolic name making programs device independent.

```
?OPN ABS,TY<CR>
```

This command opens the symbolic name "ABS" to the teletype. In this type of OPN the mode default would be assumed. These are:

- No echo - Don't echo input.
- Absolute - All 8 bits of every read are transmitted.
- Tabs - A Control I is output.

The options are:

- E - Echo all input on TTY
- A - ASCII mode, high order bit of characters masked to 0 and the line format described in Appendix F is recognized. Even parity is generated on output.
- T - Tab control. Spaces are printed to force cursor into a column that is an even multiple of 8 from the left margin. The tab character is Control I(11Q).

The options are specified at the end of the command seperated by commas. The order that they occur is irrelevent. If the symbolic name is already open when another command to open it is given, the symbolic name is reopened according to the new command.

2. CLS

Closing a symbolic name removes the name from the I/O table making the name unavailable until it is reopened.

```
?CLS ABS<CR>
```

In this example "ABS" is now closed meaning that no program should be executed that reads or writes on "ABS" . If an I/O operation is attempted the program will abort, causing the monitor to print an error message.

3. CLR

This command deletes a program name from the PTL.

```
  ?CLR EDT<CR>
```

After giving the above command

```
  ?EDT<CR>
```

will cause the monitor to try to reload the EDITOR.

4. DEP

This command lets the programmer modify memory locations directly from the monitor. The format is:

```
  ?DEP ADDRESS<CR>
```

All octal numbers typed after this command will be deposited starting at the address given. Typing a Control Z returns control to the Monitor.

Example:

```
  ?DEP 5000<CR>
25<CR>
50<CR>
175<CR>
<CONTROL Z>
  ?
```

Location 5000 would now contain an octal 25,5001 a 50 and 5002 a 175.

5. EXM

The format of the examine command is as follows:

```
  ?EXM ADDR1[,ADDR2]<CR>
```

The contents of memory locations are dumped out in octal starting at the location specified by ADDR1, through ADDR2. If ADDR2 is not given or is = ADDR1 only the location at ADDR1 is printed.

Example:

```
  ?EXM 100<CR>
303
  ?EXM 100,101<CR>
303
153
  ?EXM 100,0<CR>
303
  ?
```

6. JMP

The format of the jump command is as follows:
?JMP ADDRESS<CR>
The jump command causes the machine to start executing at the address given in the command. All registers are loaded from the save area prior to jumping.
Caution: Make sure SP register will be loaded with address of memory that can be used for a stack. For a further explanation of the save area see section 8 of the Program Monitor Calls.

7. DMP

The format of the dump command is as follows:
?DMP [NAME,]ADDR1,ADDR2[,START ADDRESS]<CR>
The name field of the command should contain the 3 character name of the program followed by any comments. The only restriction is this field should not contain a comma. ADDR1 is the address of the first location to be dumped and ADDR2 is the address of the last to be dumped. If a start address is not specified the monitor will automatically be returned to when the tape is loaded.
Example:
You want to dump a program located at 5100Q - 5352Q, name it TST, put in a comment indicating it is the first draft of the program and have it start executing at location 5100Q.
?DMP TST REVISION 0,5100,5352,5100<CR>

8. NUL

The format of the NUL command is as follows:
?NUL NUMBER<CR>
This causes the number of nulls specified to be output after every carriage return written in the ASCII mode. It is adviseable to use this command before saving long program files on cassette or paper tape as this insures no characters will be missed during assembly.
Example:
Before saving a program on audio cassette give the following command:
?NUL 4<CR>

9. CNS

The console command is used to switch between terminals connected to your Altair. Before giving a console command, set the sense switches to indicate the type of I/O board to switch to(See Appendix E). If the I/O port address is not the same as the default listed in the terminal options chart, flip sense switch 8 up and deposit the I/O port address at location 572Q.

Program Monitor Calls

The following section decribes how a user written program can use features of the Monitor to free him of the need to write I/O handlers for each program he writes.

Before any call to the monitor is preformed the B&C register pair must contain the address of a monitor control block. A monitor control block is used to specify the operation to be performed, symbolic device to use, etc. The monitor is called by executing a CALL IO. All registers are restored before returning to the calling program, and the monitor control block is left unchanged. The example program at the end of the assembler programming section uses monitor I/O.

1. READ

```
                LXI     B,RDPKT ;LOAD B&C WITH ADDRESS OF THE
                                ;MONITOR CONTROL BLOCK
                CALL    IO      ;CALL THE MONITOR
- DONT PUT MONITOR CONTROL BLOCK NEXT IN YOUR PROGRAM -
        RDPKT:  DB      20Q     ;OPERATION CODE FOR READ
                DB      "SDN"   ;SYMBOLIC DEVICE NAME
                DW      INBUF   ;ADDRESS OF THE BEGINNING OF
                                ;THE INPUT BUFFER
                DW      80      ;MAXIMUM NUMBER OF CHARACTERS
                                ;TO BE READ IN
                DW      STAT    ;ADDRESS OF STATUS WORD
                DW      END     ;END OF FILE RETURN ADDRESS
```

After the read has been completed the status word contains the number of bytes read in.

2. WRITE

```
                LXI     B,WRPKT ;LOAD B&C WITH ADDRESS OF THE
                                ;MONITOR CONTROL BLOCK
                CALL    IO      ;CALL THE MONITOR
        WRPKT:  DB      22Q     ;OPERATION CODE FOR WRITE
                DB      "SDN"   ;SYMBOLIC DEVIE NAME
                DW      OUTBUF  ;ADDRESS OF THE OUTPUT BUFFER
                DW      80      ;NUMBER OF BYTES TO WRITE OUT
                DW      STAT    ;ADDRESS OF STATUS WORD
```

When the monitor returns the status word contains the number of bytes output.

3. OPEN

```
                LXI     B,OPNPKT ;LOAD B&C WITH ADDRESS OF THE
                                 ;MONITOR CONTROL BLOCK
                CALL    IO       ;CALL THE MONITOR
        OPNPKT: DB      63Q      ;OPERATION CODE FOR OPEN
                DB      "SDN"    ;SYMBOLIC DEVICE NAMED TO BE
                                 ;OPENED
                DB      "TY"     ;DEVICE TO BE OPENED TO
                DB      XXX      ;HARDWARE CONTROL BYTE
```

The hardware control byte specifies echo control and and ASCII or absolute read mode.

Bit 1 - 1 for ASCII read mode, 0 for absolute
Bit 2 - 1 for input echo, 0 for no echo
Bit 3 - 1 for tabs to be expanded, 0 for no expansion

4. CLOSE

```
            LXI     B,CLSPKT ;LOAD B&C WITH THE ADDRESS OF
                             ;THE MONITOR CONTROL BLOCK
            CALL    IO       ;CALL THE MONITOR
CLSPKT:     DB      62Q      ;OPERATION CODE FOR CLOSE
            DB      "SDN"    ;SYMBOLIC NAME TO BE CLOSED
```

5. ERROR

```
            LXI     B,ERRPKT ;LOAD B&C WITH ADDRESS OF THE
                             ;MONITOR CONTROL BLOCK
            CALL    IO       ;CALL THE MONITOR
ERRPKT:     DB      60Q      ;OPERATION CODE FOR ERROR
                             ;HANDLING ROUTINE
            DB      "X"      ;ONE CHARACTER TO BE OUTPUT AS
                             ;ERROR MESSAGE
```

The character specified followed by a # sign will be echoed by the monitor instead of the next 2 characters that would normally be echoed.

6. PASS PROGRAM NAME

```
            LXI     B,PASPKT ;LOAD B&C WITH ADDRESS OF THE
                             ;MONITOR CONTROL BLOCK
            CALL    IO       ;CALL THE MONITOR
PASPKT:     DB      61Q      ;OPERATION CODE FOR PASS NAME
                             ;NAME ROUTINE
            DB      "PRG"    ;3 CHARACTER PROGRAM NAME
            DW      PRG      ;START ADDRESS OF PROGRAM
```

The 5 bytes of name and address are copied into the PTL and the program jumped to.

7. FIND ASCII FILE

```
            LXI     B,FFPKT  ;LOAD B&C WITH ADDRESS OF THE
                             ;MONITOR CONTROL BLOCK
            CALL    IO       ;CALL THE MONITOR
FFPKT:      DB      65Q      ;OPERATION CODE FOR A FIND FILE
            DB      "SDN"    ;SYMBOLIC DEVICE TO SEARCH ON
            DB      "FIL"    ;FILE TO BE SEARCHED FOR
```

This call causes the monitor to search for the named program on the physical device the symbolic device name is open to and return to the calling program as soon as it is found.

8. Returning to the Monitor

When a program has finished its job and wishes to ruturn to the Monitor, a JMP MON will be needed. All registers are saved in the register save area and the stack pointer it reloaded to delete anything left on the stack. The address of the monitor is on the stack when a program is executed by the monitor, so if your program has left nothing on the stack, a return instruction can be used to return to the monitor.

The symbols MON and IO are permenant equates within the assembler. The actual locations are - MON-100Q, IO-103Q

When a program returns to the monitor either by jumping to location 100Q, examining location 100Q and pressing RUN , or by typing a Control C all registers are stored in the register save area. The order they are saved in is given below.

571	FLAGS
572	A - REGISTER
573	C - REGISTER
574	B - REGISTER
575	E - REGISTER
576	D - REGISTER
577	L - REGISTER
600	H - REGISTER
601	SP - REGISTER (LOW BYTE)
602	SP - REGISTER (HIGH BYTE)
603	PC - REGISTER (LOW BYTE)
604	PC - REGISTER (HIGH BYTE)

If a program is waiting for input from the TY and a Control C is typed, the PC stored in the save area is the address of the instruction following the monitor call.

