ALS-8 PROGRAM DEVELOPMENT SYSTEM

OPERATOR'S MANUAL

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ALS-8 PROGRAM DEVELOPMENT SYSTEM

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CHAPTER I

The ALS-8 is a single terminal operating system designed for use with "8080" based micro-computers. The system software is contained on a printed circuit board in programmable read-only memory. This same board also has circuitry which will normally start the operating system once the computer is turned on. This configuration, called a "turnkey system", eliminates the startup procedures usually required from the computer's front panel switches. The fact that the ALS-8 program is always stored in memory, regardless of power conditions, eliminates the system load or "bootstrapping" normally needed by small machines.

In this manual, the name "ALS-8" will refer not only to the circuit board but also the operating system program contained on the board. The manual will describe the many capabilities of the ALS-8 and how they are used. Chapter Two also describes the hardware requirements for running an ALS-8.

The ALS-8 is a personalized operating system which attempts to maximize convenience in program development without over-controlling the machine. Operating systems, even the large computer variety, can be guilty of "over-control" when design assumptions become user restrictions. The ALS-8 has assumptions incorporated into its design as must any program, but the ALS-8 allows access to "parameters" which can redefine these assumptions. In this way, various input/output devices or memory configurations can be accommodated. Another personalized feature allows the user to expand the ALS-8 by adding his own functions to it. Each of the initial operating system functions resides in its own section of the ALS-8 memory and is activated by a command or word or "key word" sent from the terminal. Additional functions only have to be given a memory start address and a name for the associated command. The new function is executed whenever the ALS-8 sees the custom command name associated with that function.

The ALS-8 relies heavily on the concept of parameters in its internal design and its command interpretation. The fundamental idea is contained in the observation that two similar tasks differing by some element should be a single task which modifies its operation based on the value of this "element". A simple example of this concept is the ALS-8 output formatting routine. A number of printing terminals are available which could be interfaced to the computer with

ALS-8, and these terminals often vary in the width of paper they accept. Some standard widths are 72, 80, 110, and 132 characters per line. It is conceivable then that a separate ALS-8 package could be written to handle the specific terminal attached to its computer. The parameter principle suggests instead that a single ALS-8 be made with provision for defining or redefining this parameter, the terminal width. This is, in fact, exactly what is done. Before printing, the output routine checks this value to see how it should format the output line. The ALS-8 has several such parameters which it uses to control its various functions.

This concept of parameters is carried into the command structure in much the same way. While interpreting a command, the ALS-8 checks for an optional list of "arguments," which could be one or two numbers, and for a name enclosed in slash marks (/). These values are stored in the order found, and if the function chosen by the command name needs this information for its own functioning, it retrieves it from a predetermined location in memory. The only appreciable difference between arguments and parameters is that arguments are temporarily stored and only for the <u>current</u> command, while parameters describe conditions which may be of interest to <u>many</u> functions. Using the features which arise from this principle, the user can tailor the operating system to his own personal requirements.

The ALS-8 contains an assembler, file handling routines, editing, and management functions. The functions within these logically distinct sections of the operating system can be combined in many ways to aid in the writing and debugging of programs. The text for a program, and oftentimes data, is written from the terminal onto a "file" in memory where it can be examined, altered, added to, or saved for later. The ALS-8 resident assembler can convert the program text on such a file into the numeric machine language required by the CPU. This machine language is then stored by the assembler at some user-designated memory location where it can be run. Up to six of these files can be managed at one time by the ALS-8.

A very important aspect of the ALS-8 in program development is the fact that any user program has access to all the ALS-8 functions and support routines. For many problems this means that half the program is written, debugged, and ready as soon as the computer is powered up. All the user's program must do is call the already existing routines. Naturally the user program has to be aware of the conventions and assumptions associated with the routines that it calls, but it is far simpler and much faster to learn these than to write such routines from scratch each time a particular function is needed. Later sections of this manual will deal with this feature in detail.

Another important design feature of the ALS-8 is its ability to maintain and effectively use a SYSTEM SYMBOL TABLE. The user, through the appropriate commands, can enter and delete names in this list or "table". These names carry only an associated number with them which is interpreted as the value of the label. This table is accessible to the assembler and any other function (user program) which cares to reference it. This can be used quite effectively to link together programs written at different times. The address (or value) of a certain quantity does not have to be known at the time that a program is being assembled. Instead, that program can contain code which looks for this value in the symbol table.

CHAPTER II

MEMORY AND PROGRAM STRUCTURE OF THE ALS-8

A structural description of the ALS-8 is given here to define the minimum hardware requirements and to outline the principles behind its construction so that the fullest advantage may be taken of the features available. The program ALS-8 is distributed on the printed circuit board mentioned in Chapter I, and it is this board that defines some of the hardware constraints. The program itself could be used on any 8080 based computer which has retained the 64K addressing scheme of the 8080 chip. However, the circuit board does restrict correct mechanical and electrical characteristics available.

The circuit board also determines the location in memory for the program. The board itself is capable of holding 8K bytes of PROM, of which the ALS-8 takes over half. This memory page is hardwired on the board to reside in the last 8K page of memory so that it addresses from E000 hex to FFFF hex. The program itself also has memory requirements; the software assumes that at least 1K of random access memory (RAM) resides in memory, starting at location D000 hex.

While this memory configuration is enough to let the ALS-8 operate, it is insufficient for most programming requirements. It is strongly suggested that a separate memory be provided in the low part of memory, preferably starting at 0000 to serve as the user's free space for putting in programs, files and data. This is suggested because there is very little free space around the D000 RAM, and it is also suggested that the system RAM board be 4K (from D000 to DFFF).

The ALS-8 is very flexible with regard to peripheral devices, but it does make some initial assumptions about the terminal which constitute a hardware requirement. Devices attached to any 8080 based computer identify themselves to the computer with a number called a "device code". There are 256 possible codes for input devices and 256 for output devices. As initialized, it is assumed that the keyboard is INPUT DEVICE code 1 and that the print mechanism is OUTPUT DEVICE 1. It is also assumed that the computer, or the ALS-8 in this case, can retrieve status information about the terminal from input 0, the most significant bit, 10000000, represents the busy status of the output device and the next lower bit, 01000000, has the busy status of keyboard. The terminal printer is busy when its bit is 0, and the data is assumed available from the keyboard when its bit is 1. This I/O driver is in the System RAM area, and it <u>can</u> be changed by the user following system initialization; however, since this convention is assumed by a good deal of the software written for 8080 based computers, it is suggested that it be followed.

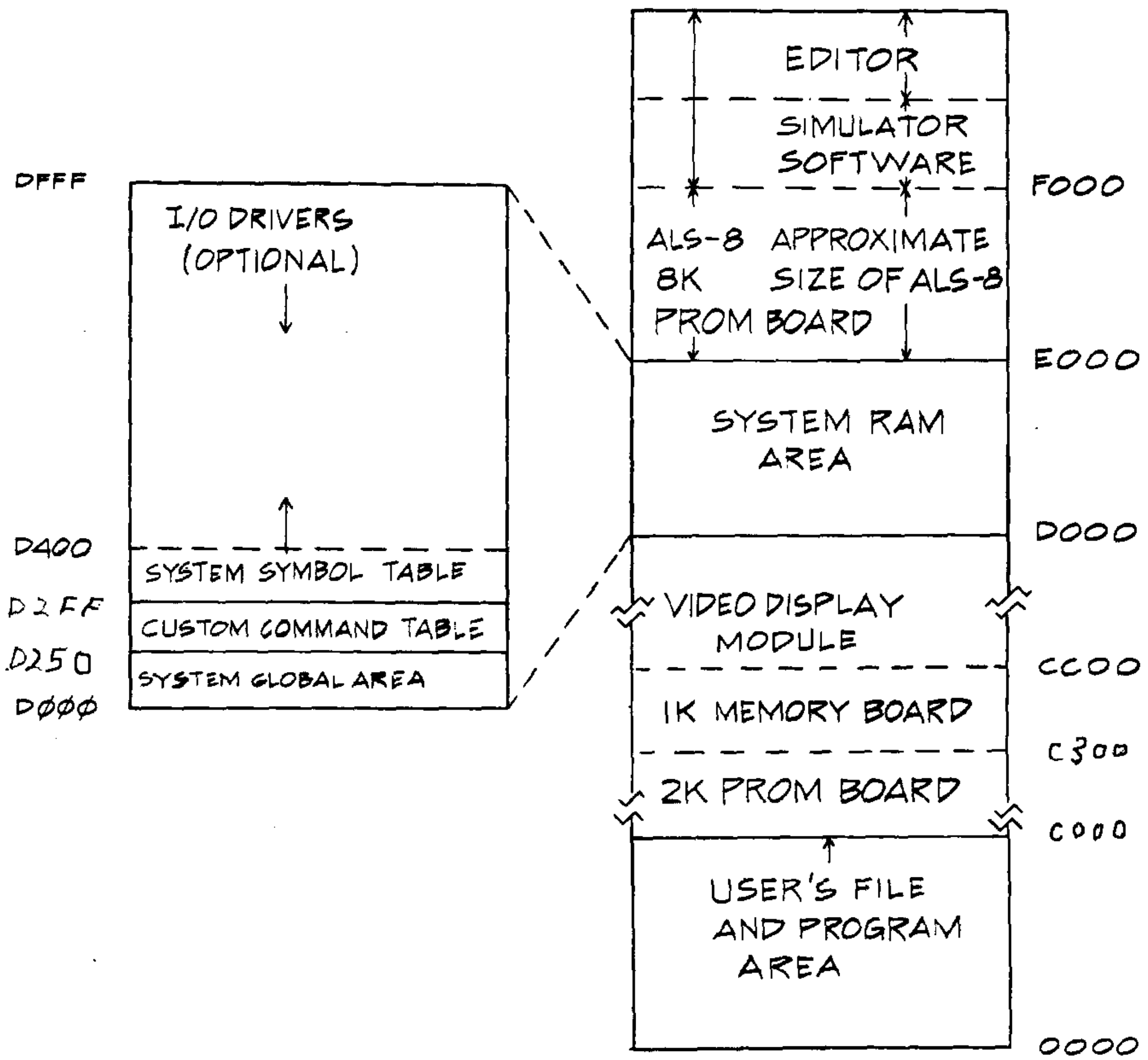
The ALS-8 keeps a great deal of information in the system RAM area, and to use the ALS-8 to its fullest, the reader should learn how this information is used. In the following discussion on the system RAM area, it will be assumed that the 4K space reserved for it is actually filled with memory. The reasons will become clear as the discussion progresses.

The first block of information in this area occupies addresses D000 to D25C and is called the System Global Area. Parameters defining or describing I/O devices, program status, and other information are stored here. Immediately following this is the Custom Command Table which contains a list of names defined by the user with the CUSTE command which will be detailed later. Each entry in this table is paired with an address given when the command was defined. When the user types in one of these Custom names, the ALS-8 realizes that it isn't a name from its own command set. It then searches this custom table, picks up the corresponding address and performs a subroutine jump (call) to that address. This table ends at D2FF which leaves room for 22 custom names.

The System Symbol Table follows the custom commands and continues out to DFFF where the ALS-8 software begins. This table, like the Custom Command Table, contains names and corresponding sixteen-bit numbers which are usually thought of as addresses. This is used most often by the ALS-8 resident assembler, but it is open for use to any user routine which cares to access it. It allows user routines to be parameterized so that the routine can access information not available at the time it is written and assembled. This is especially useful for connecting programs and subroutines written at much different times. Note that systems having only 1K board at D000 will be restricting this System Symbol Table to the area D300 to D377, only sixty-four bytes of memory. This severely limits the usefulness of this feature.

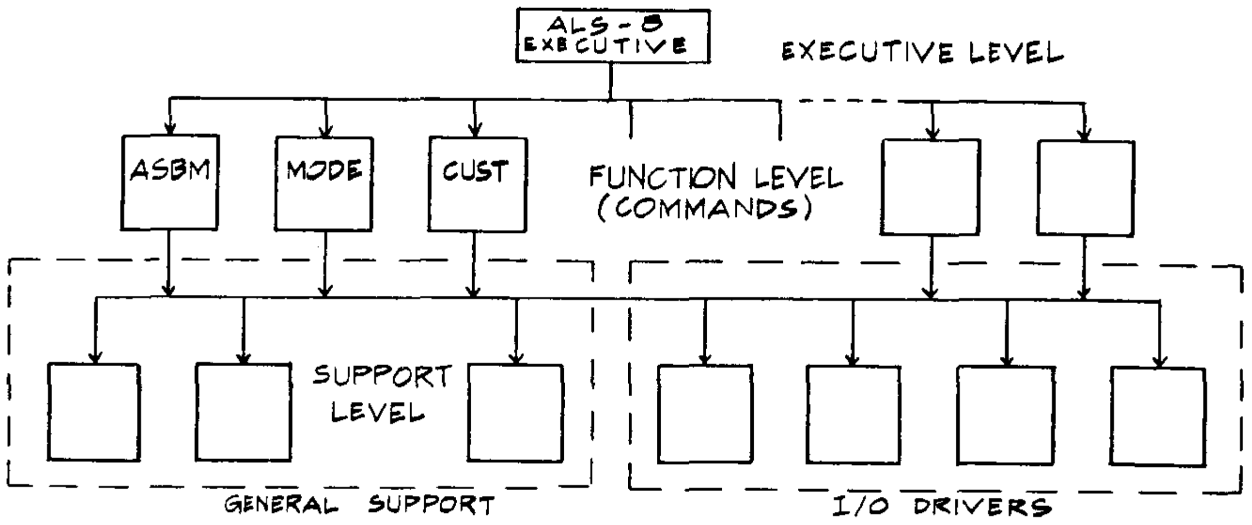
It was suggested earlier that RAM be placed in the low part of memory space for the user. This serves to minimize congestion and the possible memory conflicts arising between the system and user software. In keeping with this philosophy, special user written routines designed to handle I/O devices should be stored somewhere in the system. These routines, called I/O drives, can be put anywhere, but should probably be located in the RAM just under the E000 start of the ALS-8 program until they are put in more permanent form. This still gives the System Symbol Table as much room as possible while maintaining the system/user separation.

The diagram on page (6) summarizes the memory map described so far and shows the suggested locations for the Video Display Module and optional memory.


DFFF
I/O DRIVERS (OPTIONAL)
D400
SYSTEM SYMBOL TABLE
D2FF
CUSTOM COMMAND TABLE
D250
SYSTEM GLOBAL AREA
DØØØ
EDITOR
SIMULATOR SOFTWARE
F000
ALS-8 8K PROM BOARD
APPROXIMATE SIZE OF ALS-8
E000
SYSTEM RAM AREA
D000
VIDEO DISPLAY MODULE
CC00
1K MEMORY BOARD
C300
2K PROM BOARD
C000
USER'S FILE AND PROGRAM AREA
0000

The separation of system space from user space results in an upward progression of address values for user memory and a downward progression for system memory. Future products have assumed that this policy has been carried out and that the Video Display Module (VDM), for instance, is located just below the D000 start of system-RAM. This VDM should then start at location CC00 hexadecimal. The presence of the VDM in the C000-CFFF block means that no 4K board could be placed there. It is, however, suited to a 2K PROM board and perhaps a 1K memory board, should it become important to fill up this space completely. The space from 9000 all the way to BFFF has been marked as the best location for further extensions of the System. As I/O drivers, loaders and other user software is developed, it is suggested that they be placed in PROM in the C000 to C7FF block. Future software packages will assume this memory structure.

The program structure of the ALS-8 is most easily described with the aid of the following diagram. The conceptual parts to the program are shown as parts of a heirarchy not completely unlike the structure of a government or business. In such a diagram, it is assumed that the higher levels are able to command the lower levels but not the other way around. In the program sense then, the top most level can call on any of the routines below as subordinates. It is assumed also in this diagram that routines on the same level may call each other as needed.



The top level, the executive level in this diagram, represents the control center. It is this section which controls the communications with the terminal, decides which function is to be executed, and reports on errors to the user. Each block on the function level corresponds to a command from the ALS-8 command set. These routines, for efficiency's sake, make heavy use of the support routines on the next level, making the overall package much smaller. These support routines have been divided into two parts: general support, and I/O drivers. The I/O drivers are support routines which handle the transfer of data to or from external devices. They are logically distinct from the general support routines because only the drivers handle I/O and because the ALS-8 allows the user to define his own routines as drivers, thereby adding to this part of the system. Each new driver added usually has charge of a single device. Only drivers can be used (as will be described in the chapter on I/O drivers) to control high speed paper tape readers, cassette recorders or printers. The custom commands also add to the structure diagram but do so on the function level. In addition, they can make use of all the general support, I/O drivers, or other function level blocks to minimize their own size and complexity. Other complete, self-contained programs may be considered custom functions (like BASIC or FOCAL) and this interaction with support routines or drivers is only a convenience, not a requirement.

