SOFTWARE REFERENCE MANUAL

H8 COMPUTER

FRONT PANEL MONITOR PAM-8

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INTRODUCTION

This Manual describes the functions and operations of the Heath H8 Panel Monitor Program, PAM-8, which resides permanently in a ROM on the H8 CPU board. PAM-8 provides a sophisticated front panel display and keyboard emulation as well as handling master clear and interrupt operations. Some of the major features of PAM-8 are:

- Memory contents display and alteration.
- Register contents display and alteration.
- Program execution control (both breakpoint and single instruction operation).
- Self-contained bootstraps for program loading and dumping.
- Port input and output routines.

In addition to the above features, PAM-8 can be instructed (by means of a flag byte contained in H8 RAM) to bypass some or all of its normal functions so the sophisticated user can augment or totally replace them.

Communication with the Panel Monitor is accomplished through three devices: the keypad, the 7-segment displays, and the audio alert. The user enters commands and values through the 16-key keypad, and PAM-8 responds visually through the front panel displays. In addition to the front panel displays, PAM-8 provides the keypad entry and function feedback to the built-in speaker. Appropriate signals (short, medium, and long beeps) indicate that commands and data are accepted or rejected.

THEORY OF OPERATION

This section will supplement the information contained in the "Operation" and "Circuit Description" sections of your H8 Operation Manual. In order to fully understand how PAM-8 operates, you must be familiar with the H8 front panel and CPU. A thorough knowledge of the 8080 instruction set and its architecture is also essential.

Power Up and Master Clear

PAM-8 initializes the H8 whenever you power-up or master clear (RST). You initiate the power-up operation by turning on the rear panel Power switch. You can master clear by simultaneously depressing both the lower right-hand (RSTØ) and lower left-hand (Ø) keys of the H8 front panel keypad. Both power-up and RST cause a level zero (highest priority) interrupt and result in a long beep from the audio alert.

During initialization, PAM-8 enters a routine which determines the high limit of continuous RAM. Once the high limit of available RAM is determined, the H8 stack pointer (SP) is set to this value and control is passed to the front panel command loop. Using this feature, you can immediately determine the total amount of continuous memory above 8K by displaying stack pointer value.

Clock Interrupts

The Clock Interrupt is a crucial element in the operation of the H8 front panel system. This level one interrupt is generated by the front panel hardware every 2,000 μS. PAM-8 uses this interrupt to check for some keyboard commands, to check for user program breakpoints, and to refresh the front panel displays.

PAM-8 performs these functions using a series of subroutines which are executed as necessary when indicated by the interrupts. For this reason, all user programs must maintain a valid stack (at high memory) containing at least 80 free bytes at all times. If this stack space is not available and PAM-8 is running (it can be disabled; see the Advanced Control Section), unpredictable software damage can occur in your program. In the same manner, if your program should execute a DI (Disable Interrupt) instruction, no front panel services including the RTM (Return To Monitor) function are available until an EI (Enable Interrupt) instruction is executed or until a master clear (RST/Ø) is performed.

PAM-8 Modes/Using RST and RTM

PAM-8 is always in either the monitor mode or the user mode. In the monitor mode no user program is executing, PAM-8 loops reading the keypad and refreshing the displays. All commands entered via the keypad are valid; however, the RTM command is meaningless.

When your program is being executed, PAM-8 is in the user mode and the MON LED on the front panel is extinguished. Only two keyboard commands are valid in this mode: RST (master clear) and RTM (Return To Monitor). NOTE: Both of these commands are dual key commands. No single key command is recognized, so a user program may have free use of the entire keypad.

You can return PAM-8 to the monitor mode by using the RTM command (simultaneously press the Ø and the # keys). This command stops program execution at the end of the current instruction, stores the current value of each register, and returns PAM-8 to the monitor mode. You can then continue your program by pressing the GO key. The RST command (simultaneously press the 0 and the / keys) performs the master clear operation described earlier and does not save any register values.

Normally, when a user program is running, PAM-8 is also running. Thus, if PAM-8 is displaying the contents of the HL register pair and the user program is started, it continues to display the contents of this register pair as the program is run. If the user program changes the contents of the HL pair, the change is immediately reflected in the front panel displays. In a similar manner, if a memory location is displayed when a user program is started, it is displayed during the time the user program is run. If the user program changes the contents of the displayed memory location, the front panel display changes.

Since PAM-8 does not recognize keypad commands in the user mode, the RTM command must be used before the memory location or register being displayed is changed to a new location or a different register. Once you select the new location or different register, you can resume program execution by pressing GO.

NOTE: PAM-8 requires about 10% of the H8 CPU's resources to process the display interrupts. Programs which are compute-bound may be slowed down by simultaneous operation of PAM-8. In this situation, you may wish to turn off the clock interrupts to improve execution time. See "Using Interrupts" on Page 1-24.