Note - 30 octal bytes of stack have been allocated for user program use. If more stack space is needed, a LXI SP instruction will be needed in your program to set up its own stack.

III. ASSEMBLER OPERATIONS
IV. ASSEMBLY PROGRAMMING

III. Assembler Operation

Introduction

Typical assemblers process source code by reading the same source code 2,3, or 4 times to produce a load tape that must then be loaded before executing the program. An assembler that requires that type of procedure is extremely cumbersome for users with paper tape or cassette magnetic tape input. Off-line storage is always required for assemblies of this type. Further, high speed storage is desireable due to the extensive I/O required during processing.

The Mits loading assembler was designed to process source code directly into memory for immediate execution or to produce an absolute load tape for later execution in the space occupied by the assembler. The source code is processed only once, thereby producing executable code in a minimum amount of time. Significant improvement in program development time is achieved, especially for users with program input rates under 100 characters/second. Furthermore, the assembler is still resident in memory with the user program, so it can be used to patch program errors during debugging. Since the patches can be entered in symbolic source code and labels can still be assigned to correct execution sequences, fewer errors are introduced in the debug process. thus, complete programs can be input and developed with input from only an ASCII keyboard and a minimal amount of memory(the Monitor and Assembler require approximately 5k bytes).

The loading assembler allows direct assembly of programs to any unused memory space or indirect assembly generating a load tape for programs that need to reside in memory being used during the assembling process. Program modules(parts) can be developed and debugged seperately, then assembled with all source errors corrected for off-line loading to other program space. The modules can be linked during assembly using the preserved symbols from previous assemblies or by defining names for referenced locations in other modules. Source programs are input from a Monitor-defined device called "TTY" and all selected output is to device "LST". Input can be selected from a source file that was created by the Editor. The files can be assembled in any sequence selected.

Assembler Options

The assembler was designed as a module of the Mits operating system to be loaded by the system monitor. The assembler is loaded from the device ABS is open to when the assembler is executed for the first time. The following execution options are possible when ever starting the assembler.

ASM(A,S,P)

Where:

P=Preserve symbols entered during previous assembly(s). Used for symbolic patches and program additions

S=Symbol table listing wanted at end. All defined names and label symbols with corresponding program addresses and the next program address($) are output

A=Absolute tape dump wanted at end. Binary output for Monitor loading is output to "ABS"

All output begins at the first storage address that was defined by the first ORG(or ORR when used) and continues to the current address. Program addresses are used for the absolute tape dump and defined symbol listings.
Warning*** If assembly is begun without the P option the symbol table is cleared and is not recoverable.

Assembler Psuedo Op's

FILE Psuedo Op

The file input psuedo op forces source input to be read from symbolic device "FIL". If a file name is given as an operand, a file with that header is searched for before processing any input. The source file must end with a Control Z or EOA psuedo op so that control is restored to the Monitor at the end of file. Assembly can be continued by entering the Assembler with the P-option.
Example:

```
        FILE    TWO     ;INPUT FILE "TWO" FROM CASSETTE
```

END Psuedo Op

All of the entry options in the group(S,A) are performed each time an END pseudo-psuedo op is encountered. The END statement will also produce a listing of all undefined symbol names with program storage locations that reference the symbol. If the A-option was selected, the first 3-letters of the operand define the program name when loaded by the Monitor. Up to 77 characters following can be used to document the program(Revision, Date, etc.)
Example:

```
        END     PRG     ;IF THE A OPTION WAS SPECIFIED
                        ;THE PROGRAM WOULD BE DUMPED
```

```
                    ;WITH NAME PRG
```

EOA Psuedo Op

The Assembler will return control to the Monitor when an End Of Assembly(EOA) pseudo-psuedo op is encountered. The Monitor prints a prompt to indicate it is in control.

Memory Allocation

The user must understand the way that memory is used during the assembly process to avoid errors and to use available memory in an efficient way. The diagram in Appendix B illustrates the relative storage used during assembly.

The user must estimate the symbol space needed for each assembly before defining the first storage location. It should be apparent that short symbols and few labels or names will increase the space available for user program storage. A rule of thumb for estimating symbol table space is to reserve 1 byte of symbol table space for each statement in the program.

ORG Psuedo Op

This psuedo op is required to be the first statement of all programs. It defines the memory your program will run in and and where the Assembler should store it while the Assembler is running.

ORR Psuedo Op

If the address of the start of the program given by the ORG statement does not allow enough space for the symbol table, an ORR statement will be needed to set the address the program should be stored at during assembly. Since the symbol table is built from the end of the Assembler to this address, its maximum size can be set with this psuedo op.

Example:

```
  ?ASM<CR>


*ASM*

        ORG     5100Q   ;WANT PROG TO LOAD AT 5100Q
        ORR     17000Q  ;SINCE ASSEMBLER IS AT 5100Q
                        ;A PLACE TO SAVE THE PROGRAM
                        ;DURING ASSEMBLY MUST BE SET UP
```

DS PSUEDO OP

STORAGE IS ALLOCATED WITH THE DS PSUEDO OP. THE VALUES OF BYTES IN THE SPACE ARE NOT CHANGED AND SHOULD NORMALLY BE PRESET DURING EXECUTION PRIOR TO USE. THE OPERAND MUST BE A DEFINED SYMBOL(EQU OR SET TO A CONSTANT) OR A CONSTANT VALUE. A LABEL SYMBOL DEFINES AN ADDRESS WHICH SHOULD NOT GENERALLY BE USED FOR A STORAGE OPERAND. A DS PSUEDO OP IS GENERALLY PRECEDED BY A LABEL USED TO REFERENCE THE STORAGE ALLOCATED DURING PROGRAM EXECUTION.

EXAMPLE:

```
LABEL:   DS      20      ;THIS RESERVES 20 BYTES OF MEMORY
```

DW Psuedo Op

An address word or two byte quantity is preset(assigned during assembly) by using the DW psuedo op. The 2-byte value is stored with the least significant byte in the first memory address and the most significant byte in the next higher memory location. This feature is the same as all 2-byte operands for machine opcodes(i.e. JMP, LXI, etc). This arrangement is convenient because it allows byte references to the least significant byte using the same label as a word reference. Multiple operands are allowed and must be separated with a space or comma.

Example:

```
LABEL:   DW      LOC     ;THIS STORES THE 2 BYTE ADDRESS OF LOC
```

DB Psuedo Op

All bytes constants are defined by using the DB psuedo op Multiple operands can be used. All operands define one byte of storage except string or literal constants which are stored as one ASCII character per byte. Each operand must be separated by a space or comma.

Example:

```
        DB      0       ;STORES THE CONSTANT 0 IN 1 LOCATION
        DB      "THIS IS A STRING CONSTANT"
                        ;THE ABOVE STRING WOULD BE STORED 1 CHARACTER
                        ;TO A BYTE, SO IT WOULD TAKE 25 MEMORY
                        ;LOCATIONS
```

DC Psuedo Op

The define character psuedo op is used to define literal constants of determinable length. All characters except the last have their high order bit masked to zero, but the last character has it set to one. The last character can then be found by searching for a character with its high order bit on.

Example:

```
        DC      "AB"    ;STORES THE CHARACTERS IN 2 CONSECUTIVE
                        ;MEMORY LOCATIONS WITH THE HIGH ORDER BIT OF
                        ;THE LAST CHARACTER TURNED ON.
```

EQU Psuedo Op

A symbol can be defined prior to use by assigning it a value equal to a specified constant or another label that has already been defined. A symbolic name(not a label) is defined by using the EQU psuedo op and a defined operand. The EQU psuedo op cannot be used to change the value assigned to a name. Refer to the SET psuedo op.
Example:

```
ONE     EQU     1       ;THIS SETS THE VALUE OF ONE = TO 1
        MVI     A,ONE   ;THIS WOULD NOW BE THE SAME
                        ;AS     MVI     A,1
```

SET Psuedo Op

A name can be changed or reassigned by using the SET psuedo op in the same manner as the EQU psuedo op. It can also be used to assign a value the first time a name is defined.

BEG Psuedo Op

The operand of the BEG psuedo op in a program sets the begin execution address, output by the Assembler during an absolute dump. If the BEG psuedo op is not found, a start address of 100Q will be assumed, causing a return to the Monitor after the program loads.

RUN Psuedo Op

The operand of the RUN psuedo op is returned as a program name along with the address from the latest BEG statement to be entered into the PTL. The address of the BEG statement is then branched to. This psuedo op should only be used during on-line assembly(no ORR statement).

IV. Assembler Programming

Assembly programs include symbolic names,constants, opcodes and comments in sequential statements that are converted by the Assembler to produce executable machine instructions. Each line or program statement of source code must follow certain rules that govern the acceptable structure of the program. If they are not observed, assembly or execution errors will occur. This section will define the form that is acceptable to the Mits Loading Assembler.

Character Set

The entire 128-character ASCII character set is acceptable but all opcodes are defined in capital letters. Any combination of characters beginning with a non-numeric character can be used for statement labels or symbolic names. The maximum length for these symbols is 255 characters, but to minimize symbol table length, they should be kept as short as possible.