It is important to realize that many of the decisions made by the ALS-8 in choosing support routines or drivers for a given task depend on status information kept in the system RAM area. Although there may be quite a number of I/O driver routines identified to the system, only one input driver and one output driver are considered current at any one time and their identities are kept in this memory area. Similarly, certain parameters will influence the flow of control through the program structure.

CHAPTER III

TALKING TO THE ALS-8

The command set recognized by the ALS-8 can be naturally divided into five categories; MEMORY, FILE, EDITING, I/O and SYSTEM commands. The memory commands are used to enter data into memory or examine the contents of a section of memory. Usually these data transfers are between memory and the keyboard and printer of the terminal but with proper equipment and drivers, the memory commands become a means of saving and restoring programs. The file commands verify, relocate, and manage up to six files of information in memory while the edit commands manipulate the contents of the files. The category of system commands includes all the commands which define system parameters, symbols, and drivers. It also contains commands which execute the assembler, the optional simulator, or any user designated location(s) in memory. The following table lists the command names in their respective categories. The names marked with an asterisk are commands used only by the optional VDM Editor or Simulator software packages.

MEMORY	FILE	EDIT	SYSTEM
ENTR	FILE	DELT	IODR
DUMP	FILES	EDIT (*)	SWCH
	FCHK	LIST	MODE
	FMOV	TEXT	ASST
	FIND (*)	RNUM	ASSM
			EXEC
			SIMU (*)
			AUTO (*)
			SYML
			SYMLE
			SYMLD
			STAB
			CUST
			TERM
			FORM
			NFOR

The above list represents the default command set recognized by the ALS-8 executive routine. Individual ALS-8 functions, while operating, will recognize other lines as inputs. The ENTR command, for example, takes control of the terminal and expects to receive numeric input data to place in memory. This function must be given a special character signifying the end of input before it will return control to the ALS-8 executive. The ENTR function will not recognize entries from the executive's command set. An error message is output to the terminal when an entry line is unrecognizable.

Other than custom commands which have been covered, the ALS-8 executive does recognize a command line type not shown in the command set list. Lines beginning with a number are assumed to be line entries to a file of information stored in memory. Files are a very powerful feature of the ALS-8 which will be thoroughly covered in Chapter V. For the moment it suffices to note that they contain text (usually program text for the assembler) and that they normally sequence their contents by line numbers. The text you are now reading, however, is an example of a text file without line numbers using the optional TXT-2 extension to the ALS-8.

A number of the executive commands accept "arguments" as modifiers for the associated function. The ALS-8 executive allows a maximum of two numeric values and one ASCII argument as modifiers to a command. How the arguments are used if they are used at a11, depends on the command chosen. In use, the arguments are interpreted by the order in which they appear. Commands using an ASCII argument will expect it to be the first argument given. The ASCII argument, usually a name in one of the many tables used by the ALS-8, also has the requirement that it must be enclosed in slash marks(/). The following example shows a number of commands as they might appear with arguments.

```
ASSM 2000
ASSM  2000     3000
FILE     /FNAME/ 100
DUMP 101  110
CUSTE /HACF/307
IODR   /TAPES/ DF00 DF80
```

Most of the ALS-8 functions contain logic to handle instances where an argument has been omitted. In such instances a default rule, peculiar to the command and argument in question, will be applied. The "ASSM" command shown in the example above can be used with one or two arguments. The command starts the assembler which begins by checking for a pair of arguments. It interprets the first argument as the origin (ORG) address for the program being assembled. The second argument specifies the starting address for the assembler's binary output (machine instructions). If this second argument is missing, the assembler will take the value given in the first argument for both arguments. The assembler has no provision for defaulting two arguments so it will signal an error if the ASSM command is given with no arguments. Default rules for all executive commands will be given in the detailed description of these commands in the upcoming chapters.

Again it is mentioned that the user functions attached to custom commands have full use of the argument handling support routines; the treatment of default conditions is naturally up to the programmer.

Finally, it must be noted that there are some minor rules to be observed in the use of command inputs with arguments. The ALS-8 executive needs to separate the characters belonging to the command from those of the arguments. Similarly, it needs to separate arguments from one another. The requirement is therefore put on the user to place at least one blank after the command word and at least one blank between a pair of numeric arguments. The slash at the end of an ASCII name argument is sufficient to separate the name from any following numbers. Numeric arguments may follow an ASCII argument with no separating blanks as long as the ASCII argument was terminated with a slash mark.

Responses from the ALS-8 in general depend upon the command chosen. For the standard ALS-8 command set, the user is always assured of a response; if a response is not a normal duty for a command, the ALS-8 executive will send the word "READY" to the user's terminal after completing the command.

CHAPTER IV

MEMORY RELATED COMMANDS

The simplest commands in the ALS-8 repertoire are the memory related commands, ENTR and DUMP. They provide a means of changing and examining memory locations directly from the user's terminal. The output printing format of the DUMP command has been made compatible with input format requirements of the ENTR command. This permits these commands to be used for saving programs on a mass storage device and returning it to memory at a later time. This feature will be covered here and in the chapter on I/O drivers.

The ENTR command requires a single argument defining the starting address for the data to be entered. The command starts the corresponding ENTR function which assumes control of the user's selected input device until receiving the character"/" signifying the end of the input stream. The actual input to the ENTR function is a list of values, each between 0 and 255 decimal in magnitude. These values must be listed in the order they are to be placed in memory, and each must be separated from adjacent values by at least one blank. The following shows typical sequences using this command. Note that the input list may use any number of lines up to the "/" mark.

```
     ENTR    100
     20 303    55  40
     16  12
     107 200 303     100 0
/
READY
ENTR     2001
101 200    /
READY
ENTR   3
0  7/
READY
```

The argument and input list can be in octal, as shown above, or in hexadecimal depending on the current mode parameter set by the system class command MODE. The MODE command affects the operation of other ALS-8 commands, not just memory commands. It takes a single decimal argument, 8 or 16, which is stored in the system parameter defining the base for command inputs. If any inputs are received which are impossible to decode with the current base. a "WHAT?" will be sent to the user's terminal. The ALS-8 initializes this parameter at start time to 16 and this value is changed only with MODE. The following shows possible errors associated with the MODE parameter:

```
     MODE 16
     ENTR 156000 (Octal address)
     WHAT?
     MODE 8
     ENTR CC0D (Hex address)
     WHAT?

     MODE 16
     ENTR BF2
     52 49 EE 4F 52 F6 43 50
     5 A0 0 84 E4
     43 2 303 22
     WHAT?
```

In the last of the examples, the values up to the error are properly stored by the ENTR function. The corrected input will have to restart at the place of the error.

An added feature of the ENTR command is that the present storage address may be changed during input without having to stop the process and restart with a new argument. The "present storage address" always starts with the value given by the attached argument to ENTR, and the first input value is put in this location; inputs are placed in successive locations. The user has an opportunity at the start of each input line to redefine this current address. If the first value is followed immediately by a colon(:), it is treated as a new address rather than a memory value. While this seems only a minor convenience, it becomes the key to making the output of DUMP compatible with ENTR input. The following shows the first example of this chapter rewritten using this feature.

```
     MODE 8
     ENTR 100
     2 303 55 40 16 12 107 200
     303 100 0
     2001: 101 200
     3: 0 3 /
     READY
```

The DUMP command displays the contents of memory starting at the address specified in the first argument and continuing to the address specified by the second. As with ENTR, both the arguments and the output follow the base parameter set by MODE. The DUMP command can also be used with just a single argument; in this case it types out only the location specified in the first argument.

The lines output by the DUMP command each start with the current address followed by a colon. The remainder of the line contains the hexadecimal or octal contents of the memory locations beginning with the printing address. In either the octal or hexadecimal mode, the DUMP command puts sixteen values on each line. Because this output is formulated properly for ENTR, those users with a paper tape punch can save the output directly on tape and reread it later with ENTR. In this case, the standard ALS-8 I/O driver could be used. Saving programs on other devices will require using special drivers. The following shows a simple example of DUMP in the hexadecimal mode.

```
     DUMP 40 52

     0040: OA D8 D6 07 C9 DB 00 E6 45 00 DC 01 D3 02 F8 CF
     0050: E6 7F C9
```

CHAPTER V

FILES AND FILE COMMANDS

The ALS-8 relies very heavily on the use of files; for they represent a very powerful way of managing data in text form. A file is a sequence of information stored in user designated memory. The information is broken into "lines" which are duplicates of the terminal input lines which define them. Each line, both as it is input and as it is stored in memory, starts with a line number defining its position in the file relative to other lines. Lines with the lower line numbers are at the start or "top", of the file while higher numbered lines have positions farther "down" in the file. The lines do not have to be entered in numeric order by the line numbers. The ALS-8 will reposition other lines to make sure the proper order is kept internally. Once in memory, files can be renumbered using the RNUM command.

Files are known to the ALS-8 by name and up to six files can be defined and managed at any one time. File names may have up to five characters. Rather than having each file-related command specify which file is to be operated on, the ALS-8 has the user define "Current File". Using the FILE command, the user can specify which of his defined files is to be considered "current". All file operations will apply to this file until the Current File is redefined with the FILE command.

To create a file the user must give a name for the file and a starting address for it. This is done by using the FILE command with an ASCII argument for the FILE NAME and a numeric argument as the START ADDRESS for that file. In this way, the FILE command can be used to create a new file as well as make an already existing file current. File names are kept in the system RAM area in a table called the "File Name Table". These names can also be removed from this list of defined files by using the FILE command; a numeric argument of zero erases the name from the table but does not affect the memory containing that file. These file parameters may be restored later with the FCHK command thereby allowing the user to actually have more than six files of information in memory at one time. The ALS-8 does not, however, keep track of more than six. The following shows three short files being created. Note that the FILE command used with no arguments returns a message to the terminal defining the Current File, its start and end addresses.

```
FILE/ONE/ 100

ONE 100 100    (RETURNED BY ALS-8)
1 This is the first line of file ONE.
26 THIS IS THE SECOND.
```

```
29 Line 3
FILE /TWO/ 200

TWO 200 200

FILE /THREE/ 6A1

THREE 6A1 6A1
10 Dear John,
12      Pay me or I won't be
14 your friend.
15           See you soon,
17            Igor
FILE /TWO/

TWO 200 200
1300 File Two gets this line
1984 UPPER CASE OK.
1000 lower case ok.
2710 End TWO
FILE

TWO 0200 02C0
```

This example points out a number of requirements and features omitted in the discussion so far. Line numbers, for instance, are normally followed by a blank but this is not required by the editor functions. The example also illustrates the fact that line numbers do not have to be absolutely consecutive numbers. File line numbers are always decimal and must lie in the range 0 to 9999.

A file, "TWO" in the example, can be entered into the File Name Table and saved during the definition of :THREE" although it is empty. Later it can be made the current file and information can be entered into it.

Files naturally have a length as well as a start location and the user must be careful that, in adding text to a file, he does not accidentally write file information over a program or another file. The ALS-8 assumes that the user knows where file information and programs are located. To help the user manage his files, the ALS-8 provides three file related commands: FILES (different from FILE), FMOV, and FCHK.

The FILES command produces a listing of the files in the File Name Table. This listing includes the start and end addresses for the files so it is a simple matter for the user to spot and avoid memory conflicts. Should a memory conflict threaten, the current file can be moved to a different location in memory with the FMOV command. FMOV requires only a single argument defining the destination address for the Current File. This argument may not be zero, but no other restrictions are placed on it.

The last of the file related commands is FCHK which verifies the internal structure of the Current File and updates the file and address if necessary. If, for any reason, the file is not properly formatted in memory, FCHK will send the message "FILE ERR" to the terminal. This command can be very useful in restoring files. Earlier it was mentioned that the contents of a file were not affected by removing the file's name from the list of defined files. Assuming that subsequent operations have not altered the memory contents for that file's information, FCHK can return it to an active, useful status. Similarly, the contents of a previously saved file could be ENTR'ed into memory and reactivated with FCHK. The following example shows some typical uses of FCHK.

```
     FILE /COPY/ 700      define a file name.  Leave empty.

     COPY 700 700
     FILE /OLD/ 600       define file "OLD".  Store program in it.

     OLD 600 600
     10 WAIT  IN 377
     15       CMP A
     20       JZ WAIT
     25       RET
     40       END
     FMOV 700             move OLD to start of COPY.

     OLD 700 736

     FILES
     OLD 700   736        OLD is O K.
     COPY 700  700
     FILE /OLD/ 0         delete OLD from list.
     FILES                check defined files.

     COPY 700    700      only COPY.  thought to be empty.
     FILE /COPY/          make it the current file.

     COPY 700 700
     FCHK                 redefine end address.
     COPY 700 736
     FILES

     NEW  600  600
     COPY 700  736
     FCHK                 examine file starting at 600.
     NEW  600  636
     FILE                 check Current File, "NEW".

     NEW 600 636          contents recovered.
```

CHAPTER VI

EDIT COMMANDS

The ALS-8 contains a number of editing commands designed to manipulate the contents of a file. All of these commands operate on the Current File so the user is cautioned to check the status, and perhaps identity, of the Current File before using these functions. This, as described in the last chapter, can be done with the FILE command. ALL the EDIT commands use decimal line numbers as arguments where required. (NOTE: These commands are separate from the optional VDM EDITOR package, TXT-2, sold by Processor Technology.)

The EDIT command set contains two commands designed to print the contents of the Current File: LIST and TEXT. The LIST command outputs the Current File ordered by increasing line number. It accepts up to two arguments defining the start and stop line number for the printing. If only one argument is given, the LIST function assumes that it is only to print the single line identified by the first argument. When both arguments are omitted, the entire file is printed. The following example exercises these options. (Examples show formatted output.)

```
FILE  /SMPL/    1A2B
0 WAIT EI
0010JMP WAIT+1
0020 *   THIS SETS INTERRUPT AND WAITS
0024           END

LIST  0
0000  WAIT     EI

LIST
0000  WAIT     EI
0010  JMP      WAIT+1
0020 *  THIS SETS INTERRUPT AND WAITS
0024           END
```

The TEXT command is very much like LIST; the only difference is that its output omits the line numbers. This feature is generally used for files containing regular text as opposed to program code. This allows letters, notices, or papers to be printed without line numbers. Since the user must specify line numbers for arguments in edit commands, the TEXT command obeys the argument conventions used for LIST.

The following shows the last example reprinted using TEXT.

```
     TEXT
     WAIT   EI
            JMP  WAIT+1
     *  THIS SETS INTERRUPT AND WAITS
            END
```

The ALS-8 system RAM has two parameters pertaining to LIST and TEXT; the formatting flag and the terminal width parameter. "Formatting" refers to the spacing or layout of the printed results from the two functions. A formatting "flag" parameter is a word in a system RAM which tells LIST or TEXT whether or not they should rearrange the contents of each line in a form especially suited to assembly language output. This parameter is controlled by two system commands: FORM and NFOR, which indicate "formatting" and "no formatting" respectively. Naturally, a file not containing a program is more readable when not formatted. The FORM and NFOR commands require no arguments, and the parameter set by them remains in effect until explicitly reset by the user.

The terminal width parameter, set by the command TERM, contains an integer which represents the line width for the current output device measured in characters. This parameter has no influence on LIST or TEXT when the formatting feature is suppressed. When formatting output for either output command, the terminal width value determines the extent of formatting. When it is fewer than 80, minimum formatting is performed. When it is more than 80, the maximum formatting is performed. Terminal width also controls the maximum length of input lines as well as the acceptable line length during FCHK.

The DELT command allows the user to delete a line or group of lines from the Current File. It accepts one or two arguments identifying the first and last line numbers of the group to be DELETED FROM THE FILE. When used with only one argument, DELT assumes that it is only to delete the single line designated by the first argument. The ALS-8 executive, however, rejects line numbers input with no line. Thus, line 40 in the following can be deleted with "DELT 40" or simply 40 followed by a carriage return.

```
     FORM
     FILE

     A    0280 02AF
     LIST  36  44

     0036  DUP  LXI  H,0
     0039       DAD  SP
     0040       SHLD HOLD
     0044       RET
     DELT  40

     LIST  36  44

     0036  DUP  LXI  H,0
     0039       DAD  SP
     0044       RET
```

The last command in the edit set is RNUM which renumbers a file given a start line number and increment. When finished, the Current File's line numbers will begin with this first number, and all adjacent line numbers will differ by the value of the second argument. If the second argument is omitted, the RNUM function will use five as the increment. The largest value allowed for this increment is twenty-five. The RNUM function also will change the increment to one if the line numbers exceed 9000. The example below shows a small program being renumbered.

```
     LIST
     0025  INSTAT   IN    TTS
     0030           ANI   DR
     0035           JZ    INSTAT

     RNUM 8000 10
     TEST  1000 1030

     LIST

     8000  INSTAT   IN    TTS
     8010           ANI   DR
     8020           JZ    INSTAT
```

CHAPTER VII

I/O DRIVERS AND COMMANDS

The term "I/O Driver" refers to a routine used to transfer textual data between the ALS-8 routines (or user routines) and an associated input or output device. Its basic duties are to interpret a request for data transfer from some calling routine and to translate it into a sequence of reads or writes suited to the conventions assumed by the electronics of the external device. This relieves the calling routine of the responsibility of handling separate conventions for many devices. Conceptually, an ALS-8 routine can ask for data from any input device in the same way or send data to any output device. It must formulate the request and simply choose the routine to handle the request and the device.