Constants

Constants can be used whenever an operand is required. All constants begin with a numeric character and can end with an alphabetic character that defines the radix of conversion. If the last character is numeric, the conversion defaults to decimal. Legal conversions are as follows:

```
12340   OCTAL
5678Q   OCTAL(8 CONVERTS AS Ø)
12345D  DECIMAL
ØABCD   DECIMAL(A CONVERTS AS 1,ETC.)
Ø57EFH  HEXIDECIMAL
```

NOTE: Values are first masked leaving only the significant binary quantities, thus alphabetic conversions are legal. Byte values are set equal to the converted value using modulus 256 arithmetic. Similarly, overflow of 16-bit constants(words) during conversion is ignored.

String or literal constants are defined by enclosing all characters in " symbols. The " symbol cannot be defined in a string constant. Example:

```
DB      "THIS IS A MESSAGE"     ;THIS IS A CONVENIENT
                ;WAY TO STORE A MESSAGE FOR OUTPUT
                ;DURING PROGRAM EXECUTION
```

WARNING****** Only one character should be used if a single byte operand is required(i.e. MVI A,"ABC" will store 4 bytes).

Statement Structure

The assembly source statements may include any of the following in the order given:

1. Symbolic label of any length terminated by a colon(:). The symbol can include any ASCII character except delimiters(Space, TAB, or Comma) in any combination including instruction opcodes. The following symbols are predefined values.

```
$=Next program byte address
```

following are only valid byte(not word)values.

```
B,C,D,E,H,L,M,A=Ø,1,2,3,4,5,6,7 respectively
SP and PSW=6
```

2. A name is the same as a label except that a terminating colon is not used. A name is used in place of a label and remains undefined until a defining pseudo opcode is encountered (i.e. Equ, SET).

3. Opcode(s) or pseudo opcode(s) with required operands. All opcodes that are defined in the Altair 8800 Operators Manual and All pseudo-op's defined in section III are acceptable to the Assembler.

4. Comments are used to document the source code but are not required by any statement. Comments begin with a semi-colon(;) which terminates assembly of all following ASCII characters on the line. Lines that begin with a semi-colon contain only comments.

Statement Options

All register pair instruction operands can reference either of the two 8-bit registers in the pair.

Thus--

```
POP A is the same as POP PSW
LXI L is the same as LXI H
DCX C is the same as DCX B
```

Multiple instructions can appear on the same line of source code. This feature can be used to minimize the number of characters on a source tape and in some cases improves the program readability.

```
MOV B,H MOV C,L
RAR,RAR
```

The delimiters SPACE, TAB, or COMMA can be used anywhere in the line to improve readability.

Statement Formats

```
*****************************************************************************
*                                                                           *
*[ LABEL: ]      MNEMONIC        [ OPERAND FIELD ]        [ ;COMMENTS ]*
*     ( THIS FORMAT IS USED FOR ALL STATEMENTS EXCEPT EQU AND SET )         *
*                                                                           *
*NAME            MNEMONIC        OPERAND FIELD            [ ;COMMENTS ]*
*        ( THIS FORMAT IS USED FOR EQU AND SET STATEMENTS )                 *
*                                                                           *
*****************************************************************************
```

Programming Tricks

The choice of opcode(s) to use to achieve a specific result is generally based on the generally accepted criteria that a program should use a minimal amount of space and should execute as rapidly as possible. Often one consideration is sacrificed in favor of the other but certain practices should always be avoided in favor of another which produces the same result at less cost in time or storage. The following practices are recommended:

1. Avoid the instruction sequence
   CALL Subroutine
   RET
in favor of
   JMP Subroutine
The JMP statement will return to the same place without need for the RET thus saving one byte of program storage.

2. Avoid CPI Ø
   which requires two bytes of storage
in favor of
ORA A
   which requires one byte of storage
All flag bits are affected in the same manner without changing the contents of the A-register.

3. Avoid PUSH B,POP H
   or similar register contents transfer
in favor of
MOV H,B MOV L,C
   which executes in less time.

4. If a series of MVI 2-byte instructions are used followed by a jump to the same address,less storage can be used by LXI B(DB 1) replacing the jumps saving two bytes.

For Example:

```
AERR:   MVI     A,"A"                   AERR:   MVI     A,"A"
        DB 1                                    JMP ERR
BERR:   MVI     A,"B"                   BERR:   MVI     A,"B"
        DB 1                                    JMP ERR

  etc.

ERR:
```

A JMP to any MVI to set the "ERR" code will load the A-reg with the character to be output and will skip over the rest by executing the DB 1 as LXI B,XXXX where XXXX is the two-byte MVI instructions. the contents of B&C will change. Other register pairs can be used similarly.

Example Program

A sample program and assembly are given to illustrate the operation of the assembler and use of the monitor calls for output.

The sample program will dump out any section of memory in octal as shown later in the example. This type of memory dump can be very useful in debugging programs. In order to use this program, change the addresses at locations FIRST and LAST to the address of the first and last memory location you want dumped.

```
?ASM(A,S)


*ASM*
        ORG     20000Q  ;SET LOCATION COUNTER
                        ;WILL NEED TO BE CHANGED IF ONLY 8K MACHINE
DUMP:   LHLD    FIRST   ;GET ADDRESS OF FIRST BYTE TO BE DUMPED
        XCHG            ;PUT ADDRESS IN D&E
NEWLN:  LXI     H,BUF   ;GET ADDDRESS OF OUTPUT BUFFER
        PUSH    H       ;SAVE ADDRESS
        LHLD    LAST    ;LOAD ADDRESS OF LAST BYTE TO BE DUMPED
        MOV     A,L     ;SUBTRACT LOW ORDER BYTES
        SUB     E
        MOV     A,H     ;SUBTRACT HIGH ORDER BYTE
        SBB     D
        POP     H       ;RESTORE H&L
        JC      MON     ;JUMPS OUT IF NO MORE BYTES TO BE DUMPED
        MOV     A,D     ;START CONVERSION OF ADDRESS TO ASCII
        RAL             ;ROTATE HIGH BIT INTO C
        MVI     A,0     ;ZERO OUT REST OF A BUT DONT CHANGE FLAGS
        RAL             ;ROTATE HIGH BIT INTO LOW ORDER POSITION
        ORI     60Q     ;OR IN ASCII 0
        MOV     M,A     ;STORE IN OUTPUT BUFFER
        INX     H       ;INCREMENT BUFFER POINTER
        MOV     A,D     ;PICK UP HIGH ORDER BITE AGAIN
        RAR             ;ROTATE BITS 4,5,6 INTO LOW ORDER POSITIONS
        RAR
        RAR
        RAR
        ANI     7       ;MASK OFF ALL BITS EXCEPT LOW THREE
        ORI     60Q     ;OR IN ASCII 0
        MOV     M,A     ;STORE IN OUTPUT BUFFER
        INX     H       ;INCREMENT POINTER INTO OUTPUT BUFFER
        MOV     A,D     ;PICK UP HIGH BYTE OF ADDRESS
        RAR             ;ROTATE BITS 1,2,3 INTO LOW ORDER POSITION
        ANI     7       ;MASK OFF ALL BITS EXCEPT LOW THREE
        ORI     60Q     ;OR IN ASCII 0
        MOV     M,A     ;STORE IN OUTPUT BUFFER
        INX     H       ;INCREMENT POINTER INTO OUTPUT BUFFER
        MOV     A,D     ;PICK UP HIGH BYTE OF ADDRESS
        RAR             ;SAVE LOW BIT IN THE CARRY FLAG
        MOV     A,E     ;PICK UP LOW BYTE OF ADDRESS
        CALL    LAST3   ;CALL SUBROUTINE THAT CONVERTS 3 DIGITS
```

```
        MVI     B,8     ;LOAD B WITH NO OF BYTES TO DUMP PER LINE
NXTNUM: PUSH    H       ;SAVE H&L
        LHLD    LAST    ;LOAD ADDRESS OF LAST BYTE TO DUMP
        MOV     A,L     ;DO THE DOUBLE WORD COMPARE AGAIN
        SUB     E
        MOV     A,H
        SBB     D
        POP     H       ;RESTORE THE H&L REGISTERS
        JC      LNDN    ;JUMP TO ROUTINE TO FINISH UP IF DONE
        MVI     C,5     ;IF ANOTHER TO COME SEPERATE THEM BY 5 BLANKS
        CALL    BLANK
        XRA     A       ;SET THE CARRY FLAG TO 0
        LDAX    D       ;GET BYTE TO DUMP
        CALL    LAST3   ;CALL ROUTINE TO CONVERT 3 DIGITS
        INX     D       ;INCREMENT POINTER TO DUMP NEXT BYTE
CHKLN:  DCR     B       ;DECREMENT LINE BYTE COUNTER
        JNZ     NXTNUM  ;CONVERT NEXT NUMBER IF IT WILL FIT ON LINE
        LXI     B,OUT   ;GET ADDRESS OF MONITOR CONTROL BLOCK
        CALL    IO      ;WRITE OUT LINE
        JMP     NEWLN   ;JUMP TO WRITE OUT NEXT LINE
LNDN:   MVI     C,8     ;PAD LINE WITH 8 BLANKS FOR EACH NUMBER THAT
        CALL    BLANK   ;WOULD FIT
        DCR     B       ;DECREMENT NUMBERS THAT COULD FIT IN LINE
        JNZ     LNDN    ;LOOP UNTIL LINE FILLED WITH BLANKS
        LXI     B,OUT   ;GET ADDRESS OF MONITOR CONTROL BLOCK
        JMP     IO      ;WRITE OUT LINE
BLANK:  MVI     A,40Q   ;PUT A ASCII BLANK IN A
BL:     MOV     M,A     ;STORE IT IN THE OUTPUT BUFFER
        INX     H       ;INCREMENT THE OUTPUT BUFFER POINTER
        DCR     C       ;DECREMENT THE NUMBER OF BLANKS TO STORE
        JNZ     BL      ;LOOP UNTIL ALL STORED
        RET             ;RETURN TO CALLER
LAST3:  PUSH    PSW     ;SAVE BYTE TO CONVERT
        RAL             ;ROTATE CARRY AND HIGH 2 BITS TO LOW ORDER
        RAL             ;POSITION
        RAL
        ANI     7       ;MASK OFF ALL BUT LOW ORDER THREE BITS
        ORI     60Q     ;OR IN A ASCII 0
        MOV     M,A     ;STORE DIGIT IN OUTPUT BUFFER
        INX     H       ;INCREMENT THE OUTPUT BUFFER POINTER
        POP     PSW     ;POP BYTE TO CONVERT
        PUSH    PSW     ;SAVE FOR LATER ALSO
        RAR             ;ROTATE BITS 3,4,5 INTO LOW ORDER POSITION
        RAR
        RAR
        ANI     7       ;MASK OFF ALL BUT LOW THREE BITS
        ORI     60Q     ;OR IN AN ASCII 0
        MOV     M,A     ;STORE DIGIT IN OUTPUT BUFFER
        INX     H       ;INCREMENT OUTPUT BUFFER POINTER
        POP     PSW     ;POP BYTE TO CONVERT
        ANI     7       ;MASK OFF ALL BUT LOW THREE BYTES
        ORI     60Q     ;OR IN ASCII 0
        MOV     M,A     ;STORE DIGIT IN OUTPUT BUFFER
        INX     H       ;INCREMENT OUTPUT BUFFER POINTER
        RET             ;RETURN TO CALLER
```

```
OUT:    DB      22Q     ;MONITOR WRITE OPERATION CODE
        DB      "LST"   ;SYMBOLIC DEVICE TO WRITE ON
        DW      BUF     ;ADDRESS OF OUTPUT BUFFER
        DW      72      ;WRITE OUT 72 CHARATERS
        DW      STAT    ;ADDRESS OF STATUS WORD
STAT:   DW      0
FIRST:  DW      15100Q
LAST:   DW      15272Q
BUF:    DS      70      ;RESERVE 70 MEMORY LOCATIONS
        DB      15Q     ;ASCII CARRIAGE RETURN
        DB      12Q     ;ASCII LINE FEED
        BEG     DUMP    ;SETS ADDRESS OF PLACE TO START EXECUTING
                        ;PROGRAM
        END     DMP
```

```
 SENSE SWITCH 15 FOR DUMP
NOTE: AT THIS POINT THE PUNCH OR OUTPUT TAPE IS READIED FOR
OUTPUT OF THE PROGRAM IN ABSOLUTE BINARY FORMAT(APPENDIX A).
OUTPUT DONE


UNDEFINED SYMBOLS

SYMBOL TABLE
DUMP 020000
FIRST 020234
NEWLN 020004
BUF 020240
LAST 020236
LAST3 020165
NXTNUM 020067
LNDN 020133
BLANK 020154
CHKLN 020116
OUT 020222
BL 020156
STAT 020232
RUN DMP
015100    104    040    002    007    001    105    040    003
015110    007    001    110    040    004    007    001    114
015120    040    005    007    001    115    040    006    007
015130    002    123    120    040    006    007    003    120
015140    123    127    040    006    007    001    044    040
015150    000    000    000    000    000    000    000    000
015160    377    377    377    377    377    377    377    377
015170    377    377    377    377    377    377    377    377
015200    000    000    000    000    000    000    000    000
015210    000    022    114    123    124    272    032    016
015220    000    073    033    022    115    101    107    000
015230    000    016    000    073    033    061    104    115
015240    120    000    040    020    115    101    107    272
015250    032    110    000    073    033    335    017    065
015260    115    101    107    377    377    377    060    000
015270    043    007    122
```