The ALS-8 has a table of driver routines in its system RAM area and a parameter identifying the current pair of drivers (input and output). When an ALS-8 function requires input or output of a character, it uses this parameter to choose the proper driver. The table for these routines contains a name and pair of addresses for each entry. The IODR command handles entries to and deletions from this table, as well as defining the "current" driver and printing out the table's contents. Used with a name argument of one to five characters and two numeric arguments obeying the current value of MODE, the IODR command will enter the name and addresses into the table. If used with no arguments at all, IODR prints the contents of the table. Since drivers are selected as pairs, special functions can be implemented such as read from high speed paper tape both with and without printout. Entries can be deleted by using IODR with the entry name as an argument followed by a single zero argument. The example shows IODR being used in these ways.

```
IODR /TAPES/  DF00  DF40

TAPES DF00 DF40

IODR /TVTWT/  DF80  DFC0

TVTWT DF80 DFC0

IODR
SYSIO E200    E240
TAPES DF00    DF40
TVTWT DF80    DFC0
```

```
IODR /TVTWT/  0

IODR
SYSIO E200    E240
TAPES DF00    DF40
```

SYSIO, shown in the above, is the default I/O driver which handles the main terminal. It remains the current driver until another from the list is explicitly defined by IODR in yet another form: IODR with just a name argument. Making a driver "current" assumes that the corresponding routines are loaded and ready for use because the subsequent ALS-8 commands will have switched to using those addresses for I/O. Assuming that "TAPES" in these examples represents drivers for a cassette recording unit, data could be loaded into memory with the following:

```
IODR /TAPES/
ENTR 200
(the ENTR function will retrieve data from the cassette and
 not the terminal keyboard)
```

The discussion on drivers so far has covered only the basic duties of drivers. Because the system only has to know where the routine starts, the programmer has an enormous amount of flexibility. The driver is a program capable of handling any number of devices in a single call if desired. It has access to system parameters and tables so it can check status words or find file information. When used with functions like ENTR, the driver can accept data in whatever form the device will provide it and then reformat it so that the necessary address and colon are appended to the start of each line. There is also no restriction that more than one driver can't be assigned to a single device. One line printer driver might simply echo the data given to it on the page. Another driver in the list might count lines so it can automatically skip the paper folds and print headings at page tops. Similarly, a set of drivers could exist for communication with the VDM as within the TXT-2 extension package.

These capabilities are futher enhanced by the fact that any user program has access to the driver list. It can, if desired, ignore the "current" driver pair, search the table for a specific name, retrieve the corresponding addresses and begin using those routines. To write such a program, the user must know the addresses of the table, the parameter identifying the current driver, and the ALS-8 routines which search tables. The conventions for the routines and memory storage must also be learned, but the enormous flexibility compensates for the trouble.

CHAPTER VIII

SYSTEM COMMANDS

The commands described in this chapter cover a wide range of functions. ASSM, ASSI, and their derivatives assemble a program and load the resultant machine instructions into a designated section of memory. CUST and its derivatives, CUSTE and CUSTD, manipulate the Custom Command Table stored in system RAM. SYML, SYMLE and SYMLD are like the CUST set except that they manage the System Symbol Table in the system RAM. Other commands in this group define I/O drivers, set system parameters, and execute routines starting at user defined addresses.

All of the commands related to the ALS-8 resident assembler accept one or two arguments. The first argument defines the origin for the program, while the second, if given, specifies the start address for the machine language output of the assembler. If only one argument is given, the assembler uses it for both the program origin and the start address for the binary form of the program. The binary machine language output by the assembler is known as "object code". It is the only form executable by the 8080 CPU. The program text by contrast is not executable but much more readable for humans. It is called "source code".

The set of assembler-related commands ASSM, ASSME, ASSMX, ASSMS, ASSI, ASSIX and ASSIS all produce assembled object code programs for the program source code. Each has, however, its own option associated with it. The fourth, and where applicable the fifth, character in these command names is used to select the options to be used on a particular assembly run. The fourth character, "M" or "I", divides the group into two sets of four commands. These sets differ in the source they use for program text. The "M" group uses the Current File as its source whereas the "I" group reads the source program through the CURRENT INPUT DRIVER. The fifth character of the assembly command names control options for the assembler output listing. If omitted, as in ASSM or ASSI, the listing is a one-output-line-per-source-line printout identifying errors, addresses, and machine language values produced from the program's instructions. An "E" suffix suppresses all printout except for those lines containing errors. "S" and "X" suffixes list the contents of the symbol table immediately following the program source listing. The "X" option adds cross reference information between program symbol names and the line numbers that they occurred in. Formatting of the assembler output listing depends on the parameter defining the terminal width and the "FORM" switch.

The CUST command prints out the current contents in the Custom Command Table. The custom names must be four or five characters and are considered unique to only four characters. When a custom name is given to the ALS-8 as a command, this address is retrieved from the table and the ALS-8 passes control to this address (as a subroutine call). Entries to this table are made with the CUSTE command which requires an ASCII argument to be used as the new name and an address to be called for the command. The address argument follows the base set by the last MODE command. CUSTD deletes custom names from the table. It requires only the single name argument. Users are cautioned that the twenty-two custom name limit is their responsibility to watch as the ALS-8 does not warn when the number of entries exceeds the table's boundary.

Custom commands can be attached to any kind of program. The FOCAL and BASIC software packages both load starting at address zero, so they cannot be in the machine at the same time. Either could be loaded, though, and its name entered as a custom command. Both software packages come with a short program which must be ENTR'ed first; this program loads INTEL format paper tapes. This loader is then started and the paper tape data is stored in memory. The following outlines such a sequence.

```
MODE 16
ENTR 1800
(type in hexadecimal for INTEL paper tape loader)
/
CUSTE /LOAD/ 1800
LOAD
(start paper tape-when done reading restart ALS-8 at
 E060)
READY
CUSTE /FOCAL/ 0
CUST
LOAD 1800    FOCAL 0
FOCAL
*  (this is the ready asterisk from FOCAL)
```

The System Symbol Table is managed with the SYML, SYMLE, and SYMLD commands. SYML, like CUST, only prints out the contents of the table. SYMLE and SYMLD enter and delete names and their associated values from the symbol table. SYMLE requires a name argument of five letters or less and a numeric argument representing the symbol's value. SYMLD handles the deletion of symbol names from the table and, like CUST, requires only the name argument. Unlike the custom table, the System Symbol Table is not restricted much by a maximum length. Its physical location allows it just over 3K of memory and it is all but inconceivable that this could be overrun. The user can effectively set a maximum length of his own by setting up other tables or drivers in this 3K expanse. The example here shows two important symbol names being entered into the System Symbol Table.

```
     SYMLE /SP/ 6
     SYMLE /PSW/ 6
     SYML
     SP    6  PSW 6
     D30E (End of Table address printed following listing)
```

The symbols shown in the example above are needed by the resident assembler for programs which access the 8080 Stack Pointer, "SP", or the Program Status Word, "PSW". The resident assembler can only recognize single letter register names like B, C, D, E, H, L, and A. The user can define the SP and PSW symbols in each program he writes or enter them once in the System Symbol Table for all the assemblies he performs. The assembler produces a table for the symbols it finds in a program and this table, inaccessible to the user, is called the Assembly Symbol Table. It is created from scratch for each assembly. If the program instructions make reference to a symbol which has been given no value in the program itself, the assembler will try to fetch the value from the system's table. It is a great convenience then to be able to define symbols once in this System Symbol Table rather than each time in a program. This makes programs both shorter and more versatile, since single changes in the symbol table values can affect the origins, parameters, or subroutine connections for a number of programs.

The ALS-8 allows the user the freedom of specifying where the Assembly Symbol Table should start in memory. The STAB command defines this location from an argument which obeys the current MODE value. This start location must be defined before the first assembly is made and it is suggested that this table be placed at D700 hexadecimal. This puts it well into the system RAM area leaving over 1K for the System Symbol Table. It also leaves over 2K for the assembly Symbol Table which is sufficient for all but the largest programs. This assumes naturally that the area between D700 and E000 is not full of I/O driver routines (see Chapter II). The following might be used to start an assembly.

```
     STAB D700
     ASSM 1A0
```

The loaded output of the assembler, the object code, can be executed without having to make an entry in the Custom Command Table. The EXEC command generates a subroutine call to the address specified by its argument. When finished, the program at this location only has to generate a return with the 8080 RET assembly instruction and control will return to the ALS-8 executive. The argument to the EXEC command naturally follows the number type specified by the MODE parameter. In an earlier example, the name "FOCAL" was entered into the Custom Command Table with an associated address of zero. When "FOCAL" was given as a command the address 0 was given control by the ALS-8. This could also have been done by giving the command "EXEC 0".

In the event that a program does not automatically return to the ALS-8, it will be necessary to stop the machine from the front panel, set the address switches to E060 and hit the RESET, EXAMINE, RUN switches. FOCAL, BASIC, and INTEL LOADER are examples of programs which normally do not have an ALS-8 return. If a user program goes awry the same procedures can be used to restart the ALS-8. The user may want to check his files and data to ascertain whether or not they have been damaged by the errant program.

CHAPTER IX

COMMAND SUMMARY

This chapter contains a summary of the ALS-8 commands in the order they were presented. The reader is advised to consult earlier chapters for any details omitted here. Following chapters will cover the ALS-8 assembly language instruction set. The descriptions given here use the convention of enclosing an argument in parentheses when it is optional. Arguments will be signified by lower case names suggestive of their use; "addr1" for instance, will be an argument representing an address.

ENTR addr

This command reads numeric data from the current input driver and stores it in consecutive memory locations starting with the address specified by the argument. The data may continue for any number of lines; the function will return control to the ALS-8 executive only when it encounters a slash (/). At the beginning of every line, the current address pointer can be changed by specifying a new value followed by a colon (:). Both the data and addresses are interpreted in octal or hexadecimal according to the currently defined MODE. The length of any input line is limited by the current value of terminal width.

DUMP addr1 (addr2)

This command displays the contents of memory from "addr1" to address "addr2". If only one argument is given, only the contents of address "addr1" are displayed. The arguments and printed results obey the number base set by MODE.

MODE base

The argument "base" for this command sets an ALS-8 parameter which is used in converting binary data to readable form. The argument is decimal and must be either 8 for octal or 16 for hexadecimal. All ALS-8 arguments representing memory data or addresses will be affected by this command. Arguments which specify setting terminal width or line number will always be decimal. Initially the ALS-8 assumes a mode of 16.

FILE COMMANDS

The FILE command has many different forms each with its own distinct function. The following describes each particular form. All name arguments ray be one to five characters long.

FILE

This form will print the name of the current file, its start address and end address.

FILE /fname/

This will search through the current list of file names for "fname". When found, this file will be marked as the current file and all subsequent file operations will be made on it. If not found, the error message "WHAT" is sent to the terminal.

FILE /fname/ addr

This enters a file name, "fname", into the list of names kept it the file table. The argument sits both the start and stop addresses associated with the name. If the file already exists in the table an error message FCON is output to the SYSIO output device. The file "fname" always becomes the Current File. Addresss "addr" must not he zero.

FILE /fname/ 0

File "fname" is removed from the file table and forgotten. There will be no Current File when this command is finished.

FILES

The FILES command uses no arguments. It lists the names, start and end addresses for all the files known by the ALS-8. This command does not affect the status of the Current File.

FCHK

This command checks the structure of the Current File. It begins at the start address contained in the file table and continues until it finds an end of file mark (01 hexadecimal) or an error. An error is signaled with the message "FILE ERR." followed by the address of the error. The location of the end of file mark becomes the end address of the Current File. Using FCHK, files may be input directly into memory from magnetic tape or disc and recreated.

FMOV addr

The Current File is moved by this function to memory locations starting at "addr". The start and end address values associated with the file are also changed. The copy remains the Current File and an FCHK is automatically performed. If the file was inadvertently moved to a location without memory, a new file can be created at the old address and the contents recovered using the FCHK command.

While there is no restriction prohibiting a file from being moved to an address contained by the original, the user should note that only the copy will have a valid structure after such a move.

Text can be input to a file by simply specifying the line number and contents for that line. The line number is an integer from 0 to 9999 and it normally is followed by one blank. If the file contains a line with this same number, the new data is entered in place of the old. The contents of any file can be interpreted as text or as assembly language source. Lines intended for the assembler are composed of distinct fields which are separated by groups of blanks. These fields can be repositioned during printout by an automatic formatting feature controlled by the TERM, FORM, and NFOR commands. The TERMINAL WIDTH parameter also controls the maximum length of lines input to the file.

TERM width

The ALS-8 parameter representing terminal width is initially set to 80. The user can, however, reset this at any time with the TERM command. The decimal argument "width" contains the size of the terminal line. This influences not only output formatting, but also input line length for files (FCHK). The maximum value for TERM is 119.

FORM

This command sets a parameter in the system RAM for the ALS-8 which specifies whether or not printed listings of assembler source or files are to be formatted.

NFOR

This deactivates the formatting feature described above. The ALS-8 is initialized to the non-formatted state.

LIST line1 (line2)

This is used to print out contents of a file between the specified line numbers. When only one argument is used, the single line identified by line1 is printed. Line numbers and line number arguments are always decimal numbers. This command prints the contents of each line following the corresponding line number. (When using the optional VDM EDITOR, the LIST command will list files entered without line numbers.)

TEXT line1 (line2)

Like LIST, this command prints file contents from line1 to "line2". It does not, however, print out the line numbers at the start of each line. This is a useful feature for letter copy. Both TEXT and LIST contain the formatting routine which is controlled by FORM, NFOR, and TERM.

DELT line1 (line2)

DELT removes a line or series of lines from the Current file starting at line number line1 and continuing through "line2". In its single argument form, only the line specified by "line1" is deleted; it is usually easier to delete single lines, however, by typing the line number followed by just a carriage return.

RNUM line# (increment)

RNUM renumbers the Current File so that its first line number will be "line:" and each successive line number will be greater than the last by the quantity defined in "increment". If "increment" is omitted, RNUM will use a default increment of five. The largest allowable value for the increment is twenty-five and, regardless of increment value at the outset, RNUM will use an increment of one after the line numbers reach 9000. RNUM ends by calling FCHK, thereby checking the file after renumbering.

ASSEMBLER COMMANDS

The ALS-8 resident assembler is activated with different options from the eight commands summarized below. Each requires an origin which is used as the address from which the routine must eventually be run. The second argument to each of these commands is the start address for the storage of the assembled program. A program "origin" and "load point" must agree if it is to be run rather than temporarily stored. The variations in the commands mainly affect listing length and input source.

ASSM origin (load address)

This form assembles from source contained on the Current File. If the "load address" argument is omitted, the assembler will load at the address given by "origin". A full listing of the assembly and errors is written to the current output driver.

ASSME origin (load address)

This is the same as ASSM except that only lines containing errors are listed.

ASSMS origin (load address)

This form produces a full listing and adds a listing of the assembler's symbol table to the end. The current values, usually addresses, of the symbols are also given.

ASSMX origin (load address)

This is a further expansion of ASSMS in that the symbol table listing provided at the end is cross referenced to file line numbers. The summary for each symbol then contains its name, value, and a list of locations which used it.

The four remaining assembler commands ASSI, ASSIE, ASSIS, ASSIX are similar to the four commands just listed except for the source of the assembly language code. These four use the I/O driver selected by IODR for reading the program source. A special driver is required for this use and the user is referred to the ALS-8 Specification sheet outlining the requirements of this driver.

```
ASSI  origin  (load address)  assemble with full listing.
ASSIE origin  (load address)  assemble.  list only errors.
ASSIS origin  (load address)  assemble.  list with symbol table.
ASSIX origin  (load address)  assemble.  list with cross
                                          reference table.
```

STAB address

This command sets the starting location for the Assembler Symbol Table. This address is not initialized to a usable value so this command must be called before any assemblies are attempted.

CUST

This will print out the contents of the Custom Command Table. Each output line will contain name and address pairs. The addresses are printed according to the base by MODE and the end address of the table is printed following the list of names.

CUSTE /cname/ address

This will enter the name, "cname", into the Custom Command Table with its associated address value. If this name already exists in the table, it is merely given a new associated value. The name may be four or five characters long, but it is only unique to four. Thus "HEART" is the same custom name as "HEAR". A maximum of twenty-two such names is permitted each requiring eight bytes of table space. The table must not go beyond D300 or interference with the System Symbol Table will result.

CUSTD /cname/

This deletes the specified name from the Custom Command Table.

EXEC addr

The EXEC command performs a subroutine call to the address specified by "addr". The argument, being an address, obeys the number convention set by MODE.

SYML

This command lists the contents of the System Symbol Table. The values listed in the name/value pair are assumed to be addresses and, as such, will follow the current MODE for type. The names can be one to five characters in length. The end address of the table is printed following the list of names and values.

SYMLE /sname/ addr

SYMLE is used to enter a name and its corresponding value into the System Symbol Table.

SYMLD /sname/

This will delete the symbol, "sname", from the System Symbol Table.

I/O DRIVER COMMANDS

There are only two names in the I/O driver command set but one, IODR, has many forms. The following summarizes its functions and describes the other command, SWCH.

IODR /dname/ in out

This form of IODR enters the name "dname" into the I/O driver table with the two addresses, "in" and "out". When this driver pair becomes active, the ALS-8 functions will try to read text data through a routine located at the address "in". Similarly, output from these functions will be sent to the routine assumed to be at address "out". This form of the command does not activate this driver pair, only defines it. If address "in" is zero, followed by a proper output address, the current SYSIO input driver will be assigned as the input driver. Also, if the output driver address is zero, the current SYSIO output driver will be assigned. If the output address is omitted, after being preceded by a valid input address, a special output address will be assigned to allow no output. (BIT BUCKET)

IODR

Used without arguments, this command prints out the contents of the I/O driver table. Each line of the printed summary contains the name, the input driver address, and the output driver address.

IODR /dname/

This informs the ALS-8 that the default system driver, SYSIO, is to be used for one more command line. The driver pair, "dname", is then used until an ALS-8 command returns control to the executive. This one command delay enables the user to choose an ALS-8 function from his terminal before switching control to the new drivers. SYSIO, the terminal driver pair, is automatically reactivated at the conclusion of the ALS-8 function or under error conditions.

SWCH

When used after the above form of IODR, the new drivers are activated for use by the ALS-8 executive, not an ALS-8 function. The executive then will read a command and any associated data with these drivers before returning to SYSIO.

CHAPTER X

THE ALS-8 ASSEMBLER

The resident assembler is perhaps the strongest feature of the ALS-8. It is a program designed to convert the text for a program into the binary machine code form of a program. The textual representation, called "source code", is very readable by humans but only binary form is executable by the computer hardware. In typical use, the source program is written onto a file and edited. This is then assembled with one of the ASSM commands and the resultant binary, or "object code", is stored in memory. There it can be used as a driver, a custom command, or a program to be run by the EXEC command.

A source program written in assembly language is interpreted by the assembler on a line-by-line basis. Since files are also line structured, they become a natural storage area for program source. (The ASSI command series insures that ALS-8 files are not the only storage medium for programs.)

Each line of the program must conform to certain rules in order to be assembled correctly. An asterisk at the start of a line identifies the line as being a comment and its contents are not subject to the rules of the assembly language. Lines without an asterisk are "statements" and these can be divided into as many as four separate parts called "fields". Each field has an entirely different function to the assembler. The first, the "label field", gives a symbolic name to that line which can be referenced by any statement in the program. The label must start with an alphabetic character in column 1 of the line (after any file line numbers). It may be any number of continuous characters, though the assembler will ignore all characters beyond the fifth. This means that the label names "bridge", "bridg", and "bridget" will all represent the same label. All fields are separated from one another by one or more blanks.

STATEMENTS may contain either symbolic 8080 machine instructions or pseudo-ops. The four fields of each statement, NAME,OPERATION, OPERAND and COMMENT are scanned left to right by the assembler. The assembler requires at least one blank

```
     NAME  OPERATION  OPERAND  COMMENT
```

between each field for identification. For automatic formatting however, the comment field must be preceded by at least TWO BLANKS. Instructions which use only the operation field as does

RZ should be followed by a "dummy" operand if comments are to be used with the statement. (Blanks in the following example are shown as dashes ["-"] for clarity.)

```
     RZ-.--COMMENTS ADDED AFTER TWO SPACES
```

CONSTANTS
****

The ALS-8 Assembler allows the use of constants within the operand field. Hexadecimal and decimal, as well as octal constants may be used. When using either octal or hexadecimal, the value should be followed by a "Q" or "H" to indicate OCTAL and HEX respectively. When a value does not include a following identifier, it defaults to DECIMAL but a "D" may be used for clarity when desired.

```
     MVI A,128    Move 128 decimal to register A.
     LXI H,2FH    Move 2F hexadecimal to registers H&L.
     MVI B,40Q    Move 40 octal to register B.
     JMP   0FFH   Jump to address FF hexadecimal.
```

As shown by the last example, all constants must begin with a numeric quantity. When hexadecimal values begin with the letters A-F, they should be preceded by the numeric value zero.

EXPRESSIONS
****

An expression is a sequence of one or more SYMBOLS, CONSTANTS or other expressions separated by arithmetic operators. The ALS-8 Assembler allows the use of four primary operators: ADDITION (+), SUBTRACTION (-), MULTIPLICATION (*) and DIVISION (/). Expressions are scanned left to right with no precedence given to any operator. Calculations are made using 16 bit arithmetic (module 65536) and overflow of values is allowed. Single byte values for immediate instructions (as with MVI A) must evaluate to a value between -256 to +255 or an assembler error will result.

```
     MVI   A,255D/10H
     LDA   POTTS/256*OFSET
     LXI   SP,30*2+STACK
```

There are two other special operators which may be used to reference either the right (>) or the left (<) byte of a 16 bit value. For example:

```
     <1234H evaluates to 12H
     >1234H evaluates to 34H.
```

ASSEMBLER ERROR INDICATIONS
****

The following error flags are output by the assembler when the error occurs. As determined by the type of error, some of the flags are output during pass one to indicate an invalid assembly.

O -- OPCODE ERROR	The symbol found in the operation field was not recognized as a valid 8080 instruction or pseudo operation of the assembler.
L -- LABEL ERROR	The symbol found in the name field contains improper characters.
D -- DUPLICATE LABEL	Two labels with the same name within the assembly.
M -- MISSING LABEL	Instruction requiring a label doesn't have symbol in name field.
V -- VALUE ERROR	Expression in operand field is outside range required.
U -- UNDEFINED SYMBOL	Name given for operand cannot be found in symbol tables.
S -- SYNTAX ERROR	Syntax of statement does not follow the requirements of the assembler.
R -- REGISTER ERROR	False name given to register.
A -- ARGUMENT ERROR	Argument for operand improper.

Since the label field is optional, the assembler must have a convention for identifying the second type of field, the operation field, when the label is missing. The operation field must, for this reason, be preceded by at least two blanks when it starts a line. The contents of this field will be a two, three, or four letter mnemonic chosen from the assembly language set. This mnemonic defines the general instruction to be assembled and it uses, where necessary, the third field, the "operand", to modify or complete the instruction. An "ADD" in the operation field tells the assembler that one of the 8080 registers is to be added to the 8080 accumulator.

The fourth possible field is the comment field which, as its name implies, is reserved for comments. The assembler, then, disregards anything after the third field. In statements which have no operand field, it is a good idea to precede the comment with a period followed by two blanks. Since no operand is required, the period has no affect and the listing will be properly formatted. Most of the examples in this chapter are listed as though they were formatted and printed by the TEXT command. The example below shows how a sample program file might actually be input and exist in memory. Blanks are written as "-" to show their significance; file line numbers are also shown.

```
3-*-THIS-SUBROUTINE-SHIFTS-(H,L)-CIRCULAR-LEFT
5-LUP-XRA-A--CLEAR-THE-CARRY
8--CMP-B--SEE-IF-SHIFT-COUNT-DOWN
13--RZ-.--RETURN-TO-CALLING-ROUTINE
14--DCR-B--DECREMENT-COUNT
16--MVI-A,80H--TEST-MSB-OF-HL
22--ANA-H--COMMENTS-OPTIONAL
24--DAD-H--SHIFT-LEFT
26--JZ-LUP--IF-MSB-WAS-ZERO
29--INX-H--CIRCULAR-BIT-IN
35--JMP-LUP
40--END
```

The above illustrates the fact that "column 1" of each program statement line must be separated from the file line by at least one blank. When printed with the TEXT function the above becomes:

```
*  THIS SUBROUTINE SHIFTS (H,L) CIRCULAR LEFT
LUP    XRA    A       CLEAR THE CARRY
       CMP    B       SEE IF SHIFT COUNT DONE
       RZ     .       RETURN TO CALLING ROUTINE
       DCR    B       DECREMENT COUNT
       MVI    A,80H   TEST MSB OF H,L
       ANA    H       COMMENTS OPTIONAL
       DAD    H       SHIFT LEFT
       JZ     LUP     IF MSB WAS ZERO
       INX    H       CIRCULAR BIT IN
       JMP    LUP
       END
```

Instructions in the assembly language manipulate seven 8-bit registers, a 16-bit program counter called "PC", memory, I/O devices, and a 16-bit stack pointer "SF". Both the assembler and the hardware use a number convention for identifying these registers. The numbers 0,1,2,3,4,5, and 7 each represent one of the 8-bit registers. Depending on the instruction, a 6 can represent memory, the stack pointer, or a special program status word, "PSW". Many of the instructions assume a destination register for the results they generate and many will also make assumptions on one of their input operands. Addition, for example, is handled by the ADD instruction in the assembly language and it assumes that the contents of register 7, called the accumulator, will be added to an eight bit quantity from memory (6) or the registers (1 through 5). Its result always goes to register 7. The operand for this register is a number specifying which 8-bit value is to be added to register 7. This operand appears in the operand field for the instruction as shown.

```
LABL   ADD   7     DOUBLE THE ACCUMULATOR
       ADD   0     ADD IN REGISTER 0
XAD    ADD   3     ADD IN REGISTER 3
       ADD   6     ADD IN VALVE FROM MEMORY
```

The assembler uses a pair of tables, the Assembler Symbol Table and the System Symbol Table, to find number values associated with a symbol name. Label names from the label field are stored into the Assembler Symbol Table along with the addresses they represent in the object code. Assembling the short example above would have added the names "LABL" amd "XAD" to this table. The assembler always has eight entries in this table, B,C,D,E,H,L,M, and A, for which it has the values 0 through 7. These are the names given to the registers and the assembler will replace one of these names found in an instruction with the appropriate register number. The last example could be rewritten:

```
LABL   ADD   A    DOUBLE THE ACCUMULATOR.
       ADD   B    ADD IN REGISTER B
XAD    ADD   E    ADD IN REGISTER E
       ADD   M    ADD IN VALUE FROM MEMORY
```

A number of the 8080 operations use pairs of registers for 16-bit operands and for these operations, register B is paired with C, D with E, H with L, and the program status word PSW is paired with A. B, D, H, and PSW are the high order bytes in these values. The instruction DAD, for instance, performs a "double add" between the (H,L) pair and the (B,C) or (D,E) pair. The result is stored again it (H,L). For these instructions, the pair is designated the name of the most significant byte so the possible PAD instructions are:

```
     DAD   B
     DAD   D
     DAD   H
     DAD   H
     DAD   SP

       which are equivalent to:

     DAD   0
     DAD   2
     DAD   4
     DAD   6
```

Note that 6, which could represent memory, SP, or PSW, is taken by the DAD instruction hardware to mean the stack pointer. "DAD M" or "DAD PSW" are equivalent to "DAD 6" and will then be treated by the hardware as "add SP to (H,L)". Note also the default list of register names does not include PSW or SP. These may be entered into either the System Symbol Table with the SYMLE executive command or into the Assembler Symbol Table with the EQU assembler instruction (to be described). The assembler will first try to fetch a value for a symbol from its own table and, failing, will then try the System Symbol Table.

A number of the 8080 instructions are "conditionals" meaning that the full operation is performed only if a condition is met. The program status word, PSW, uses five of its eight bits to represent the testable conditions. These bits are called Sign, Zero, Aux, Parity, and Carry, and they reflect the state of the accumulator after certain instructions. The more significant bit of the accumulator is copied to Sign by certain instructions. Similarly, certain instructions will set the Zero bit (to 1) when the accumulator contains a zero value and it is reset (to 0) when A is non-zero. Parity is set to 1 when A contains an odd number of binary 1's and is reset when even. The Carry bit's function is most easily described with the conceptual aid of a ninth bit on the accumulator. Some instructions will put the opposite (0 for 1; 1 for 0) of the carry value into Carry; others will copy carry into Carry. The reader is again reminded that some instructions do not affect the values in PSW regardless of the contents of A. The actions taken by each instruction concerning the PSW condition bits will be given with the description of each instruction.

In the upcoming instruction summary, two types of assembler instructions will be described: executable instructions and "pseudo-ops". The executable instructions are those assembly statements which must be converted into binary object form for eventual execution by the CPU. Pseudo-ops, or pseudo–operations, have the appearance of other program statements but do not produce object code for the CPU. Instead they are used to pass information to the assembler program itself. "ORG" for instance, is used with its operand to define the "current address counter" for that position in the program being assembled. "END", another pseudo-op, signals the end of the assembly language source code; the assembler will not try to read or interpret lines beyond the line containing "END".

ASSEMBLY LANGUAGE INSTRUCTIONS

****

This section describes the assembly language instructions and their function ordered by increasing complexity. An alphabetically ordered summary will be given later with the object codes generated for each instruction. In the following description, optional fields will be enclosed in parentheses and operands for the instructions will be represented by a short lower case mnemonic. The operand "reg represents any constant, symbol, or expression wits a value from zero to seven. This value is used to select one of the seven registers or memory: B, C, D, E, H, L, M, A. Operand "addr" can be an expression, constant, or symbol which gives a value to be used as a 16-bit argument, usually an address. A numeric argument is represented by "const 8" and "const" values supplied for "const 8" must be 8 bits or less in magnitude.

The following three instructions provide the most direct means of transferring 8-bit data from register to register, memory to register, or register to memory. There is no single instruction to transfer from one memory location directly to another.

```
     (label)   LDA    addr  -  LOAD Accumulator
```

This instruction fetches a byte from the memory location specified by "addr". This value is then stored in A. PSW is not affected.

```
     (label)  MOV    dreg, sreg  -  move register to register
```

This instruction moves the contents of the source register, "sreg", to the destination register "dreg". B, C, D, E, H, L, M, and A (0 through 7) are legal values for "sreg" and "dreg" except that both may not specify memory (M). When either "sreg" or "dreg" specify memory, the CPU uses the contents of the (H,L) register pair as the address of the memory byte to fetch or store. The contents of the source register are not affected. PSW is also not affected by the instruction.

```
        MOV    M,E   move contents of E into memory
                      location specified by (H,L).
MOVER   MOV    E,B   copy B into E
        MOV    C,M   load C from memory

       (label) STA   addr STORE accumulator
```

STA transfers the contents of the accumulator to the memory location specified by "addr". PSW is unaffected.

Arithmetic, logical, and comparison operations are handled by eight instructions. Each of these operations is assumed to take place between the accumulator and a register (or memory location) specified in the operand field. All, except CMP, produce an 8-bit result which is placed in the accumulator. The program status word bits in PSW are all affected by any of these instructions.

```
     (label)  ADD   reg  -  ADD register to accumulator
```

The value in register "reg" is added to the accumulator and PSW is updated. PSW "Carry" is set to 1 if the arithmetic produces an overflow from the most significant bit (MSB).

```
     (label)  SUB   reg  -  Subtract register from A
```

This instruction subtracts the value specified by "reg" and places the result in A. The PSW carry bit is set to 1 if a borrow was necessary during the subtraction; the actual ninth bit carry, discussed earlier, would actually be zero in a borrow situation. This is an example of carry being inverted for storage in Carry.

```
(label)  ADC   reg  -  Add the specified register and Carry
                       to the Accumulator
```

The specified register and the current contents of Carry are added to A and the result is placed in A. This is used primarily in "multiple precision" additions in which a number is actually contained in several (usually adjacent) memory locations. Such an addition starts at the low order end of the two numbers with the Carry bit reset to zero. Successive additions with ADC on more significant bytes in the numbers are corrected for overflow from the last (less significant) addition.

```
(label)  SBB   reg  -  Subtract with borrow from A
```

This is the multiple precision form of SUB. It subtracts the Carry (borrow) from A as well as the value in "reg". This is actually done by adding the Carry bit to the value in "reg" before the subtraction is made. The PSW status bits are updated after the subtraction.

```
(label)  ANA   reg  -  logically AND reg and A
```

This function performs a "logical and" (a Boolean multiplication) on the contents of "reg" and the accumulator. Conceptually this operation is performed independently on each bit position of the two operands (A and "reg"). The corresponding bit position in the result is set to 1, if, and only if, both of the operand bits are 1's. 00110011 and 01010101 will leave the value 00010001 in A. The Carry bit is always reset; other status bits are set or reset according to the result.

```
(label)  ORA   reg  -  logically OR reg and A
```

This instruction performs a bit-wise "logical or" (Boolean add) on the accumulator and the specified register. Each bit of the result is set to 1 if either of the corresponding operand bits is 1. 00110011 OR 01010101 will produce 01110111 for a result. The Carry bit is always reset to zero. Other status bits are set as dictated by the properties of the result.

```
(label)  XRA   reg  -  logical EXCLUSIVE OR reg and A
```

XRA is a bit-wise logical "exclusive-OR" function for the

OPERANDS, A and "reg". Each bit of the result will be 1 if one (and only one) of the corresponding operand bits is 1. The operand values 00110011 and 01010101 produce an "exclusive-OR" result in the accumulator of 01100110. PSW status bits are handled as in ANA, ORA. This function is often used to clear the accumulator and Carry with an "XRA A".