V. EDITOR

V. Text Editor

The editor is used to create and modify source program files using the four editing commands. These now include the alter command, used to make corrections within a line, eliminating the need to replace all mistyped lines. The insert, delete, and replace command are still included and have been improved to ease the job of modifying a program.

Symbolic device names used by the Editor

Before running the editor, all symbloic device names used by it are open to the TY, and need to be changed only if the device is not correct. They are listed below along with mode information needed for proper operation.

FIL - File I/O device name
- A - ASCII read mode should be specified
- T - Tabs should not be specified
- E - Can be speified if the user wants a listing
  Tabs will not be expanded

ALT - Alter command I/O
- A - ASCII mode should not be scecified
- T - Tabs should be specified
- E - Echoing should not be specified

LST - Write and print command I/O
- A - ASCII mode should be specified
- T - Tabs should be specified
- E - Echoing is not used during writing

Buffer Area

The first 2 K of memory following the editor is allocated as a buffer to store the lines of text that you are editing. If the size or location of this buffer area need to be changed, two addresses within the editor must be changed. Starting at location 5124Q is the address of the beginning of the buffer and the address of the end of the buffer starts at location 5530Q.

Loading the Editor

Open symbloic device ABS to the AC or TY depending on whether your copy of the editor is on audio cassette or paper tape. The editors file name is EDT and is loaded by typing EDT<CR> .
Example:
To load the Editor from paper tape type:

```
  ?OPN ABS,TY<CR>
  ?EDT<CR>
(TURN ON PAPER TAPE READER)
START INPUT
```

* (The astrisk it printed whenever the editor is ready for a command)

If after completing an edit and returning to the monitor you want to use the editor again, type:

```
  ?EDT<CR>
START INPUT
*
```

If you would like to continue editing lines left in the editors buffer area when you last exited the editor, use the R execution option. Example.

```
  ?EDT(R)
*
```

Start input is not printed in this case and the buffer is not reinitialized. This feature is especially useful when assembling directly from the editors buffer.

Range and Line Number Specifications

When a range is called for by an instruction, the following syntax is required.

Line Number,[Line Number]

Line Numbers

Three types of line numbers are now recognized by the Editor. They are as follows:

NUMBER(N)	THE N'TH LINE IN THE BUFFER.
.[+ OR - NUMBER]	RELATIVE ABOUT THE CURRENT LINE.
*[- NUMBER]	RELATIVE ABOUT THE LAST LINE IN THE BUFFER

EXAMPLE.

p

Prints the last line in the buffer.

*P1Ø

Prints the tenth line in the buffer.

*P.+1Ø

Assuming this command was executed after the P1Ø command, line 2Ø would be printed.

Editor Commands

I [Line Number] Insert Command

The insert command causes the editor to enter the insert mode at the line specified. After all lines to be entered have been typed, type a Control Z to return to the command level of the editor. If no line number is typed all lines are inserted before the first line.

D Range Delete Command

Deletes all lines in the specified range.

R Range Replace Command

Deletes the lines in the range and enters the insert mode.

P [Range] Print Command

Prints all lines within the range or all lines in the buffer if no range is given. Line numbers are printed to the left side of the lines.

W [Range] Write Command

Same as print command except line numbers are not printed.

String Search Command

F[String][<ESCAPE>[Line Number]]

The find command searches the buffer area starting at the given line number, printing the first line it finds the string in. If no string is given, the string from the last find command issued is searched for. If no line number is typed, the editor starts searching at the current line plus 1 (ie .+1). The escape is optional when not typing a line number.

S Save File Command

Save command prints
FILENAME=
An optional 3 character file name is typed followed by a carriage return. The editor responds by typing CHANGE SENSE SWITCH 15 as soon as this message has finished printing turn on the device the file is to be dumped on. Change the position of sense switch 15 to indicate the device is ready. When all lines have been dumped, the editor returns to the monitor. When a file name is given, a header block is written containing the file name. If no file name was typed, no header block is output.

L Load File Command

The load command prints
FILENAME=
An optional 3 character file name is typed, followed by a carriage return. If a file name is typed, a header block containing the proper file name is searched for and the file following it is loaded into the buffer. If no file name is typed, all lines are loaded until an end of file is read. This command reads files from symbolic device FIL.

<ESCAPE> Backup Command

If an escape is typed to the editor a dollar sign is echoed and and the current line minus 1(ie .-1) is typed.

<LF> Next Line Command

If a line feed is typed to the editor the current line plus 1(ie.+1) is printed.

E Exit Command

Causes the editor buffer read pointer to be reset to the beginning of the buffer, and returns to the monitor.

A Line Number Alter Command

The alter command puts the Editor into Alter mode, allowing the programmer to change lines without replacing them. The following command characters are recognized but not echoed, and all commands can be prefixed by a repetition factor of up to six digits. This repetition factor is refered to as "N" in the following description, and is assumed to be one(1) if not given.

Alter Mode Commands

D - Deletes the next n characters in line. A slash is output followed by all characters deleted and a closing slash.
Example:
The current line is
BLAB: MOV A,B
*A. Give Alter Command
You type 3D and the editor responds by typing /BLA/ indicating that BLA has been deleted from the line.

I - Inserts all characters typed after the I into the line at the current current place in the line. All characters are echoed and typing an <ESCAPE> will get you back to the alter mode.

R - Deletes the next N characters in the line and enters the insert mode.

S - Typing a S followed by any character will cause a search for the N'th occurance of that character.

Blank - Typing a blank will cause the next N characters in the old line to be copied into the new line and be printed out.