(label) CMP reg - Compare A to Reg

This instruction performs an 8 bit unsigned compare of the values in A and "Reg". The following status results:

(A) < (Reg)	Carry is <u>set</u>, zero is <u>reset</u>
(A) = (Reg)	Carry is <u>reset</u>, zero is <u>set</u>
(A) > (Reg)	Carry is <u>reset</u>, zero is <u>reset</u>

A compare is actually done by internally subtracting "Reg" from A but storing the result.

There are eight instructions much like the register operations described above, and they are called the Immediate Instructions. They differ from register operations in that a register (or memory) value is not used as an operand. Instead, the operands are the accumulator as before, and an eight bit value which is given in the operand field of the instruction. This operand value may be the result of an expression, the value of a symbol, of a constant, as long as the magnitude of the value does not exceed eight bits. As with register operations, all PSW bits are affected by these instructions.

(label) ADI const8 - add value of const8 to A

The 8-bit value of "const8" is added to the accumulator. As in ADD, its register operation counterpart, all PSW bits are affected.

(label) SUI const8 - subtract immediate from A

The immediate value is subtracted from A. PSW bits, including Carry, follow conventions of SUB.

(label) ACI const8 - add value and Carry to A

"Const8" and the Carry bit are added to A. PSW is affected.

(label) SBI   const8 - subtract immediate with borrow

This instruction subtracts Carry bit and immediate value.

(label) ANI   const8 - AND the immediate with A.

ANI performs a logical AND on the immediate value and the accumulator. It is often used to isolate certain bits in A for testing. The logical operation is described in ANA.

(label) ORI   const8 - immediate OR with A

This function performs a logical OR on the immediate value and register A.

(label) XRI   const8 - immediate exclusive OR on A

This produces an exclusive-OR result from A and the value following. See XRA

(label) CPI   const8 - compare immediate with A

This performs a compare of Register A with the CONST8. See CMP.

There are several other commands which affect the contents of the 8 bit registers. They have been separated since they behave differently with respect to the program status word, PSW. Note that these instructions affect some condition bits and not others.

(label) MVI   reg,const8 - move value into register

This instruction is similar in some ways to the immediate instructions though it does not affect the PSW. The 8-bit value of "const8" is moved into the specified register.

(label) INR reg - increment register

The register specified by "reg" is incremented by one and all the PSW bits except CARRY are updated.

(label) DCR reg - decrement register

The register, or memory location addressed by the H & L registers, is decremented by 1. As with INR, all PSW bits except carry are affected.

(label) CMA - complement the accumulator

This instruction reverses each bit of the accumulator. 1's become 0's and 0's become 1's. The PSW is not affected.

There are four instructions used to shift the contents of accumulator. Each of these instructions shifts the contents only one place left or right depending on the particular instruction. None of the shifts affect any PSW bits except carry. The direction "right" or "left" in these descriptions assumes that the more significant bits of the accumulator lie to the left.

(label) RLC - rotate left, through carry

This is a circular left shift in which the carry bit receives the bit value shifted from the most significant bit of the accumulator. This same value shifted into carry is also shifted into the least significant bit of A. 01101110 becomes 11011100 after the shift and the Carry bit is left as 0. Another shift of this value gives 10111000 and a Carry value of 1.

(label) RRC - rotate right, through carry

This shift is a right shift similar to RLC except the least significant bit is shifted to Carry and the MSB position.

```
(label)  RAL    -  9 bit shift left
```

This function shifts the accumulator one place left. The most significant bit is shifted into Carry as in RLC, but the old value of Carry is shifted into the low end of the reg A. Shifting 01101110 with a value of 1 in Carry produces 11011101 and a Carry of 0. A second shift of this data produces 10111010 and a Carry of 1.

```
(label)  RAR    -  9 bit right shift
```

The accumulator contents are shifted one place right with the least significant bit being sent to Carry and the old value of carry being shifted into the MSB of the accumulator.

```
(label)  LDAX   regbd  -  load A from memory (indexed)
```

The accumulator is loaded with the value from memory whose address is obtained from the register pairs (B,C) or (D,E). The operand, "regbd", can then only equal "B" or "D".

```
(label)  STAX  regbd   -  store A into memory (indexed)
```

The contents of A are stored in memory at the address given by the (B,C) or (D,E) register pairs. The pair is chosen by the operand "regbd" which may only be "B" or "D".

The 8080 is also equipped with a full set of transfer instructions which have the ability to alter the flow of a program through execution. There are three categories of transfers: "jumps" "subroutine related instructions" and "interrupt transfers". Of the ten jump instructions, only two are "unconditional transfers" meaning that the execution sequence of the program is always altered by them. The "conditional transfers", on the other hand, examine the status word PSW to see if the proposed jump is to be made. If the condition bits of the PSW do not meet the requirements of the instructions, no transfer is made and the program will resume execution at the next instruction in memory.

UNCONDITIONAL TRANSFERS

```
     (label)   JMP   addr
```

This instruction always transfers control to the address in memory specified by the operand field, "addr". The next instruction to be executed will be the one starting at this address.

```
     (label)   PCHL
```

This performs the same function as the JMP instruction except the address for the transfer is taken from the H and L pair of registers and not the operand field. Generally this instruction is used to branch to a routine in memory whose address has been located in a table. It could be used to branch to a computed address, but any small errors in the calculation could produce some mysterious bugs.

CONDITIONAL TRANSFERS

```
     (label)  JZ   addr   Jump if zero
```

JZ examines the status bit "ZERO" of the PSW and transfers to the address "addr" if this bit is set to 1. This 1 in the ZERO bit represents a zero value in a register at the last time the condition bits were set by an instruction. Most of the instructions affecting the PSW reflect the status of the accumulator, register A, though a few (INR DCR) will change the ZERO bit and others when their result goes to any of the registers.

```
     (label)  JNZ   addr  Jump if non-zero
```

This instruction also examines the ZERO bit of the PSW, but it transfers when the last pertinent result was a non-zero value. A non-zero result resets the ZERO status bit to 0.

```
     (label)  JP   addr  Jump if plus (non-minus)
```

JP examines the SIGN bit within the PSW and transfers when this bit is zero. A zero for the SIGN bit represents a positive value for the last pertinent operation,

```
(label)  JM   addr   Jump if minus
```

JM examines the SIGN bit and transfers when it represents a negative value (minus) for the last result.

```
(label)   JC   addr   Jump if CARRY
```

This instruction jumps if the CARRY bit has been set on the last operation. For addition operations, a jump is made if the sum of the two operands has exceeded the limit of 8-bit numbers. The overflow bit is stored in the PSW bit, CARRY. Subtractions requiring a "borrow" will also set this CARRY.

```
(label)   JNC  addr   Jump if no CARRY
```

A jump to the address, "addr", is made if the last operation did not produce a CARRY.

```
(label)   JP   addr   Jump if PARITY even
```

The PARITY bit of the PSW is "even" when the number of bits set to 1 in the result is even. This instruction transfers to "addr" when this condition exists.

```
(label)   JPO   addr   Jump if PARITY odd
```

JPO transfers to the address "addr" when the PARITY bit in the PSW represents a result with odd parity. Parity is generally used to verify data transmitted from an external device.

CARRY BIT INSTRUCTIONS

There are two special instructions which manipulate only the status of the CARRY bit in the PSW. These will affect all CARRY related conditionals as well as the addition, subtraction, and shift instructions which use CARRY. These two instructions are frequently used to return a simple status condition from a subroutine.

```
     (label)   STC   -   set CARRY (to 1)
```

This instruction sets the value of CARRY to 1. No other condition bits are affected by this command.

```
     (label)   CMC   -   complement CARRY
```

CMC reverses (complements) the current value of CARRY. If CARRY equaled 1, this instruction will change it to a 0. If CARRY was 0, CMC changes it to a 1.

SUBROUTINE TRANSFERS

A transfer to a subroutine is made with one of the CALL instructions described below. When a CALL instruction is made, two addresses become important. The "transfer address", the address of the subroutine being called, is contained in the operand field of the CALL instruction. Program control will be transferred to this address immediately following the call. As the call is being made, however, a "return address" is computed and stored on the next position of the stack. When the subroutine is finished, it can execute one of the RETURN instructions which will fetch this address from the stack (pop the stack) and a jump will be made to this address. This return address represents the location of the instruction immediately following the call instruction which gave control to the subroutine. Subroutine calls within subroutines store their return addresses at successive stack locations so the corresponding return instructions can properly locate their return addresses.

As with the jump instructions, both the CALL and RETURN operations are divided into unconditionals and conditionals with the same suffix convention as used with JUMPS.

```
     (label)   CALL  addr   -   call the subroutine at "addr"
```

This instruction performs an unconditional subroutine call to the address specified by the operand "addr".

```
(label)   RET   -   return to address found on stack
```

RET pops a value off the stack which it uses as a transfer address for a jump. Since it always retrieves its "operand" from the stack, it does not need anything in the operand field. This return is unconditional.

SUBROUTINE CONDITIONAL INSTRUCTIONS

The reader is reminded that only certain instructions influence the condition bits of the PSW (program status word). A full description is given at the beginning of this chapter.

```
(label)   CZ   addr   -   call if last result equaled 0
```

This instruction calls the routine located at address "addr" if the ZERO bit of the PSW is set to 1 representing a zero result in the last operation.

```
(label)   CNZ  addr   -   call if last result was non-zero
```

A call is rade if the last PSW related operation produced a non-zero result.

```
(label)   CP   addr   -   call if result positive
```

This instruction examines the status of the SIGN bit within the PSW and performs a subroutine call if this bit indicates a positive result from the last instruction.

```
(label)   CM   addr   -   call if negative result (minus)
```

CM calls the routine at address if the SIGN bit is set representing a negative result from the last PSW related instruction.

(label)   CC   addr   -   call if CARRY

CC calls the subroutine at "addr" if the CARRY bit has been set to 1. CARRY is set to 1 when there is a carry from an addition, a borrow from a subtraction, or there is a bit 1 produced by one of the shift or Carry instructions.

(label)   CNC   addr   -   call if no CARRY

This instruction calls the subroutine at address "addr" if the CARRY bit is zero.

(label)   CPE   addr   -   call if PARITY even

This instruction calls "addr" if the PARITY bit was reset by the last PSW related operation. "Resetting" PARITY is equivalent to making it a zero. Even parity for a result indicates that it contained an even number of binary 1's (and 0's).

(label)   CPO   addr   -   call if PARITY = 1, "parity odd"

The subroutine call is made if the PARITY bit of the PSW is set to 1 indicating "odd parity".

(label)   RZ   -   return if last result was zero

A return from subroutine is made if the last result recorded in the PSW was a zero.

(label)   RNZ   -   return if last result was non-zero

This instruction returns from the present subroutine if the last result was non-zero.

(label)   RP   -   return if positive

A return, using the address pulled off the stack is made if the last result had a zero sign (was positive).

(label)   PM   -   return if minus

This returns from the routine if the last result was minus.

(label)   RC   -   return if CARRY (=1)

This instruction performs a subroutine if the PSW bit CARRY is set to 1. CARRY is set by the Carry instructions, shifts, additions with overflow, or subtractions with borrows.

(label)   RNC   -   return if no CARRY (=0)

RNC returns if there was no CARRY generated from the last instruction. See the above instruction.

(label)   RPE   -   return if PARITY even

A return is executed if the value of the PARITY is 0 indicating even parity in the last operation.

(label)   RPO   -   return if PARITY odd

Another instruction, RST, also performs transfers, but it is rarely used as such. It will be described later with the interrupt related instructions.

16-BIT OPERATIONS

A number of the 8080 functions can perform arithmetic operations on 16-bit values stored in register pairs. The B and C registers form a pair as do D,E and H,L; the Stack Pointer, SP, is used as a fourth possible operand for these instructions. None of these instructions affect any of the condition bits.

```
     (label)   LHLD   addr   -   load H,L with the values at
                                 "addr"
```

This instruction moves two bytes from memory into the H,L register pair. The operand, "addr", identifies the address of the byte to be transferred to the L register and the next memory address is used for H.

```
     (label)   SHLD   addr   -   store H,L into memory at "addr"
```

The contents of the L register are moved to the address specified by "addr" and the contents of the H register are moved to memory location "addr+1"

```
     (label)   LXI   rp,const   -   store 16-bit constant in
                                    pair "rp"
```

The register pair "rp" is given a 16-bit value as determined by the second operand, "const". Numerically the operand "rp" must equal 0,2,4,6 which are generally represented by the symbolic names B,D,H, SP. Either operand may be an expression acceptable to the assembler which will produce a register pair integer or a 16-bit value for those operand positons.

```
     (label) INX rp - increment register pair "rp"
```

This instruction adds one to the register pair specified by the operand "rp" No condition bits are affected even if carries are produced internally for the operation

```
     (label) DCX rp - decrement register pair "rp"
```

DCX subtracts one from the register pair "rp". As with INX and the other 16-bit instructions, none of the condition bits in PSW are affected.

(label) DAD rp - add rp to H,L

This performs a 16-bit add between the operand register pair, "rp" and the H,L registers; the result is stored in the H,L pair. The operand can be B,C ("B"), D,E ("D"), H,L ("H"), or SP.

(label) XCHG - exchange the contents of D,E with H,L

XCHG swaps the contents of the D,E register pair with the contents of the H,L pair.

STACK OPERATIONS

The "stack" is an area in memory identified and manipulated through the 16-bit address held in the "Stack Pointer", SP. As previously described, it is used by the subroutine related instructions, "CALL" and "RET" (and their conditional relatives). In operation, a 16-bit value, an address for the subroutine instructions; is sent to the memory locations identified by the address in the SP. The specific locations chosen are SP-1 for the "most significant" byte and SP-2 for the lower order byte. The SP contents are then decremented by two to be ready for the next stack operation. Such an operation is called a "push" and the reverse operation where data is removed from the stack is known as a "pop". Note that the pointer moves "down" in memory with successive pushes and moves "up" for pops.

The operations about to be described give the programmer direct control of the stack and its pointer. The stack can be a very versatile data storage area for particular applications, but the programmer must be careful that the data stored in the stack is not confused with the return addresses stored there from subroutine calls.

Two of the stack instructions use a register pair operand which will be denoted by "rp" in the following. This operand identifies B,C, D,E, H,L, AND PSW,A. In the last case, the Program Status Word is placed at location SP-1 and the accumulator is placed at SP-2 for stack pushes. This form of saving the PSW is necessary for interrupt handling or some subroutine calling sequences.

(label)   PUSH rp   -   push contents of rp onto stack

The contents of the register pair "rp" are placed on the stack and the pointer, SP, is decremented by 2. Numerically, "rp" must be 0,2,4,6 which represent the pairs, B,C,D,E,H,L and PSW,A.

(label)   POP rp   -   pop data from stack into rp

Data is removed from the stack and placed into the registers identified by the operand "rp". The ordering of the bytes taken from the stack follows the same rules used for PUSH. The pointer SP is incremented by 2 at the end of the operation.

(label)   SPHL   -   move H,L contents into SP

The contents of the H,L pair are moved into the stack pointer, destroying its previous contents. This provides a convenient way of changing the SP during a program, thereby allowing two or more stacks to exist at one (one data, one subroutine control, etc.). The SP is usually initialized by the LXI instructions.

(label)   XTHL   -   exchange SP and H,L contents

The contents of the H,L register pair are exchanged with the two bytes at the top of the stack (as pointed to by the SP).

INPUT/OUTPUT INSTRUCTIONS

The two input/output instructions for the 8080, IN and OUT, both operate on the accumulator contents. The operand field is used to define a "device code" which identifies the external device which is to produce or receive an 8-bit value. This device number car, be any number between 0 and 377 octal. Each device attached to the computer has such a number assigned at the time it is wired to the machine and the device code given in the I/O command must equal that of the device before it will respond. Reading a non-existent device number with the IN instruction will put an octal 377 in the accumulator.

```
     (label)   IN   dev   -   read device number "dev"
```

The external device with input device number "dev" will return an 8-bit value which is stored in the accumulator. None of the PSW condition bits are affected. The default input device for the ALS-8 is assumed to be device 1 and its status (busy or idle) is accessible through input device 0.

```
     (label)   OUT   dev   -   send contents of A to device
                               "dev"
```

The contents of the accumulator A are sent to the output device numbered "dev". The ALS-8 assumes by default that an output device 1 exists and that its condition can be checked also through input device zero.