<CR> - Typing a carriage return will print out the rest of the old line, inserting the characters at the same time into the new line. The old line line will the be replaced by the new one and control is returned to the command level of the editor.

Q - Causes control to return to the command level of the editor without replacing the old line. This command is used to abort an alter during which you made a bad mistake.

Sample Edit

In the following example characters typed as alter mode commands that would not be echoed are inclosed in parenthses.

```
  ?EDT<CR>
START INPUT
*I<CR>
THIS IS A DEMONSTRATON
OF THE EDITOR.
<CONTROL Z>
*A1<CR>
(2ST)THIS IS A DEMONSTRA(<SPACE>)T(I)I(<ESCAPE>)<CR>
*W<CR>
THIS IS A DEMONSTRATION
OF THE EDITOR.
*A2<CR>
(3<SPACE>)OF (2D)/TH/<CR>
W2<CR>
OF E EDITOR.
A.<CR>
(SE)OF (R)/E/THE(<ESCAPE>)<CR>
*W<CR>
THIS IS A DEMONSTRATION
OF THE EDITOR.
*E<CR>
  ?
```

VI. DEBUG

DBG DOCUMENTATION VER 1.Ø

Package Summary:

The DEBUG package provides the user with the following capabilities:

1) Display memory locations, registers, or flags in any of several output I/O modes (including a symbolic instruction mode).

2) Modify memory locations, registers, or flags using corresponding input modes.

3) Set (or display or remove) breakpoints in the code to be debugged.

4) Enter and execute user code either
   A) at a specified location or
   B) automatically in such a way as to proceed properly from the most recently encountered breakpoint.

The commands accepted by DBG are 1-character commands or combinations of 1-character commands and data. These commands will be described in the remainder of this document.

Note: In the examples that follow, <CR> represents a carriage return character, <LF> a line feed, <RUBOUT> a delete character, <TAB> a tab (Control-I), <UPARROW> a ^.

Numbers may be typed in either as octal (the default) or as decimal by preceding the number with a number sign (#). Therefore #255 is equal to 377. It a single byte value is expected and a value greater than 377 is input, only the low order eight bits (byte) of the value is used.

RUBOUT:

If in the course of entering commands or data an error is made, a rubout character can be typed at any time to abort user input. DBG will type a question mark (?) and begin accepting commands on a new line.

I/O Modes:

Information is usually displayed and then re-entered in accordance with the current I/O mode. The I/O mode can be set by typing an ESCAPE or dollar sign (echoed $) followed by a character that specifies the I/O mode:

$O Specifies octal mode.
$D Specifies decimal mode.
$W Specifies double byte octal mode.
$A Specifies ASCII mode.
$S Specifies symbolic instruction mode.

$O Mode

In octal mode, each location is typed as an octal value between 0 and 377. The line feed or up arrow characters always advance or back up the location counter by 1. Input is expected to be a one byte value between 0 and 377. Example:

```
10/ 0 55<CR>
10/ 55 #48<CR>
10/ 60
```

$D Mode

Decimal I/O mode is identical to $O (octal) mode except that output is decimal and input is always assumed to be decimal (no number sign should precede input).

$W Mode

In double byte octal mode ($W) the location and location plus one are interpreted as a double byte (16 bit) quantity. Assuming location 10 contains 0 and location 11 contains 1, then:

```
$W 10/ 400 200
10/ 200 <LF>
12/ 0
```

Line feed and up arrow always add or subtract two from the location counter.

The value re-entered in $W mode (the 200 in the above example) is interpreted as being a 16 bit (double byte) value and is stored in memory low order byte first, high order byte second.

$A Mode

ASCII mode is used to type out or input ASCII information. When a location is opened in ASCII mode, the ASCII representaition of the byte store in there is typed:

```
$O 10/ 0 101<CR>
$A/
10/ A
```

When ASCII information in input, DBG expects the user to type a delimiter, a string of ASCII characters, and then a terminating delimiter which is the same as the initial delimiter.
Example:

```
10/ A "B"
```

This enters the character B into location 10. The delimiters(") are not stored in memory. Multi character strings may be entered:

```
10/ B "FOO"
```

(Note: One should not try to use the special characters <CR>, LF>, <TAB>, ¨, <ESC OR $>, <RUBOUT>, =, ;, !, ., +, -, / as delimiters as these characters have special meanings for DBG. Double quote and single quote should suffice for most string entry.) Typing slash (/) after a string has been entered will reopen the first location in the string:

```
10/ A "FOO"/
10/ F
```

Typing <LF> after a string has been entered will open the location after the last location stored in:

```
10/ A "FOO"<LF>
13/ Z
```

The only character which may not be entered in an ASCII string is <RUBOUT>. <RUBOUT> may be used to terminate the entry of an ASCII string. However, any characters that had been entered prior to the typing of the slash are still there.

```
10/ A "FO<RUBOUT>
?
10/ F <LF>
11/ O
```

Special note: The high order bit (D7) of data entered via $A mode will always be set to zero.

$S Mode

Symbolic (instruction) mode is used to type out locations as if they were instructions, and to enter instructions into memory using their mnemonics. Example (suposing locations 7-16 octal contained 0):

```
$S 5/ NOP LXI H, 8192<LF>
10/ NOP MVI B,100<LF>
12/ NOP MVI M,0LF>
14/ NOP DCR B<LF>
15/ NOP JNZ 12<LF>
16/ NOP JMP 100<CR>
```

In this example, a short program has been entered to set the 64 decimal bytes starting at location 8192 decimal to zero. After it finishes, the program returns to the monitor by jumping to location 100 octal. Decimal numbers may be used in the address or immediate fields of an instruction by preceding them with a number sign (#). DBG may be used in the fashion demonstrated above to 'improvise' programs. After they have been written and debugged, the monitor DMP command may be used to

store them on cassette or paper tape. The symbolic I/O mode is often very useful in patching or changing instructions in existing programs to fix bugs temporarily before the source code is re-assembled.

<LF> in symbolic mode opens the location which is the current location plus the number of bytes of the instruction typed out (or just entered) -1.

<UPARROW> opens the current location minus the number of bytes of the instuction typed out (or just entered). This may or may not be meaningful, as the previous intruction may not be the same number of bytes as the one just typed in or displayed.

The default mode (when DBG is first entered) is octal.

Slash:

A memory location can be displayed by typing its octal address followed by a "/". This address may be octal or decimal and is independent of the I/O mode. Thus

30/

or

#24/

Will cause the contents of octal location 30 to be displayed in the current I/O mode. In the case of symbolic I/O mode, up to 3 bytes (e. g. a JMP) may be displayed depending on the type of instruction found in the first byte. Registers can also be displayed by typing a "/" after their 1-character names. For example

L/

Will cause the contents of the l register to be displayed in the current I/O mode. (The value actually displayed is not actually the L register but a memory location used to maintain the user's L register while DBG executes.)

The flag register (condition codes) is displayed similarly by typing

F/

Since the contents of the flag register is usually interpreted as settings of the carry (C) zero (Z) sign (S), parity (P) and half carry (H) flags, a special type out mode has been provided so the user can display the flags in a meaningful fashion without having to interpret the octal value of the flags:

F/ 106 !ZP

In this example, the flag register was opened in octal mode. In order to display which flags were set, the character ! was typed and the debug package typed back 'ZP' which meant that the zero and parity flags were set. The exclamation character may be used to type out any loctaion in 'CONDITION CODE' format. This can prove useful when examining condition codes that have been pushed on the stack by the 'PUSH PSW' instruction.

There is no corresponding method to enter condition codes symbolically. The user must re-enter any change he wishes to make in the current I/O mode (octal is suggested). See the table below under the F register for the bit positions of the different flags.

The stack pointer may be displayed by typing:

S/

This will display the lower 8 bits of the stack pointer in the current I/O mode. To display the high 8 bits, type linefeed. Typing TAB (Control I) after opening the low eight bits of a register or location will open the location pointed to by the register pair or double byte memory pointer. i.e. to look at the byte pointed to by the H and L registers, type:

```
L/ 4 <TAB>
5004/ <The contents of this location>
```

In this example, H would have contained 12 octal. A TAB is also useful when the I/O mode is symbolic and a 3-byte instruction has just been displayed. The current location pointer will be set to the address part of the displayed instruction, and the contents at that new address will be displayed. This feature permits simplified program tracing when jumps and calls are encountered. If the last value displayed was not a three byte instruction displayed in symbolic mode, then TAB will open and display the location pointed to by the double byte (low byte first, high order byte second) which reside in memory starting at the current location (as in the previous example).

```
70/ JMP 5000 <TAB>
5000/ SHLD 4750
```

The user program registers are stored inside DBG when a breakpoint is encountered during the execution of a user program. The order of the registers in memory is as follows:

```
REGISTER
NAME
-
F         (CONDITION CODES)
          BIT      MEANING (IF = 1)
          ---      ---------------
          Ø        CARRY
          2        EVEN PARITY (NUMBER OF ONES IN RESULT WAS EVEN)
          4        HALF CARRY FOR BCD OPERATIONS
          6        ZERO
          7        SIGN (ONE MEANS MSB OF RESULT WAS 1)
A
C
B
E
D
L
H
S         (STACK LOW EIGHT BITS)
          (STACK HIGH EIGHT BITS)
```

Thus, once a particular register is opened, linefeeds, and/or uparrows may be used to display the register above or below the one currently opened.