INTERRUPT RELATED INSTRUCTIONS

The 8080 is prepared to accept signals from external devices which can alter its program flow. This is invaluable for handling certain types of sporadic or slow devices. It can allow the CPU to work on a program without worrying constantly about the status of devices. This is accomplished with the aid of the "Interrupt Enable Flag", also known as "INTE". When this flag is on (enabled) a device can force an interrupt which initiates a sequence of events in the computer. The "INTE" flag is immediately disabled to keep other devices from confusing things while the first interrupt is being handled. The CPU is then required to take an instruction (8-bits only) from the interrupting device, execute it and then continue. Special hardware can be attached to the computer which will cause the CPU to jump to any predetermined location in memory. Without this special "vector interrupt" hardware, the normal convention has the interrupting device issue a Restart instruction which is a subroutine, like jump to one of eight possible memory locations: 0, 10,20,30,40,50,60,70 octal. At the location specified by the vector hardware or the restart, there should be a subroutine capable of handling the interrupt condition. The restart instruction ("RST") pushes a return address onto the stack so the program which was operating can be properly resumed with an RET instruction executed in the interrupt routine.

(label) EI - enable interrupts

This instruction enables the interrupt flag, "INTE". Devices attempting to interrupt while this flag is disabled will be ignored by the CPU and its related hardware; INTE is automatically disabled when an interrupt occurs.

(label) DI - disable interrupts

This disables the interrupt flag, preventing any devices from altering program flow with an interrupt. The computer is in the disabled state when the front panel switch "RESET" is activated. For machines with no interrupting devices, the INTE light on the front panel can be used by these instructions to signal certain program states such as "program done" or "error".

(label) RST n - call routine at location n*8

This transfer instruction generates a subroutine call to an address which is computed from the operand "n". The operand, which must itself be between 0 and 7 in magnitude, is multiplied by 8 to produce one of the following addresses: 0,10,20,30,40,50,60,70 octal. The subroutine call is then made to this address with the return address being stored on the stack as in any other subroutine call. An "RET" in the subroutine located by the RST will return control to an address pulled from the stack. Devices using this instruction during interrupt put the 8-bit equivalent of this instruction on the data lines for the CPU to execute.

```
(label)   HLT   -   halt the CPU and wait for interrupt
```

The CPU is completely stopped by this instruction and can only be reactivated by an interrupt. Should the interrupt flag happen to be disabled at the time this instruction executes, the whole machine must be reset from the front panel. The halt condition is reflected in the front panel light marked "HLTA".

VARIABLE STORAGE AND THE NO OP

The instructions presented so far represent operations or functions within the 8080 hardware. The ALS-8 assembler converts the textual form of these instructions into a binary form which will be executed by the hardware. The assembler also recognizes a number of instructions which do not produce "executable" code. In general, this class of assembler instructions defines storage arrangements, addresses, or contents for the program under construction. These instructions are called "Pseudo-ops" (being "false" in the sense that they don't produce executable code).

An instruction, the NOP, generates a binary instruction of zero which is ignored by the execution hardware. It is sometimes used in programs to "pad" areas of code where changes are expected to be made via the front panel. The versatility of the ALS-8 makes this unnecessary, but the instruction can still be used to generate zero bytes for variable storage. As will be shown, there are instructions from the pseudo-op set which can allocate blocks of memory for variables much more easily than successive NOP's.

```
(label)   NOP   -   do nothing.  (reserve this space)
```

This assembly language instruction corresponds to an operation code (binary) of zero which is ignored by the CPU when executed.

```
(label)   DS   amount   -   reserve an "amount" of memory
```

This pseudo-op reserves a number of successive memory locations starting at the current position in the program. The number of memory locations is determined by the operand "amount" which can be any 16-bit number, or equivalent expression. The contents of these locations is not defined.

```
     (label)   DB   n   -   define contents for single byte
```

This instruction reserves a single memory location and defines for it a value as determined by the operand "n". The value of the operand must not exceed eight bits.

```
     (label)   DW   n   -   define word and contents (16-b)
```

The operand for this instruction is evaluated as a 16-bit quantity and stored in two memory locations. The least significant byte of the quantity is stored at the "current address" and the most significant is stored below it.

```
     (label)   ASC   #string#   -   put character string in
                                     memory
```

This puts a string of characters into successive memory locations starting at the current location and continuing until the entire string has been put in memory. The special symbols ,# at either end of the above example are called "delimiters"; they define the beginning and end of the ASCII character string. The assembler uses the first non-blank character found after the mnemonic "ASC" as the delimiter. The string is defined as starting immediately after the first delimiter and ending just before the second occurrence of the delimiter. Characters to the right of the second delimiter are assumed to be comments. A carriage return will act as the second delimiter in cases where it is omitted. When formatting is used, the string must not contain two or more successive spades within the first four characters:

```
     (label)   EQU   n   -   assign value n to symbol "label"
```

The symbol in the label field for this instruction is entered into the assembler's symbol table with the 16-bit value found in the operand field. Note that both the label field and an operand field are required for this instruction.

COM (symbol) - enter symbol into system symbol table

The symbol must be previously defined and is entered into the System Symbol Table.

NLST - suppress printed output of assembly listing

This instruction sets a flag in the assembler which will suppress the printing listing from this line until that flag is reset by the LST instruction. Neither NLST or LST may have a label field.

LST - begin assembly listing

This reactivates the listing feature which will remain on until turned off by NLST. If the listing feature is already active when this instruction is encountered, it is .simply ignored. Neither NLST or LST affect memory position or contents in any way.

END - marks the end of the program

This instruction is a signal to the assembler that no more statements are to be assembled from the current device or file being assembled. For programs being assembled from a file in memory, this instruction is not necessary as the end-of-file mark performs the same function.

SIMULATOR EXTENSION PACKAGE
****

OPERATION MANUAL

The SIM-1 Extension Package for the ALS-8 is a program designed to "run" 8080 machine language in the same manner as the 8080 computer running the simulator program. Because the Simulator is an operating program, the user has full control of the "run" allowing powerful program debugging as well as a direct view of the computer's operation. Since each instruction, as well as its effects, can be viewed on a single step basis, the Simulator represents an ideal "teaching" machine for 8080 Micro-Computer operation.

By using the Simulator commands, the user can modify or display storage, set simulated 8080 flags and registers, perform or test input and output operations, set and reset breakpoints and realtime run addresses, as well as trace program flow.

The Simulator is entered from the ALS-8 by giving the SIMU command. On entry the program does a carriage return/linefeed on the last selected output device, followed by an asterisk prompt. The last selected MODE also remains in effect and is used by the Simulator.

After giving the prompt, the simulator is ready to receive a command indicating the operation desired. Some commands, such as "run" (G for go), start operation of the software computer. Prior to running the program, however, certain commands allow the operator to set the PROGRAM COUNTER or REGISTERS in order to set the proper conditions for the simulation prior to the simulated computer start-up.

SET COMMANDS
****

P address(H,Q,D) --SET PROGRAM COUNTER

Set program counter to the value of "address". Conversion of the parameter is determined by the last selected "MODE' or by the following, optional, parameter.

S regx=value (regy=value..) --SET REGISTER VALUE

Set register "x,y.." to "value" where value given according to MODE or following parameter (H-HEX,Q-OCTAL,D-DECIMAL). Multiple assignments per line are allowed; however, each register name must be followed by the equal sign and then the selected value. The next register name must then be preceded by a space. Valid register names are A,B,C,D,E,H,L with "S" and "F" used to indicate the Stack Pointer and Flags (PSW) respectively.

All commands can be used any time the Simulator has given a prompt. While running, the program checks the front panel switches as well as the SYSIO input port for display and/or break indicators. Control "X" causes the Simulator to stop running and return to the command mode.

The two high-order sense switches determine the display mode of the simulator as it simulates the running program. If no breakpoint has been set, these switches are interpreted as follows:

SWITCHES		DISPLAY MODE
7	6	
0	0	SINGLE STEP MODE Execute one instruction and display on current output device. If C/X is input to the System input driver, then return to the command mode. If any other character is received then execute and display one more instruction.
0	1	CONTINUOUS RUN (With Display) Execute and display each instruction until receiving C/X.
1	0	Execute and display one instruction; then return to the command mode.
1	1	Force return to command mode from any Simulator condition.

The output display from the Simulator indicates the current status of the software 8080 as well as the current conditions of the program. The display is initialized to follow the last MODE setting but may be changed to decimal by giving a simulator mode command.

The display consists of the current location of the program counter followed by the FLAGS as set by the last instruction executed. These are then followed by each of the registers and the current memory location pointed to by the H & L registers. The stack pointer and instruction just executed then end the display. This is illustrated below.

```
     PPPP CZSPI  AA   BB CC DD EE HH LL  MM SSSS  B1 B2 B3
```

```
Where: PPPP -is the address of the simulated instruction.  The
       display shows results following execution of the
       instruction.

            C - Carry Flag (0 or 1)
            Z - Zero Flag
            S - Sign Flag
            P - Parity Flag
            I - Interdigit Carry Flag

           AA - Accumulator (reg A)
           BB - Register B
           CC -          C
           DD -          D
           EE -          E
           HH -          H
           LL -          L

           MM - Memory contents pointed to by HL
         SSSS - Current address of the Stack Pointer

           B1 - Current instruction -
           B2 - Byte two of the instruction (if used)
           B3 - Byte three of the instruction (if used)
```

In addition to this display, the operator may dump selected memory locations or enter data to memory locations using the DUMP and ENTR commands.

```
     D address (address)  This command dumps the contents  of
                           address to address following the
                           conventions of the ALS-8 dump command.
     E address            Enter data to memory following ALS-8
                          ENTR conventions.
```

The GO command starts the simulator at the current value of the program counter. It is used to initially start simulation as well as continuing after stopping.

```
     G     Go-- Start simulation

     X     Exit-- Return to ALS-8
```

At this point, the user is advised to write a short program and assemble it to a known location in memory. After obtaining a listing, the Simulator commands described so far should be used in actual practice.

BREAKPOINTS AND "REAL TIME RUN" ADDRESSES

Running a simulation with the display on is normally used only through the problem areas of the program. In order to reach these areas, or to test values during a program loop, a BREAKPOINT is set to stop simulation and display only at the address given by the breakpoint. The breakpoint is not cleared at each display so program loops may be checked repeatedly by giving a new GO command following each display. Also, if single step operation is again desired, the breakpoint should be cleared prior to giving, the GO command.

```
     B address  -- SET BREAKPOINT

                   Breakpoint is set to "address" and the
                   simulator will display each time the program
                   reaches this address.

     CB         -- CLEAR BREAKPOINT
```

The sense switches are interpreted as follows when a breakpoint is set:

```
 SWITCHES   DISPLAY MODE
********** ******************************

 7     6

 0     0    Execute program until breakpoint is reached; display
            current status and return to command after giving
            prompt.
```

0	1	Same as above.
1	0	Execute only one instruction and return to command mode.
1	1	Unconditional return to command mode.

Some sub-routines require a speed of operation beyond that of the Simulator. In order to meet this requirement, the Real Time mode of operation should be used. If the real time address is that of an 8080 CALL instruction, the simulator will make a REAL TIME CALL to that location, effectively giving up control.

```
 R address  -- SET REALTIME RUN ADDRESS
CR          -- CLEAR REALTIME RUN ADDRESS
```

INPUT INSTRUCTIONS

****

During simulation input operations can be performed in three different modes, SIMULATED, REALTIME and PRE-SET. Each method is used depending on the information needed by the user.

SIMULATED

If an input instruction is encountered during the simulation for a port defined as SIMULATED, the Simulator will stop and obtain input values from the operator. The following information is printed prior to receiving input:

```
INPUT PORT n=
```

Where "n" equals the port given in the program being run by the simulator. The simulator stops to the right of the equals sign and waits for input from the operator. Since input goes to the accumulator, the value input must lie in the range 0-255.

REALTIME INPUT

If an input instruction is encountered during the simulation for a port defined as REALTIME, the simulator will obtain the required input directly from the indicated port. This operation is identical to the standard 8080 obtaining input.

PRE-SET INPUT

The preset option allows any input port to have a value preset between 0 and 255.

OUTPUT INSTRUCTIONS
****

Program output, during simulation, can take one of three forms for any desired output port. These options, SIMULATED, ASCII or REALTIME, are selected depending on the information required by the user.

SIMULATED

If an output instruction is encountered during simulation for an output port defined as SIMULATED, the Simulator will indicated that an output has occurred to the indicated port. This includes both the port number and output value as indicated below. (No actual output to the port occurs.)

OUTPUT PORT n=NN

Where "n" equals the port number and NN equals the value that would have been sent to the port.

ASCII OUTPUT

The ASCII output option is similar to Simulated output except the value "NN" is output as an ASCII character. If the value is a control Character, its output is identical to Simulated operation.

REALTIME OUTPUT

As implied, REALTIME OUTPUT sends the value to the indicated port just as though the actual 8080 were operating.

INPUT/OUTPUT COMMANDS
****

IC	portn	SET SIMULATED INPUT PORT
		Set "portn" to SIMULATED mode. (All ports are in this mode on first entry to the simulator)
IS	portn value	SET PRESET PORT
		Set "portn" to PRESET "value"
IR	portn	SET REALTIME PORT
		Set "portn" to realtime mode.
CI		Clear all input port assignments and set all to simulated mode.
OC	portn	SET SIMULATED OUTPUT PORT
		Set "portn" to Simulated. All ports are initialized to this mode on entry to the simulator.
OA	portn	SET ASCII OUTPUT PORT
		Set "portn" to simulated ASCII output.
OR	portn	SET REALTIME OUTPUT PORT
		Define "portn" as realtime port.
CO		CLEAR ALL OUTPUT DEFINITIONS

DISPLAY MODE
****

The display mode of the Simulator is normally determined by the ALS-8 MODE on entry to simulation. This, being either octal or hexadecimal, usually presents the proper information required by the operator. The Simulator has one additional display mode, DECIMAL, which can be selected at any time during simulation.

This mode command "M" will select Decimal output if it is followed by the value 10 (20 if entry mode was octal).

OPTIONAL SIMULATOR ENTRY POINT
****

Often, during simulator operation, it is desirable to return to the ALS-8. In order to return to the simulator without clearing I/O port definitions, it is required that the command SIMU followed by any non-blank character be used. SIMUS is recommmended. This allows the exact conditions on exit to be restored upon re-entry.

OTHER SIM-1 EXTENSION FUNCTIONS
****

AUTO COMMAND

Every ALS-8 contains code to recognize commands other than the standard set. AUTO is one such command whose actual operating code is contained in the SIM-1 Extension Package (making it rather dangerous for those without it to use the AUTO command). In use, the AUTO command allows input to standard ALS-8 files with the AUTO code adding the line numbers.

COMMAND FORM: AUTO (n)

When used without the optional parameter "n", the AUTO command will start sequencing line numbers beginning at one and incrementing by one for each additional line. If the optional parameter is included, then line numbers will begin one beyond the last line in the current file. The parameter "n" can be any value between 0 and 7 with no significance placed on what the value is. Return from the driver to the standard ALS-8 is made by depressing the "ESC" key as the first character of a line. (Note: If there are NO LINES IN A FILE, do not use the optional parameter.)

As a note of interest, the code comprising the AUTO command represents a special I/O driver implemented to pre-process input from the selected I/O driver. This is, of course, a driver on top of a driver, but then the ALS-8 was designed for such nonsense.

TXT-2 EXTENSION PACKAGE

****

OPERATOR'S MANUAL

The TXT-2, an optional extension to the ALS-8, opens a new dimension to the powerful file operation and management of the ALS-8. In addition to an EDITOR, the TXT-2 also contains a VDM output driver and the FIND command. Code for one additional function is also within the package, though the name of the command is not known to the ALS-8 (a minor matter). The use of these commands will be described following the description and operating procedure of the EDITOR.

EDITOR

****

The TXT-2 converts the contents of the "current" ALS-8 file into a continuous display on the VDM screen. Single letter control character commands allow cursor, as well as direct file line movement, on the screen. Since all file operations are direct and the contents of the file are always displayed on the screen, editing becomes a simple matter either with or without file line numbers.

Upon entry, the EDITOR program takes control of the current ALS-8 File and displays the file contents (or lack thereof) on the screen sixteen lines at a time. Command keys are provided to roll through the file or to position the cursor over any character within the file (even in a position where none exists). Also provided are controls to insert and delete characters or lines as required by the result desired.

As with all memory files, a file beginning and end address exist. The TXT-2 EDITOR also has one additional parameter, a value indicating the end of assigned memory. This parameter can be given any value and is used to prevent a file from growing beyond assigned bounds.

The EDITOR is entered by using the EDIT command of the ALS-8. The current file is displayed on the screen and if there are less than sixteen lines, a number of fill characters. As lines are added, these fill characters disappear off the bottom of the screen.

Since a file must first exist, the user must create or select a file prior to entering the EDITOR. The ALS-8 FILE command is used for these operations.

In the explanation that follows, the user is urged to try each command on an actual file. No words can describe the visual effect each operation performs on the screen. For best "learning" results, the file should have, or be given, at least thirty-two lines.

Prior to using the editor, the end of assigned memory parameter should be set to a known value. The parameter can be set to a null value by giving the command EXEC FFF3 (HEX). This nullifies the proper operation of the parameter and a further explanation will cover the correct usage later in the manual.

CURSOR POSITIONING COMMANDS

****

The keys, A,S,W,Z, form a triangle on the input keyboard. When pressed simultaneously with the CONTROL KEY, they will move the cursor as indicated below.

```
CONTROL/ W    move cursor up
         A    move cursor left
         S    move cursor right
         Z    move cursor down
```

Any character input, other than control characters, will normally replace the character at the current cursor position. The "normally" condition is placed on this statement to allow for the character insert mode to be described later.

CONTROL/ Q   CURSOR HOME COMMAND

In addition to the "triangle" movement controls, the TXT-2 also includes a "HOME" key which sets the cursor to position zero on line seven. Do not use this control unless there are at least seven lines on the screen.

SCREEN SCROLL COMMANDS

****

Screen scroll commands are provided to allow the file to be "rolled" through the screen area until the desired file line is reached. Each command key corresponds to a position relative to the triangle previously described.

```
     CONTROL/ E    scroll up one line
              X    scroll down one line
              R    scroll up sixteen lines
              C    scroll down sixteen lines
```

DIRECT FILE POSITIONING COMMANDS
****

In addition to cursor positioning controls, the TXT-2 also contains code to receive and search for specific text within the file. The editor FIND command (different than the ALS-8 find command) is CONTROL/ O.

```
     CONTROL/ O    editor text search
```

Upon depressing the search command, the screen will blank and a colon (:) prompt will appear. At this point, the editor is waiting for an input line of one or more characters from the operator. This input can contain up to thirty-nine characters. Any occurrence of these characters within the file, regardless of preceding or following characters, will represent a find. Therefore, only enough characters to uniquely define the desired text need be input. As an example, "the qu" can be used to locate a line in the file containing "the quick brown fox".

After receiving a carriage return following the input text, the editor will search the file from the beginning forward for an occurrence of the text input by the user. Upon finding the line, the editor will position the line containing the text at the first line on the screen. If no occurrence was found within the file, the editor will return to the first line of the file for screen presentation.

```
     CONTROL/ I    continue search
```

If an occurrence was found and the user wishes to continue the search, the continue command should be used. This command causes the editor to pick up the first file line off the bottom of the screen and to continue the search from there.

Any text on the screen is not searched.

FILE MODIFICATION COMMANDS

****

CONTROL/ T   character insert mode switch (on-off-on...)

Normal file characters, input from the terminal, are placed in the file in either of two modes. These modes, normal and insert, are alternately selected using the insert mode control.

When off, characters are placed at the present cursor position and the cursor moves to the right one place. When on, however, characters are inserted into the file at the current cursor position, moving the character at that position and the rest of the file right.

CONTROL/ H   delete character command

The delete character command removes the character at the current cursor position and moves the remaining portion of the line to the left.

CONTROL/ B   insert line command

The line insert control moves the current cursor line down and inserts a blank line in its place. The cursor is moved to the first character position of the new line.

CONTROL/ P   delete line command

This control removes the current cursor line from the file.

CONTROL/ J   (linefeed) blank remaining line and scroll up

Linefeed deletes all characters on the current cursor line from the current cursor position to the right. The file also scrolls up one line and the cursor moves to the first position on the new line.

CONTROL/ M   (Carriage Return) scroll up and insert one line

Carriage return scrolls up one line and inserts a blank line in the file. The cursor is moved to the first character position of the new line.

OTHER COMMANDS

****

CONTROL/ F   exit command

On EXIT, the editor clears the screen and does an FCHK on the file prior to returning to the ALS-8 executive. For long files some delay may be experienced (about 1/2 second) before receiving the "READY" message.

CONTROL/ Y   repeat command

The repeat command requires two keystrokes following the command. The first represents the command or character to be repeated, while the second is the number of repeat increments.

The repeat increment is offset by an ASCII bias to allow the numbers 1-9 to represent their actual values. All other characters have an equivalent value as determined by their ASCII representation.

```
CONTROL/Y----->> COMMAND OR CHARACTER ------>> # OF REPEATS
```

OTHER FUNCTIONS PROVIDED BY THE EXTENSION PACKAGE

FIND

****

As was mentioned, the TXT-2 extension also contains code for the ALS-8 FIND COMMAND. This command gets an input string from the user and prints all occurrences of the string within the current file.

After receiving the FIND command, followed by a carriage return, a colon (:) prompt will print on the current output device. At this point, the desired string is input, once again followed by a carriage return. Following this, all occurrences of the string will print out on the current output driver.

ESET COMMAND

****

The VDM EDITOR uses a parameter to limit the maximum address the file may reach. Code has been included within the TXT-2 to set this value, but no corresponding command has been provided. The standard ALS-8 CUST command can be used to insert this command if the following sequence is executed:

```
     CUST /ESET/ FFF3
```

After this the command ESET, followed by an address, will set the parameter to the value of the address given. It should be noted that the file may reach but not exceed this value.

VDM DRIVER

Also included in the TXT-2 package is a driver to allow the ALS-8 to use the VDM as an output device. This driver is in PROM allowing access at all times. The address for the driver is FE77 (hex) and the IODR command is used to enter the name in the DRIVER TABLE. For use as a stand-by driver, the following sequence is recommended:

```
     IODR /VDM/ input address   FE77
```

The driver may also be made the-SYSTEM DRIVER by using the following sequence:

```
     IODR /SYSIO/ 0  FE77
```

The standard terminal output driver can then be assigned as a hard-copy supplemental driver by using the following:

```
     IODR /PNTR/ 0 D0A9
```

The VDM driver is especially suited to commanding the ALS-8, and it is recommended that it be changed to the SYSIO driver right after system initialization. The following special keys are implemented in the driver:

```
     CONTROL/ Z clear screen
              A turn cursor on or off
              S set display speed prior to operation
```

The display speed command will output the message: SPEED? on the VDM screen whenever it is given. The user should respond with a value between 1 and 9 indicating the display speed desired. A value of 1 represents approximately 2000 lines per second while 9 is rather slow at 3 characters per second.

The speed may also be changed any time during output by pressing the corresponding key between 1 and 9. The display can also be stopped by depressing the "space bar". Once stopped, any character other than speed values or another space bar will continue the output at the same speed. The space bar will allow one character to be printed for each sequential space character received.

During all output operations with either the standard ALS-8 terminal driver, or with the VDM driver, a test for the ESC character is made. If received, all output will be discontinued and a return made to the SYSIO driver with a "READY" message.

When the built-in VDM driver is first activated, the screen must be cleared (CTL-Z) and the speed set (CTL-S) to initialize the VDM. For example:

```
     IODR /SYSIO/   0   FE77
          X                   Type anything to switch drivers and
                              it will display: "What?"
       Control-Z              Clear the screen
       Control-S              and set the speed.
```

APPENDIX A - STANDARD SYSTEM NOTES

1. System Entry Points

There are three primary entry points into the ALS-8 system. The first is used to perform system initialization such as when the system is first powered on, or when the ALS-8 is first loaded. The second entry point is used to only partially reset the system while keeping some of the internal tables intact for later use. The third entry point is used to return control to the ALS-8 monitor. The entry points are:

Address (hex)	Use
E024	This is the entry point which will completely initialize the ALS-8 system. The various tables and data within the system RAM area will be initialized.
E000	This entry point will perform a partial system reset initializing only the system standard I/O drivers in the system RAM area.
E060	This entry point is used to return control to the ALS-8. This entry point requires a valid stack pointer but will set the stack pointer after use.

2. Standard System I/O Drivers

The ALS-8 makes use of a SYSTEM driver pair known as "SYSIO". This driver pair is composed of an Input driver and an Output driver. When the ALS-8 is initialized, these drivers, the name "SYSIO", and their addresses are moved from the ALS-8 to the system RAM area. Changes may be made to these drivers, or other drivers may be addressed to support non-standard devices.

The addresses of the SYSIO drivers at initialization are at four locations, two each for Input and Output. The first location is the address of the current I/O driver and the second is the address of the drivers associated with the named driver pair "SYSIO". Each address occupies two bytes, with the low order byte of the address followed by the high order byte.

Current Input Driver	D0CD (addresses are in hex)
SYSIO Input Driver	D094
Current Output Driver	D0D0
SYSIO Output Driver	D096

The standard system Input driver is located at D098, and the Output driver is located at D0A9. A special input status routine must also be available at location D0A4 and must pass back a ZERO flag only when no character is waiting to be input. The standard system I/O drivers are restored from the ALS-8 to the system RAM area whenever the system is reset or initialized (entry points E024 or E000). The following is an assembly listing of the standard system I/O drivers to be used as an aid both in understanding how the drivers work and how to write other drivers.

```
D098                   *
D098                   *
D098                   *                  ALS-8 SYSTEM I/0 DRIVERS
D098                   *
D098                   *
D098                   *
D098                   *     INPUT DRIVER
D098                   *
D098 CD A4 D0          INP8   CALL   STAT   GETSTATUS
D09B CA 98 D0                 JZ     INP8   LOOP UNTIL AVAILABLE
D09E                   *
D09E DB 01                    IN     UDATA  GET DATA FROM INPUT PORT
D0A0 E6 7F                    ANI    127    STRIP OFF PARITY
D0A2 47                       MOV    B,A    PUT COPY IN ALTERNATE REGISTER
D0A3 C9                       RET
DOA4                   *
D0A4 DB 00             STAT   IN     USTA
D0A6 E6 40                    ANI    DAV    TEST FOR DATA AVAILABLE
D0A8 C9                       RET
D0A9                   *
D0A9                   *     OUTPUT DRIVER
D0A9                   *
D0A9 CD A4 D0          OUTP8  CALL   STAT   GET INPUT STATUS
D0AC CA B8 DO                 JZ     NOCHR  JUMP IF NO INPUT HAS BEEN RECEIVED
D0AF DB 01                    IN     UDATA  GET CHARACTER
D0B1 E6 7F                    ANI    127
D0B3 FE 1B                    CPI    ESC    IS IT AN ESCAPE?
D0B5 CA 60 E0                 JZ     EORMS  IF SO CHANGE DRIVER AND OUTPUT "READY"
D0B8 DB 00             NOCHR  IN     USTA
D0BA E6 80                    ANI    TBE    IS PORT READY FOR OUTPUT?
D0BC CA B8 DO                 JZ     NOCHR
D0BF 78                       MOV    A,B    GET CHARACTER FOR OUTPUT
D0C0 D3 01                    OUT    UDATA
D0C2 C9                       RET
D0C3                   *
D0C3                   UDATA  EQU    1      DATA PORT NUMBER
D0C3                   USTA   EQU    0      STATUS PORT NUMBER
D0C3                   DAV    EQU    40H    DATA AVAILABLE EST BIT
D0C3                   TBE    EQU    80H    TRANSMITTER BUFFER EMPTY AT BIT 7
D0C3                   ESC    EQU    1BH    ESCAPE CHARACTER
DOC3                   *
D0C3                   *

DAV     0040     ESC     001B     INP8    D098     NOCHR   D0B8
OUTP8   D0A9     STAT    D0A4     TBE     0080     UDATA   0001
USTA    0000
```

3. System Return Points

The ALS-8 transfers control to a routine with a standard CALL instruction for either the EXEC command or a custom command. The CALL'd routine may use the stack, and (if used properly) may return to the ALS-8 via a standard RET instruction. The ALS-8 stack provides for 16 levels of stacking.

When a routine is CALL'd, two parameters are communicated between the routine and the ALS-8. These parameters, known as SWCH1 and SWCH3, are used to decide if the "READY" message is to be displayed and if the I/O drivers are to be automatically switched back to the SYSIO driver pair.

When SWCH1 is not zero on returning to the ALS-8, the "READY" message will be displayed and the SYSIO driver pair will be selected. Only when SWCH1 is zero is SWCH2 considered. When SWCH2 is not zero (and SWCH 1 is zero) no message will be displayed, and the I/O drivers will remain as they were. When SWCH2 is zero (and so is SWCH1) the SYSIO I/O drivers will be selected and a CRLF will be issued. SWCH1 is located at D0FD and SWCH2 is located at D0FE. These two parameters afford control over I/O driver selection.

There are five standard return points back into the ALS-8 when a standard RET instruction is not used. These various return points may be used as an alternate method of returning to the ALS-8, but the stack must be usable.

Name	Address	Function
EORMS	E060	This is the normal return point. The SYSIO drivers will be selected, then the message "READY" will be displayed.
FOR	E0B7	The ALS-8 will perform all the SWCH1 and SWCH2 tests as if a standard RET instruction had been issued.
EORNS	E0D1	The current driver will remain in control, and only a CRLF will be issued.
WHAT	E7DD	The SYSIO driver will be selected, then the message "WHAT?" will be displayed.
MESS	E7E0	The SYSIO driver will be selected, then the message as pointed to by the HL register pair will be displayed. This message must terminate with a CR (0D hex).

APPENDIX B - ASSI, Assembly from Input Driver

The ASSI command allows an assembly to be performed by reading the source data from a user-supplied Input driver rather than from the current source file in memory. A typical example of this application is when it is necessary to assemble a program from cassette tape which would otherwise not fit within the existing memory.

The ASSI command uses the current input driver to retrieve the source data. Instead of inputting one byte at a time as would a standard input driver, the input driver for the ASSI command inputs one entire source line each time the driver is called. For this reason, an ASSI input driver probably would not function for any other purpose.

Each time the input driver is called it must pass one entire line into memory beginning at location D1E4 (hex). If line numbers are to be passed as well, the ASCII characters for the numbers should be placed into memory beginning at location D1DF (hex) for four bytes. A line begins at location D1E4 (this is known as "IBUF") and terminates with a CR (0D hex).

The assembler requires two passes of the source file in order to complete an assembly. Therefore, the Input driver must make some provision both for detecting the end of the first pass as well as for rewinding the source data so that the entire source data may be passed to the assembler a second time. When the end of the source is detected, the input driver must pass a line containing " END" to the assembler so that the assembler will know that the end of a pass has been reached.

APPENDIX C - ALS-8 on Cassette and with SOLOS/CUTER

ALS-8 is distributed on various media, including CUTS format cassette. This cassette consists of one file which loads into memory beginning at location DF80 through the end of the ALS-8 (nearly FFFF, the end of memory address space). Although the ALS-8 program actually begins at E000, a short program resides in front of the ALS-8 which establishes the necessary linkages with either SOLOS or CUTER. This program resides at the very end of the ALS-8 system RAM area and also contains special I/O drivers which provide compatible operation with either SOLOS, CUTER or other compatible surrogate.

When the ALS-8 cassette is first loaded and executed at location DF80, the I/O drivers will be properly altered so that the standard SYSIO I/O drivers will function properly with SOLOS/CUTER, a "STAB D700" will be simulated, and the begin address of the SOLOS/CUTER jump table will be used to simulate an "ESET" command. An assembly listing of this initialization program follows. The SYSIO I/O drivers will be altered within the ALS-8 itself, so that whenever the ALS-8 is later reset (via entry at either E024 or E000) the updated SYSIO drivers compatible with SOLOS/CUTER will be moved into the system RAM area.