DOT:

The address of the most recently displayed location is saved in a "CURRENT LOCATION POINTER". The location at that address can be redisplayed at any time (even after changing I/O modes) by typing

```
./
```

or simply

```
/
```

The dot (which can be optionally omitted) can be thought of as a symbol for the address of the current display location. This pointer can be offset in either direction using a + or - and a number. Thus:

```
.+5/
```

displays the contents 5 locations after the current one, and

```
-33/
```

displays the contents of the location 33 octal locations before the current one. (As before, typing of the "." is optional.)

Multiple subtractions and additions may be performed to calculate addresses or other sixteen bit (two byte) values:

```
100+20-30/
70/ 25
```

The equal sign (=)

The equal sign may be used to type out the current value of calculation:

```
100+20-30=70 -#8=60
```

Semicolon:

In general, whereas a slash can be typed at any time to display the current location in accordance with the current I/O mode, a semicolon can be typed at any time to display the current location in octal independent of current I/O mode. The I/O mode is not changed by a semicolon, but if location modifying information immediately follows the octal display, the input information will be accepted in octal. Thus if the current I/O mode were symbolic the octal equivalent of a symbolic instruction at location 100 could be examined easily with a semicolon as follows:

```
100/ MOV A,C;  171
```

Line Feed and Up-Arrow:

A line feed (usually typed after some location has been displayed) causes the current location pointer to be advanced to the next location, and that location will be displayed. This permits rapid display of successive memory locations. If the current I/O mode is symbolic the current location pointer advances by the number of bytes in the instruction just displayed. Thus a rapid symbolic display of program segments is possible.

The up-arrow command acts similarly to a line feed except that it decrements rather than increments the location pointer.

Location Modification:

Immediately after a location has been displayed it is subject to modification. (Susceptability to accidental modification at this point can be removed by typing a carriage return.) Input for modifying the location must conform to the current I/O mode. (Exception: After a semicolon as described above.) A failure to conform to the current I/O mode, or entry of uninter- uninterpretable data will result in rejection of the input data. (A question mark will be typed by DBG.) In general, spaces are always ignored on input and can be typed or omitted with no effect in any I/O mode.

The following special characters:

<CR>, <LF>, /, ;, <TAB>, +, -, <ESCAPE>, !, =, <UPARROW>

Will always cause termination of data input strings as they have special meaning to DBG.

A "/" can be used as a terminator to get an automatic feedback of the typed input data. In the following example, the I/O mode is symbolic.

```
./JMP 200 LXIB, 12 3/
200/ LXI B,123
```

Three bytes starting at location 200 are set by the above commands. The second line was typed entirely by DBG in response to the "/" terminator. This sequence checks both the correctness of the entered data (which at first looks questionable) and the previously uncertain value for the current location pointer.

If input is purposely terminated by a line feed, up-arrow, slash, or tab, the input will be processed and the appropriate new location will be displayed. Thus, for example, the following sequence demonstrates clearing of a small block of memory locations that previously all contained 377's:

```
30/ 377 0<LF>
31/ 377 0<LF>
32/ 377 0<LF>
33/ 377 0<LF>
```

In the above sequence DBG typed all but the initial "30/" and the repeated "0 <LF>"'S.

Breakpoints:

Breakpoints are set using the X command. For example:

```
30X
```

causes the first unused breakpoint to be set at location 30. Similarly,

```
.X
```

or just

```
X
```

will cause a breakpoint to be set at the current location pointer.

There is capacity for setting 8 different breakpoints numbered internally 0 thru 7. When an X command is executed the first free breakpoint is allocated to the breakpoint being set. If there are no free breakpoints, a question mark is printed, and one of the existing breakpoints must be deleted before a new one can be set. When any breakpoint is encountered the address of that breakpoint is always displayed for the user by DBG:

```
5 BREAK @1000
```

means that breakpoint number five was encountered at octal location 1000.

It is permissable to change the instruction at any breakpoint at anytime while running DBG.

```
2 BREAK @1000
1000/ XRA A ORA A<CR>
```

If an RST instruction is executed which is the same RST used by DBG but was not inserted by DBG as a breakpoint, DBG will type out the breakpoint number as 10:

```
10 BREAK @205
```

It is possible to proceed from such breakpoints, but this kind of conflict between user RST's and DBG RST's usually indictates that a user RST service routine is not being executed and DBG is intercepting the RST. Under these circumstances, the breakpoint RST should be changed so it does not conflict with user RST's.

Changing the RST used by DBG.

It may become necessary to change the RST used by the debug package to another RST. to accomplish this you can use DBG itself to make a modification which will allow you to set the breakpoint RST to any of the eight possible RST's. Start looking for the first MVI instruction in DBG by entering symbolic typeout mode and line feeding until you find it.

```
$S       CR>              ;OPEN SYMBOLIC MODE
12722/   SHLD 4205 <LF>   ;OR WHATEVER
ETC.
13000/   MVI A,377        ;DISPLAY RST SETUP INSTRUCTION
         MVI A,317  <CR>  ;CHANGE IT TO RST 1.
13000G                    ;RESTART DEBUG PACKAGE
```

It is important to note that when DBG is started, it always initializes the appropriate RST location (0,10,20,30,40,50,60,70 octal) to a JMP instruction to the breakpoint handling code inside DBG. Thus, when DBG is started initially, it will always clobber (store into) locations 60,61 and 62 octal with a JMP instruction.

Checking Breakpoints:

The Q command causes all program set breakpoints to be displayed.

Example (assuming DBG has just been started):
```
10X
20X
377X
Q
0@10
1@20
2@377
```

Each breakpoint is typed out by its number, an at (@) sign, and then the address where the breakpoint is set. Any breakpoints that are not mentioned by a 'Q' command are not in use.

Removing Breakpoints:

Typing Y (carriage return) will remove all breakpoints. Typing Y followed by <DIGIT> will remove breakpoint DIGIT>:
```
Y5
Y
```

Execution:

The 'G' or go command permits entry of user code at an arbitrary location, the address should be followed by a G. Thus:

```
30G
```

will cause execution to begin at octal location 30. As in other situations the current location pointer can be used in place of an address. Thus

```
.G
```

or simply

```
G
```

will cause execution to begin at the user address indicated by the current location pointer.

If a user program loops endlessly (a typical symptom is that no response is made to input) the debug package can be re-entered by stoping the program (either with Control-C if monitor interrupts are being used or by manually stoping the machine) and restarting DBG from the monitor or at its starting location.

Proceeding from a Breakpoint:

If it is desired to proceed from the last encountered breakpoint, the single character command "P" can be used. Restrictions: This command cannot be used if no break point has yet been encountered during execution or user code. If this is tried, a question mark will be typed.

Multiple Proceeds:

An number before a P has a different meaning than before a G. Such a number indicates the number of times a P command should be executed (the number of times that any encountered breakpoint should be ignored) before control is returned to DBG. Thus the command

30P

will cause execution to proceed in the user program until breakpoints have been encountered 30 (octal) times. This feature is especially useful in proceeding from a loop that contains a breakpoint.

Typing out a Sequence of Locations:

The "T" command is used to type out a sequence of locations in the current I/O mode. The format of the command is:
X,YT

where X is the beginning address and Y is the ending address. For instance:

100,500T

would type out the first 256 bytes of the monitor in the current I/O mode.

DBG System Documentation

The debug package resides directly above the monitor. whenever the debug package is entered, it saves the user registers in memory inside the debug package. It then replaces any breakpoints that may have been set with the original instruction contained in the location where the breakpoint was set. The RST location is then initialized to point to the DBG breakpoint service routine.

When a 'G' or 'P' command is typed, DBG replaces all instructions which have breakpoints set at their locations with the DBG breakpoint RST, and saves the original instruction in a table inside DBG so the original instruction may be restored if DBG is restarted or a breakpoint is encountered. Then all the original user registers are restored. If this is a 'P' command, a complicated sequence of operations are performed to correctly execute the instruction located at the breakpoint address. This is especially difficult for CALL's,and RST's, as the instructions are actually executed inside the debug package, and not at the breakpoint location. After simulation of the breakpointed instruction is finished, DBG jumps to the instruction after the one

breakpointed. (or in the case of true conditional JMP's, CALL's or RST's to the proper location). When a breakpoint RST is executed, DBG saves all the users registers and restores breakpointed instructions.

The debug package program name is DBG and is loaded by typing:

```
  ?dbgCR>
(RUN THE TAPE)
DEBUG
```

Debug starts at 5100Q and ends at 11577Q, allowing AM2 to be in memory at the same time.

APPENDIX

APPENDIX A

ABSOLUTE LOAD TAPE FORMAT

BEGIN/NAME RECORD

BYTE 1	125 OCTAL	BEGIN SYNC
BYTES 2-4	NAME	PROGRAM NAME
BYTES 5-N	COMMENTS	END STATEMENT DOCUMENTATION (I.E.PROGRAM REVISION AND DATE)
BYTE N+1	15 OCTAL	TERMINTATES THE PROGRAM NAME RECORD

PROGRAM LOAD RECORD

BYTE 1	74 OCTAL	LOAD SYNC BYTE
BYTE 2	Ø-377 OCTAL	NO. OF LOAD BYTES(N)
BYTE 3	L.S. BYTE	LOAD ADDRESS
BYTE 4	M.S. BYTE	" "
	DATA BYTES	
BYTE N+5	*	CHECKSUM BYTE

* THE CHECKSUM IS GENERATED BY ADDING W/O CARRY ALL BYTES EXCEPT THE FIRST TWO.

END-OF-FILE RECORD

BYTE 1	17Ø OCTAL	PAPER/AUDIO CASSETTE EOF
BYTE 2-3		BEGIN EXECUTION ADDRESS

APPENDIX B

ASSEMBLY MEMORY MAP

MEMORY BLOCKS	BOUNDARIES
	TOP OF MEMORY
USER SPACE	
	FIRST WORD OF PROGRAM STORAGE (SET BY ORG OR ORR IF GIVEN)
SYMBOL TABLE (CHAR. LENGTH +3 BYTES/SYMBOL)	
	SYMBOL TABLE BUILDS UP FROM HERE
TEMPORARY ASSEMBLER VARIABLES	
	FIRST WORD OF VARIABLE STORAGE
ASSEMBLER PROGRAM STORAGE (VERSION 1)	
	FIRST WORD OF ASSEMBLER (5100Q)
MONITOR TABLES & HANDLERS	
RESTART TRAPS	
	BOTTOM OF MEMORY

RECOMENDED MEMORY LAYOUT WITH EDITOR AND ASSEMBLER

MEMORY BLOCKS	BOUNDARIES
	TOP OF MEMORY
EDITOR BUFFER AREA	
	FIRST WORD OF BUFFER
USER AREA	
SYMBOL TABLE	
ASSEMBLER (VERSION 2)	
	FIRST WORD OF ASSEMBLER (11520Q)
	DEFAULT START OF EDIT BUFFER
EDITOR	
	EDITOR STARTS AT 5100Q
MONITOR	
	BOTTOM OF MEMORY

Appendix C

Assembler Errors

Error codes are the first two characters on the line following occurance of an error. The characters replace the characters that are normally echoed on a TTY or Compter terminal.

B# No origin specified

D# Double defined symbol

I# Illegal operand
Undefined byte symbol
String not allowed
Name value must be defined
ORR or ORG must be defined value

N# No name defined

O# Memory overflow
Program space not large enough

Q# Symbol table overflow
Program storage should begin at higher memory address

S# Symbol undefined

Monitor Errors

All monitor error messages are output inplace of the 2 spaces in the monitor prompt.
Example:

```
  ?OPN FIL,EV,A
H*?
```

A* Attempt to store over monitor
No program can load before 5100Q.

C* Typing a Control C caused a return to the monitor.

D* Name already in PTL
Use the CLR utility to remove the program name from the PTL.

F* I/O table full
Use the CLS utility program to close an unused symbolic name freeing space in the table to open the name you need.

H* Hardware device undefined
An attempt was made to open a symbolic name to a nonexistant

hardware device.

L* Load error.
A checksum error occured while loading a program.

M* Memory malfunction
Memory not working or nonexistant.
After storing into memory the stored byte did not compare exactly with the value stored. This is checked when the monitor loads a program.

N* I/O device name not open
Before trying to read from a symbolic device, that device should be opened. See open command under monitor utility programs.

P* Program table(PTL) full
Use the CLR utility to clear the name of a program that is'nt needed any longer.

S* Syntax error in command line

U* Program name not in ptl

V* Illegal operation
An illegal operation code was given in a monitor control block.

Appendix D.

If you need to set up any special purpose I/O handlers, the following addresses may be useful.

Console input interrupt routine - 4414Q
Console input non-interrupt routine - 3436Q
Console output routine - 3422Q
Console tab counter - 4614Q
ACR input routine - 4521Q
ACR output routine - 4532Q
ACR tab counter - 4617Q
Edit buffer read routine - 3374Q

The structure of the monitor table that would need to be modified is as follows:

```
        DB      "DN"    ;TWO CHARACTER DEVICE NAME
        DW      DEVIN   ;ADDRESS OF DEVICE INPUT ROUTINE
        DW      DEVOUT  ;ADDRESS OF DEVICE OUTPUT ROUTINE
        DW      DEVTAB  ;ADDRESS OF DEVICE TAB COUNTER
                        ;THIS IS ONE BYTE OF STORAGE USED
                        ;TO STORE INFORMATION ON THE CURSOR POSITION
```

Their is room in the table for an entry to be added at location 220Q.

Example:

Suppose you want to have input from the ACR echoed on your terminal and to refer to it in an OPN command as the "AT". The following added at location 220Q would accomplish this.

```
        DB      "AT"
        DW      3527Q   ;THIS FORCES INPUT FROM THE ACR
        DW      3575Q   ;THIS CAUSES OUTPUT TO BE SENT TO THE CONSOLE
        DW      TABL    ;THIS ALLOWS THE TABS TO WORK CORRECTLY
TABL:   DS      1
```

If you want to use monitor I/O with a device not supported by Mits, this can be accomplished by writing your own handler and putting it in high memory. Input routines should return a character in the A register while output routines should output the character in the A register. The routine should check the status of the device, loop until ready, and perform any character conversions if needed(ie. BOUDOT to ASCII or ASCII to BOUDOT).

Example:

You have a high speed paper tape reader connected to I/O port 12 and 13. Its motion is controled by the output to port 13. A 1 turns the reader on and a 0 turns it off.

Put the following routine in unused memory(probably in the highest locations in your machine).

```
HSRD:   MVI     A,1     ;SET A = TO 1
        OUT     13Q     ;TURN ON READER
        IN      12Q
        RAR             ;ROTATE STATUS BIT INTO THE CARRY FLAG
```

```
        JC      TRMIN   ;WAIT FOR INPUT READY BIT TO GO LOW
        XRA     A
        OUT     13Q     ;SHUT READER OFF
        IN      13Q     ;INPUT THE CHAR FROM TERMINAL
        RET
    AT LOCATION 220Q PUT THE FOLLOWING:
        DB      "PT"    ;DEVICE NAME
        DW      HSRD    ;ADDRESS OF READER INPUT ROUTINE
        DW
        DW              ;SINCE NO OUTPUT ROUTINE TAB COUNTER NOT NEEDED
```

To open ABS to the high speed reader in order to read in absolute program tapes, use the following open command.

```
?OPN ABS,PT
```

Appendix E.

When the Altair is first turned on, there is random garbage in its memory. The monitor is supplied on a paper tape or audio CASSETTE. Somehow the information on the paper tape or cassette must be transfered into the computer. Programs that perform this type of information transfer are called Loaders.

Since initially there is nothing of use in memory, you must toggle in, using the switches on the front panel, a 20 instruction Bootstrap Loader. This loader will then load the MONITOR. SO, to Load the MONITOR, follow these steps:

1) Turn the Altair ON.

2) Raise the STOP switch and RESET switch simultaneously.

3) Turn your terminal (usually a Teletype) to LINE.

Because the instructions must be toggled in via the switches on the front panel, it is rather inconvenient to specify the positions of each switch as up or down. Therefore, the switches are arranged in groups of 3 as indicated by the broken lines below switches 0-15. To specify the positions of each switch we use the numbers 0-7 as shown below:

	Switches		
Leftmost	Middle	Rightmost	Number
Down	Down	Down	0
Down	Down	Up	1
Down	Up	Down	2
Down	Up	Up	3
Up	Down	Down	4
Up	Down	Up	5
Up	Up	Down	6
Up	Up	Up	7

So, to put the octal number 315 in switches 0-7, the switches would have the following positions:

			Switches					
7	6	/ 5	4	3	/ 2	1	0
UP	UP	/ DOWN	DOWN	UP	/ UP	DOWN	UP
	3		1			5	

Note that switches 8-15 were not used. Switches 0-7 correspond to the switches labeled DATA on the front panel. A memory address uses all 16 switches.

The Bootstrap Loader is the following program:

The following Bootstrap Loader is for users loading from paper tape and using a REV 1 Serial I/O board.

Address	Data
000	041
001	256
002	017
003	061
004	022
005	000
006	333
007	000
010	017
011	330
012	333
013	001
014	275
015	310
016	055
017	167
020	300
021	351
022	003
023	000

The following 21 byte Bootstrap Loader is for users loading from paper tape and using a REV 0 Serial I/O board on which the update changing the flag bits has not been made. If the update has been made, use the above Bootstrap loader.

000	041
001	256
002	017
003	061
004	023
005	000
006	333
007	000
010	346
011	040
012	310
013	333
014	001
015	275
016	310
017	055
020	167
021	300
022	351
023	003
024	000

The following Bootstrap Loader is for users with the MONITOR supplied on an Audio Cassette.

```
000     041
001     256
002     017
003     061
004     022
005     000
006     333
007     006
010     017
011     330
012     333
013     007
014     275
015     310
016     055
017     167
020     300
021     351
022     003
023     000
```

88-PIO BOOTSTRAP

```
000     041
001     256
002     017
003     061
004     023
005     000
006     333
007     000
010     346
011     040
012     310
013     333
014     001
015     275
016     310
017     055
020     167
021     300
022     351
023     003
024     000
```

2 SIO BOOTSTRAP

```
000     076
001     003
002     323
003     020
004     076
```

```
        005     021 (=2 STOP BITS
        006     323 025=1 STOP BIT)
        007     020
        010     041
        011     256
        012     017
        013     061
        014     032
        015     000
        016     333
        017     020
        020     017
        021     320
        022     333
        023     021
        024     275
        025     310
        026     055
        027     167
        030     300
        031     351
        032     013
        033     000

4 PIO BOOTSTRAP

        000     257
        001     323
        002     020
        003     323
        004     021
        005     076
        006     004
        007     323
        010     020
        011     041
        012     256
        013     017
        014     061
        015     034
        016     000
        017     333
        020     020
        021     346
        022     100
        023     310
        024     333
        025     021
        026     275
        027     310
        030     055
        031     167
        032     300
        033     351
        034     014
```

035	000

MITS HIGH SPEED READER BOOT

000	257
001	323
002	020
003	323
004	021
005	323
006	022
007	057
010	323
011	023
012	076
013	014
014	323
015	020
016	076
017	004
020	323
021	022
022	076
O23	016
024	323
025	023
026	041
027	256
030	017
031	061
032	051
033	000
034	333
035	020
036	346
037	100
040	310
041	333
042	021
043	275
044	310
045	055
046	167
047	300
050	351
051	031
052	000

So, to load the Bootstrap Loader:

4) Put switches 0-15 in the Down position.