The ALS-8 cassette contains only one file called "ALS-8". To load and execute this file under either SOLOS or CUTER:

1. Be certain that 12K of RAM esists from D000 through FFFF.
2. Place the ALS-8 cassette into the cassette playback unit.
3. Enter "XEQ ALS-8" to either SOLOS or CUTER. The tape will now read in, and the ALS-8 initialization program will automatically be executed.
4. Once the initialization program completes, the ALS-8 will display the message "READY".

```
                    *  THIS PROGRAM IS LOADED AT THE VERY END OF THE
                    * ALS-8 D000 RAM AREA.  BECAUSE IT IS A PART OF THE
                    * ALS-8 FILE ON CASSETTE TAPE, IT PERFORMS PRIMARY
                    * INITIALIZATION OF THE ALS-8 FOR EITHER SOLOS OR
                    * CUTER.
                    *
                    *
     DF80           START  EQU    *      THE ALS-8 FILE BEGINS EXECUTION HERE
DF80 23                    INX    H      CHECK BYTE 1 OF SOLOS/CUTER JUMP TABLE
DF81 7E                    MOV    A,M    THIS MUST BE A 'JMP'
DF82 FE C3                 CPI    0C3H   IF NOT THEN THIS CANNOT BE SOLOS/CUTER
DF84 C2 24 ED              JNZ    ALS8   NO--USE NORMAL ALS8 I/O DRIVERS
DF87 2E 1F                 MVI    L,>SINP  NOW CHECK THE SINP ROUTINE
DF89 7E                    MOV    A,M    THIS MUST BE A 'LDA'
DF8A FE 3A                 CPI    3AH    IF NOT THEN THIS ISN'T SOLOS/CUTER EITHER
DF8C C2 24 E0              JNZ    ALS8   NO--STD I/0 DRIVERS THEN
DF8F 7C                    MOV    A,H    GET THE ADDRESS OF SOLOS/CUTER
DF90 32 DO DF              STA    XXINP+2  RELOCATE THE INPUT CALL W/IN STAT
DF93 32 FC DF              STA    XXOUT+2  AND THE OUTPUT CALL W/IN OUTP8
DF96 2E 00                 MVI    L,0    PREP TO GET SOLOS/CUTER MINUS ONE
DF98 2B                    DCX    H      NOW IS MINUS ONE
DF99 22 91 D1              SHLD   ESET   POST SOME VALUE FOR ESET
DF9C 21 E9 DF              LXI    H,RET  PT TO A RETURN INSTRUCTION
DF9F 22 A1 D1              SHLD   CTLU   ROUTINE FOR CTL-U DURING EDIT
DFA2 21 00 D7              LXI    H,0D700H  PICK A DUMMY STAR VALUE
DFA5 22 4F ED              SHLD   STAB   NOW ALS8 WILL GET INIT'ED TO A "SAFE" STAB
DFA8 21 D8 DF              LXI    H,INP8  GET THE ADDR OF THE INPUT ROUTINE
DRAB 22 DE E1              SHLD   PTRS   POST NEW ADDRESSES INTO ALS-8
DFAE 21 EA DF              LXI    H,OUTP8  ALSO THE OUTPUT ROUTINE ADDR
DFB1 22 E0 E1              SHLD   PTRS+2  AND POST IT TOO
DFB4 21 EE E1              LXI    H,MVTO  PT WHERE TO MOVE 2ND DATA
DFB7 11 C7 DF              LXI    D,MVFM  THE STAT ROUTINE IS MOVED
DFBA 06 11                 MVI    B,MVLEN  THIS IS THE NUMBER OF BYTES TO MOVE
     DFBC           LP1    EQU    $      LOOP TO MOVE THE ENTIRE STAT ROUTINE
DFBC 1A                    LDAX   D      GET ONE BYTE
DFBD 77                    MOV    M,A    MOVE IT
DFBE 23                    INX    H      NEXT
DFBF 13                    INX    D
DEC0 05                    DCR    B      DO IT PROPER NUMBER OF BYTES
DFC1 C2 BC DF              JNZ    LP1    MOVE ENTIRE ROUTINE
DFC4 C3 24 E0              JMP    ALS8   INITIALIZATION IS ALL DONE---START IT UP---
                    *
                    *
                    *
                    *
                    * THESE ARE THE I/0 DRIVERS THAT WILL MAKE THE ALS-8
                    * BE COMPATIBLE WITH SOLOS/CUTER/CONSOL.
                    *
                    *  THIS ROUTINE WILL BE THE STATUS ROUTINE
                    *  THIS IS PLACED INTO THE ALS-8 PROPER,
                    *  BUT IS FINALLY PLACID INTO SYSTEM RAM AT LOCATION
                    *  D0A4.
                    *
     D0A4           STAT   EQU    0D0A4H  THE STAT ROUTINE WILL BE HERE
                    *
     DFC7           MVFM   EQU    5      THIS CODE WILL BE MOVED FROM HERE
DFC7 3A FF DF              LDA   CHAR    SEE IF STATUS ALREADY GOTTEN
DFCA B7                    ORA    A      IS THE STATUS ALREADY THERE
DFCB C2 B2 DO              JNZ    STAT2-MVFM+STAT  YES--SAY SO AGAIN AND AGAIN AND AGAIN
DFCE CD 1F CO       XXINP  CALL   SINP   GET STATUS AND/OR CHAR
DFD1 C8                    RZ     .      NO CHAR AVAILABLE
DFD2 32 FF DF              STA    CHAR   POST THIS CHAR IS WAITING
     DFD5           STAT2  EQU    $      CHAR ALREADY WAITING
DFD5 3E 40                 MVI    A,40H  PASS BACK SOME NON-ZERO CHAR
DFD7 C9                    RET    .      AND STATUS IS NOW COMPLETE
     0011           MVLEN  EQU    S-MVFM  THIS IS THE LENGTH OF THE CODE TO MOVE
                    *
                    *
                    *
```

```
                      0700 *  THESE ROUTINES EXIST AT THE TOP OF THE
                      0710 *  0000 4K BLOCK OF MEMORY.
                      0720 *
                      0730 *
DFD8                  0740 INP8   EQU    $      INPUT ROUTINE
DFD8 CD A4 DO         0750        CALL   STAT   GET STATUS
DFDB CA D8 DF         0760        JZ     INP8   WAIT FOR A KEY
DFDE 3A FF DF         0770        LDA    CHAR   WHEN KEY IS HIT, IT WILL RE HERE
DFE1 E6 7F            0780        ANI    7FH    CLEAR HI BIT IN CASE
DFE3 47               0790        MOV    B,A    PASS CHAR BACK IN REG B
DFE4 AF               0800        XRA    A      BUT WE ALSO HAVE TO CLEAR CHAR WAITING
DFE5 32 FF DF         0810        STA    CHAR   NO CHAR IS WAITING NOW
DFE8 78               0820        MOV    A,B    ALSO PASS RACK CHAR IN REG A
DFE9 C9               0830 RET    RET    .      CHAR IN A AND B (ALSO USED FOR JUST A 'RET')
                      0840 *
                      0850 *
                      0860 *
     DFEA             0870 OUTP8  EQU    $      CHARACTER OUTPUT ROUTINE
DFEA CD A4 DO         0880        CALL   STAT   IS THERE BY CHANCE A CHAR WAITING
DEED CA FA DF         0890        JZ     NOCHR  NO--THEN JUST DO AN OUTPUT
DFF0 C5               0900        PUSH   B      SAVE CHAR TO BE OUTPUT
DFF1 CD D8 DF         0910        CALL   INP8   GET THE CHAR THAT IS THERE
DFF4 FE 1B            0920        CPI    1BH    IS IT AN ESCAPE?
DFF6 C1               0930        POP    B      RESTORE CHAR TO BE OUTPUT 1ST
DFF7 CA 60 E0         0940        JZ     EORMS  YES--THEN ABORT AND SAY READY
     DFFA             0950 NOCHR  EQU    $      NOW WE CAN OUTPUT CHAR IN REG B
DFFA CD 19 CO         0960 XXOUT  CALL   SOUT   OUTPUT THE CHAR
DFFD 78               0970        MOV    A,B    AND RETURN SAME CHAR IN REG A ALSO
DFFE C9               0980        RET    .      CHAR IS OUT NOW
                      0990 *
                      1000 *
DFFF 00               1010 CHAR   DB     0      0=NO CHAR IS WAITING, ELSE IT IS THE CHAR
                      1020 ********* END OF PROGRAM ************
                      1030 *
                      1040 *
     CO1F             1050 SINP   EQU    OC01FH  SOLOS STANDARD INPUT ROUTINE
     C019             1060 SOUT   EQU    0C019H  SOLOS STANDARD OUTPUT ROUTINE
                      1070 *
     E024             1080 ALS8   EQU    0E024H  ALS-8 INITIAL ENTRY POINT
     E060             1090 EORMS  EQU    0E060H  ALS8 RETURN IF ESCAPE IS HIT
     E04F             1100 STAB   EQU    OE04FH  THE STAB GETS INIT'ED HERE
     D191             1110 ESET   EQU    OD191H  ESET VALUE STORED HERE
     D1A1             1120 CTLU   EQU    0D1A1H  CTL-U DURING EDIT ROUTINE ADDR HERE
     E1DE             1130 PTRS   EQU    0E1DEH  PTRS TO INP8 AND OUTP8 W/IN ALS8
     E1EE             1140 MVTO   EQU    0E1EEH  THE STAT ROUTINE W/IN THE ALS8
                      1150 *
                      1160 *
                      1170 *

ALS8    E024     0120 0160 0410
CHAR    DFFF     0570 0620 0770 0810
CTLU    D1A1     0240
EORMS   E060     0940
ESET    D191     0220
INP8    DFD8     0270 0760 0910
LP1     DFBC     0400
MVFM    DFC7     0320 0590 0660
MVLEN   0011     0330
MVTO    E1EE     0310
NOCHR   DFFA     0890
OUTP8   DFEA     0290
PTRS    E1DE     0280 0300
RET     DFE9     0230
SINP    CO1F     0130 0600
SOUT    C019     0960
STAB    E04F     0260
START   DF80
STAT    D0A4     0590 0750 0880
STAT2   DFD5     0590
XXINP   DFCE     0180
XXOUT   DFFA     0190
```

Appendix D

SOLOS/CUTER Interface Specifications

The SOLOS/CUTER interface is based on:

1. A predefined set of 'pseudo' I/O ports allowing software compatibility and providing an easy means of supporting any I/O device.
2. A well defined set of register usage conventions.
3. A system jump table of entry points.
4. A defined tape format including headers and CRC characters.

Both SOLOS and CUTER observe and support these specifications such that any program written using this interface will function (except for specific device dependencies) under the control of either SOLOS or CUTER. A part of the interface specifications also allows a user written SOLOS/CUTER surrogate. Such a surrogate, when properly written, will allow a program written for SOLOS/CUTER to function with the surrogate.

The first aspect of the interface is that of the pseudo ports. The basic SOLOS/CUTER interface allows the support of four 'pseudo' I/O ports (0 - 3). These pseudo ports are logical ports providing a reference for the program only. System input (keyboard) and output (display) are directed via these pseudo ports. The STANDARD definition for pseudo ports is:

Pseudo Port	Input	Output
0	Keyboard	VDM Display
1	Serial input	Serial output
2	Parallel input	Parallel output
3	User defined input	User defined output

These pseudo ports allow device independent I/O. Provided that device dependent character sequences are not used, an I/O request to pseudo port 0 appears to the requesting program to be the same as a request to pseudo port 1, 2 or 3. what this means is that, although four pseudo ports are defined in the interface specifications, a user written surrogate would not need to decode pseudo ports.

The second aspect of the SOLOS/CUTER interface is the defined register usage. Each of the system entry points has specific register requirements which will be discussed later.

Whenever a program is executed via SOLOS/CUTER the stack pointer, the stack, and registers HL are defined as follows:

1. The Stack Pointer (register SP) is valid and offers a useable stack. The size of this stack is not specified but should be adequate for at least a few calls. The executed program is expected to establish its own stack; however, some stack should be available.
2. The stack itself should be established such that:
   - (a) A "REV instruction can be used as an exit by the executing program.
   - (b) The locations at Stack Pointer -1 and -2 in memory contain the address of the executed program itself. This information can be accessed by machine code similar to:

```
LXI  H,-1   A constant minus one.
DAD  SP     HL=SP-1 now.
MOV  A,M    A=our own high address.
```

   Code such as this can be used to allow a routine to be made self-relocating to a 256 byte boundary.
3. Registers HL contain the address of the SOLOS/CUTER jump table. Because this jump table may be located at any 256 byte boundary in memory, register L will be zero. Register H can then be used to alter the executing program accordingly. As noted later, the jump table also provides an indication whether the program is executing on a Sol or other computer.

The third aspect of the SOLOS/CUTER interface is the jump table. By making all system requests via this jump table, an executed program can be made compatible between SOLOS, CUTER or other properly written surrogate. The jump table is described on the following page. A more complete description is contained in the SOLOS/CUTER User's Manual.

SOLOS/CUTER JUMP TABLE

Address	Label	Length	Brief Description
xx00	START	1	This byte allows power-on reset for SOLOS. It is 00 hex on a Sol; 7F hex on other than a Sol.
xx01	INIT	3	This is a "JMP" to the power-on reset.
xx04	RETRN	3	Enter at this point to return control from an executing program.
xx07	FOPEN	3	Byte access file open.
XX0A	FCLOS	3	Byte access file close.
xx0D	RDBYT	3	Byte access read one byte.
xx10	WRBYT	3	Byte access write one byte.
xx13	RDBLK	3	Read an entire file into memory.
xx16	WRBLK	3	Write an entire file from memory.
XX19	SOUT	3	Standard character output routine. This must be an "LDA" pointing to the byte containing the current system output pseudo port value.
xx1C	ROUT	3	Character output to pseudo port specified in register "A".
xx1F	SINP	3	Standard character input routine. This must be an "LDA" pointing to the byte containing the current system input pseudo port value.
xx22	AINP	3	Character input to pseudo port specified in register "A".

The most often used routines are: RETRN, SOUT and SINP. Other entry points may or may not be used.

JUMP TABLE INPUT ENTRY POINTS

SINP   address xx1F

This entry point will set register "A" to the current system input pseudo port. This must be an "LDA" instruction. After loading register "A", this entry point proceeds by executing "AINP" described below.

AINP   address xx22

This entry point is used to input one character or status information from any pseudo port. On entry, register "A" indicates the desired pseudo port. Because this entry point is a combination status/get-character routine, it is the user's responsibility to interpret return flags properly. When a character is _not_ available, the zero flag will be _set_. When a character _is_ available, the zero flag will be _reset_ and the character will be returned in the "A" register. As an example, the following code will wait for a character to be entered:

```
LOOP CALL  SINP   get status or the character
     JZ    LOOP   status says character not
                  available yet
     ...   ...    character is in register "A"
```

JUMP TABLE OUTPUT ENTRY POINTS

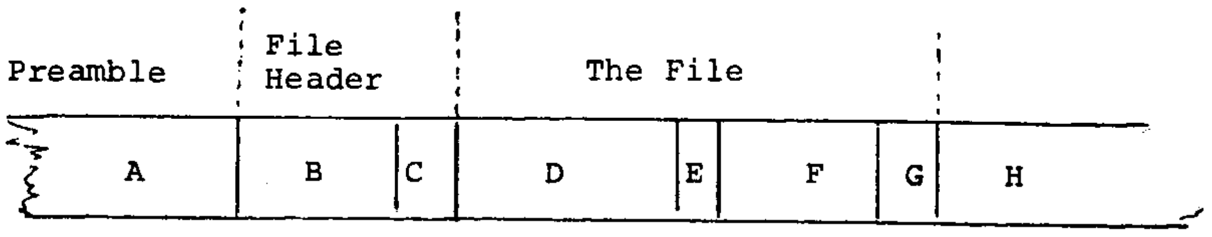
SOUT   address xx19

This entry point will set register "A" to the current system output pseudo port. This must be an "LDA" instruction. After loading register "A", this entry point proceeds by executing "AOUT" described below.

AOUT   address xx1C

This entry point is used to output the character in the "B" register to the pseudo port specified by the value in the "A" register. On return, the PSW and register "A" are undefined. All other registers are as they were on entry. A user written output routine (AOUT surrogate) may buffer or delay the output as required for the supported device.

The fourth aspect of the SOLOS/CUTER interface is the format in which the data is recorded on tape. When data is written to tape, it is referred to logically as a "file". Each file has its own header which describes the file. On cassette tape, each header is followed by the file itself. The file itself is written to tape in segments of 1 to 256 bytes. Each segment is immediately followed by a Cyclic Redundancy Check character (the CRC). The following is the general format of one file on cassette tape:



Where:

A. Preamble

Preceding every file header is a special preamble. This is a series of at least ten nulls (zeroes) followed by a one (01 hex). This special sequence, and only this sequence, indicates a probable file header follows.

B. File Header

This is the 16 byte file header. The layout of a file header is:

```
NAME  ASC  'ABCDE'  A 5 character file name.
      DB   0        Should always be zero.
TYPE  DB   'B'+80H  File type character.  If bit
                     7=1, this is a non-executable
                     data file.
SIZE  DW   LENGTH   Number of bytes in file.
ADDR  DW   FROM     Address file is to be read into
                    or written from.
XEQ   DW   EXEC     Execution beginning address.
      DS   3        Space not currently used.
```

C. File Header CRC

This is the CRC character for the file header. If, when reading a file header, the CRC character is not correct, then the file header is to be ignored. A search would then be made for a new preamble (A above).

D. File Segment First

This is the first segment of the file itself. A segment is from 1 to 256 bytes. In this example, this segment is 256 bytes.

E. File Segment One CRC

This is the CRC character for the preceding segment--in this example, the preceding 256 bytes.

F. File Segment Last

This is the last segment of the file. In this example, this is 44 bytes. Therefore, the length of this file is 256+44=300 bytes.

G. File Segment Last CRC

This is the CRC character for the preceding segment--in this example, the preceding 44 bytes.

H. Interfile GAP

This is a gap between files and is typically a clear carrier for about five seconds.

CRC Computation

The CRC character is computed for each segment or header. The following code performs the CRC computation assuming: Register "A" is the character just written to tape, and Register "C" is the final CRC. Register C should be set to zero prior to writing the first character of a segment. After writing the last character of a segment and executing this code, Register "C" is the CRC character for this segment.

An 8080 Subroutine to do CRC Computation

```
DOCRC  EQU  $    A=NEXT character and C=CRC
       SUB  C
       MOV  C,A
       XRA  C
       CMA
       SUB  C
       MOV  C,A
       RET
```