5) Raise EXAMINE.

6) Put 041 (the data for address 000) in switches 0-7.

7) Raise DEPOSIT.

8) Put the data for the next address in switches 0-7
(For address 001 this is 175)

9) Depress DEPOSIT NEXT.

10) Repeat steps 8-9 until the entire Loader is toggled in.

Next check that the Bootstrap Loader is in correctly:

11) Put switches 0-15 in the Down position.

12) Raise EXAMINE.

13) Check that lights D0-D7 correspond with the data that should be in address 000. A light 'on' means the switch was up; A light 'off' means the switch was Down. So for address 000, lights D1-D4 and D6-D7 should be off, and lights D0 and D5 should be on.

If the correct value is there, go to step 16.
If the value is wrong, go to the next step, 14.

14) Put the correct value in switches 0-7.

15) Raise DEPOSIT.

16) Depress EXAMINE NEXT.

17) If you have not checked the entire Bootstrap Loader, Repeat steps 13-16 until you have.

18) If you found a mistake, go back to step 11 and check the Bootstrap Loader again.

19) Put the tape of the MONITOR into the tape reader. Be sure the TAPE is positioned at the beginning of the leader. The leader is the section of tape at the beginning with 6 out of the 8 holes punched.
If you are loading from Audio Cassette, put the cassette in the recorder. Be sure the tape is fully rewound.

20) Put switches 0-15 in the Down position.

21) Raise EXAMINE.

22) There are six different Bootstrap Loaders, one for each of the six types of I/O boards listed in the load option chart. Be sure that you use the correct one for your particular board.

LOAD OPTIONS

OCTAL LOAD DEVICE MASKS	SWITCHES UP	OCTAL CHANNELS	STATUS BITS ACTIVE
SIOA,B,C (NOT REV Ø) 1/200	NONE	Ø,1	LOW
ACR 1,200	A15(AND TERMINAL OPTS.)	6,7	LOW
SIOA,B,C (REV Ø) 40/2	A14	Ø,1	HIGH
88-PIO 2/1	A13	Ø,1	HIGH
4PIO 100/100	A12	20,21	HIGH
2SIO 1/2	ALL (AND A1Ø UP=1 STOP BIT DOWN=2 STOP BITS	20,21	HIGH

23) If the load device is an ACR, the terminal options (see second chart) can be set on the switches (along with a15) before the loadein is done. If A15 is set, the checksum loader will ignore all of the other switches and the monitor will ignore A15.

24) If the load device and the terminal device are not the same, and the load device is not an ACR, then only the load options should be set before the loading. When the load completes ,the MONITOR will start-up and try to send a message to the load device. Press STOP, EXAMINE loaction 5121, set the terminal option switches, and then depress RUN.

TERMINAL OPTIONS

TERMINAL DEVICE	SWITCHES UP	OCTAL CHANNEL DEFAULT
SIOA,B,C (NOT REV Ø)	NONE	Ø,1
SIOA,B,C (REV Ø) (A9 WILL BE IGNORED FOR THIS BOARD)	A14	Ø,1
88-PIO	A13	Ø,1
4PIO	A12	2Ø,21 (INPUT) 22,23 (OUTPUT)
2SIO	A11	2Ø,21 (A1Ø UP=1STOP BIT DOWN=2STOP BITS)

Iif sense switch A9 is raised, interrupt I/O will not be enabled. See Appendix F for discription of this feature.

The default channels listed above may be changed as desired by raising A8 and storing the lowest channel number (INPUT FLAG CHANNEL) in location 7777 (OCTAL).

Note: The "INPUT FLAG CHANNEL" may also be refered to as the "CONTROL CHANNEL" in other Altair documentation.

The above information is useful only when the load device and the terminal device are not the same. During the load procedure A8 will be ignored; therefore,the board from which the monitor is loaded must be strapped for the channels listed in the load option chart.

25) When loading paper tape from a device connected to a SIO A,B,C or a 88-PIO board, start the tape reading and then depress run. If the device is connected to a 2SIO or 4PIO depress RUN and then start the tape reader. If you are loading from cassette, turn the cassette recorder to play. Wait 15 seconds and then depress RUN.

26) The new Checksum Loader will display 7647 on the address lights when running properly. When an error occurs (checksum "C"-bad data, memory "m"-data won't store properly, overlay "O"-attempt to load over top of the checksum loader) the address lights will then display 7637. The ASCII error code is stored in the accumulator (A) and is being output on channels 1, 21, and 23.

27) When the tape finishes reading, the MONITOR should start up and print the normal prompt - ? . If you are loading from cassette, STOP the player imediately so other files can be loaded.

Appendix F.

Audio Cassette Users

The following table shows the order and length of files on the cassette of Package II.

Program Name	Time from Start of Tape (in seconds)
MONITOR	13 - 125
ASM	120 - 230
EDT	240 - 310
AM2	320 - 415
DBG	430 - 510

When you are about to record a new file on a cassette, position the cassette after the last file. When using either the editor or assembler to dump out a file, start the recorder a few seconds before flipping sense switch 15. A gap of this type should be inserted between all files on a casette.

ASCII Line Input

The following describes the action taken for various special characters.

<CR> - Ends a line. The monitor returns to the calling program when typed. It is not counted in the line length returned. A line feed is also written out if input is being echoed.
<LF> - ends a line. Only a line feed is echoed. See above.
<ESCAPE> - Ends a line. $ is echoed. See above.
Octal 0 - Ignored
<Control A> - rubs out complete line typed.
<RUBOUT> - Backspaces one character for each one typed.
<Control> z - End of file, branches to address given in control block.

Interrupt I/O

Package II now supports input interrupts from the terminial device. One I/O card in the Altair can be wired for input interrupts directly to the bus interrupt line(PINT), or to the lowest priority on the vectored interrupt card. If the terminal is set for interrupts, typing a <Control C> will stop execution of a program and return to the monitor. All registers are saved in the register save area as described in the monitor section of this manual.

Assembler Versions

Two copies of the assembler are supplied in Package II. Version 1 loads starting at location 5100Q and the symbol table starts at 12366Q. Version 2 loads at location 11520Q and the symbol table starts at 17006Q.

Running version 1 gives you maximum memory for program space but does not allow the editor to be resident at the same time. Version 2 lets you load Debug or the editor between the monitor and the assembler allowing you to assemble directly from the editors buffer using the edit buffer read feature. If this setup is to be used the editor must be patched to move the buffer area. The buffer area is assumed to be immediately after the editor, and if not changed, would destroy the assembler. See Appendix B for recommended memory layout.

Absolute File Names

Version 1 - ASM
Version 2 - AM2

MITS

"Creative Electronics"

SOFTWARE AGREEMENT

This software is copywrited and the property of MITS, Inc., 6328 Linn Avenue, N.E., Albuquerque, New Mexico, and has been supplied by MITS to you. This software is furnished subject to the following restrictions: it shall not be reproduced or copied without express written permission of MITS, Inc.

To do any of the above without approval by MITS, Inc. will make you liable and open for MITS, Inc. to take legal action against you.

This agreement shall be considered accepted and binding upon your receipt of this and any software.

LOADING PROCEDURE:

0. Turn on Teletarm 1030. Set DUPLEX TO "LOCAL" & SPEED TO 30
1. Key in Bootstrap from Page 48. Reset
2. Start CPU after all-zero tone has changed to "leader" tone (256) which is about 15 sec after starting cassette player.
3. (Sense switches 10, 11 and 15 must be up for Step 2.
4. Initialize per Page 51, but do "Null 5" command at first opportunity (5 char cycles for carriage return)

Note: 8 [illegible] occupies locations 0 to 377Q

SEE P. 49
for BOOTSTRAP

March, 1976

Dear Software Customer:

Enclosed please find a copy of our new Package II. Package II is the Assembler, Text Editor, System Monitor, and Debug Package for the ALTAIR 8800. Package II replaces Package I and Debug Software. We have taken the liberty of substituting this new software package for your order.

As Package II has a marketable value of $75.00, please be advised that if a copy of Package II is requested by yourself that a higher price will be imposed. That price would be the difference in price between the present software package price you have received and the Package II price of $75.00 plus the standard $15.00 copying charge.

If you have questions, please contact our Customer Service Department.

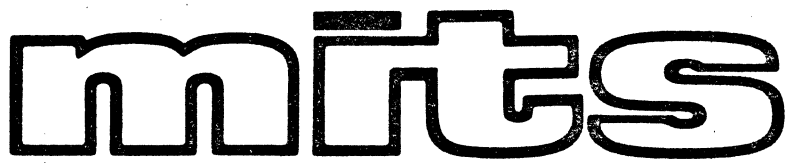
Sincerely,

Pam Holloman
Director of Marketing

PH:gb

PII

2450 Alamo SE Albuquerque, NM 87106 505·243-7821



2450 Alamo SE
Albuquerque, NM 87106