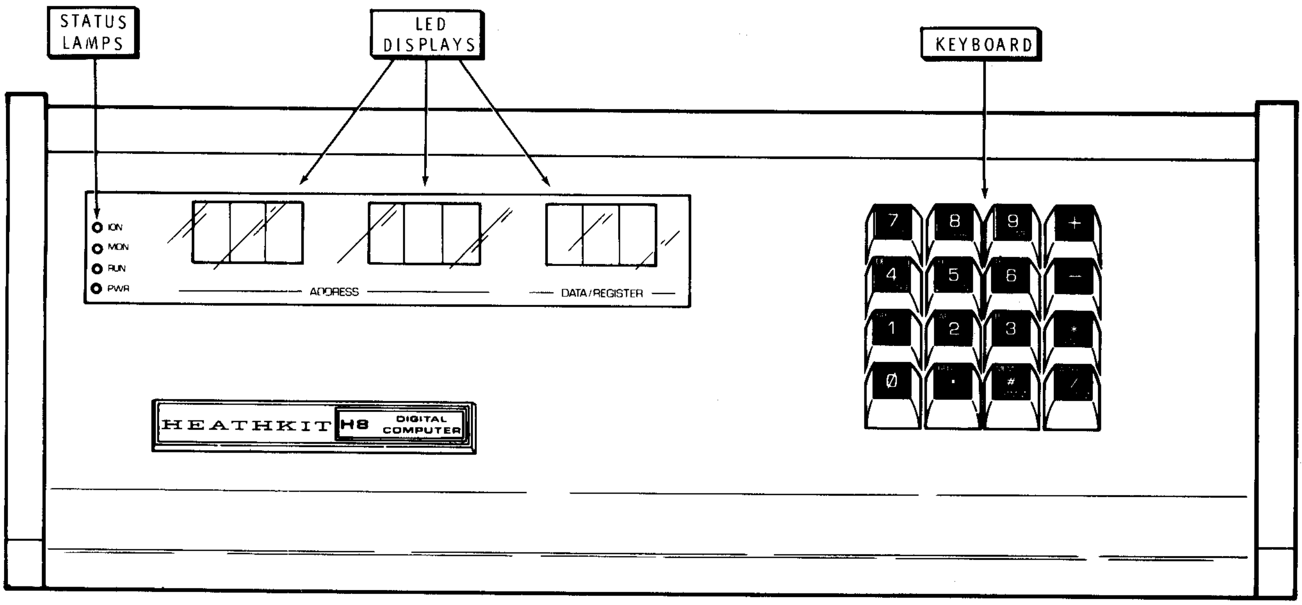


Figure 1-1

H8 Displays

You must understand the H8 front panel presentation in order to use PAM-8. The display is made up of 9 digits, in three groups of three digits each. See Figure 1-1. Each group of three digits displays one byte (eight bits) of information. This information may be the contents of a designated register or memory location, or it may be the address of a memory location itself. The register names are also displayed.

All binary numbers are converted to octal format for display on the H8 front panel. The following table shows binary to octal conversion.

BINARY NUMBER	OCTAL NUMBER
000	0
001	1
010	2
011	3
100	4
101	5
110	6
111	7

Each byte is displayed as two-and-one-half octal digits. The octal numbers lie in the range of 000 to 377 for binary numbers in the range 00000000 to 11111111, as shown below.

```
00   000   000
|     |     |
|     |     └── Least significant octal digit (0-7),
|     └──────── Middle octal digit (0-7).
└────────────── Most significant octal digit (0-3).
```

NOTE: As there are only eight bits in a byte, the most significant octal digit only represents two bits and is therefore displayed as 0 to 3. If the user should inadvertently enter the octal digits 4 to 7 into the most significant digit, the most significant bit is lost. Losing this bit converts 4 through 7 into the digits 0 through 3 respectively.

Also note that 16-bit numbers, such as memory addresses and certain register contents, are still displayed as two eight-bit numbers. Therefore, the H8 front panel representation of the number is made up of **two** groups of three octal numbers in the range of 000 to 377. This representation of 16-bit binary numbers is known as **offset octal**, and is used consistantly throughout all H8 displays of 16-bit numbers. Offset octal must not be confused with octal. For example:

```
11 111 111  11 111 111     A 16-bit binary number
 |   |   |   |   |   |
 3   7   7   3   7   7     Offset octal representation (377   377)

1 111 111 111 111 111      A 16-bit binary number
|   |   |   |   |   |
1   7   7   7   7   7      True Octal representation (177777)
```

The lower example shows true octal representation of a 16-bit binary number. This is **not** used by the H8 front panel displays or any H8 software. Occasionally you will see offset octal numbers printed with a decimal point separating the upper and lower bytes. For example:

```
    377.377
Hi Byte   Lo Byte
```

H8 Keypad

The H8 Keypad consists of 16 keys, as shown in Figure 1-1. When the keypad is operating under the control of PAM-8, it exhibits a number of unique properties.

- Each keystroke is verified by a short beep from the audio alert.
- Octal digits are entered using the keys 0 through 7.
- Holding a key down continuously repeats the key's function.
- The + key increments memory port or register locations.
- The – key decrements memory port or register locations.
- The * key cancels previous keypad entries.
- The ALTER key causes PAM-8 to enter the alter mode.
- The MEM key causes PAM-8 to enter the display memory mode.
- The REG key causes PAM-8 to enter the register mode.

Many of the keys on the keypad have multiple functions, depending on the PAM-8 mode being used. In the register mode, for example, the numeric keys (1-6) call the register indicated in the upper left-hand corner of the key. When the PAM-8 is in neither the register nor the memory mode, the keys perform the functions indicated in the lower right-hand corner of the key.

The # and / keys have additional special functions, as indicated earlier. When the / key is pressed simultaneously with the 0 key, the RST (master clear) sequence is initiated. When the # sign key is depressed simultaneously with the 0 key, the RTM (Return To Monitor) function is initiated, the user program is stopped, and PAM-8 regains control.

Each key is covered in greater detail as the various function are discussed.

DISPLAYING AND ALTERING MEMORY LOCATIONS

One of the major features of PAM-8 is its ability to examine the contents of any H8 memory location and to modify the contents of that memory location if it is RAM.

When the H8 is first powered up, PAM-8 is in the display memory mode. This mode is indicated by all digits displaying octal numbers and no decimal points being on.

Specifying a Memory Address

If you wish to display or alter the contents of a memory location. You must first place PAM-8 in the memory address mode and then enter the desired memory address. Place PAM-8 in the memory address mode (if not already there) by pressing the MEM (Memory) key. Specify the address to be displayed or altered by entering the 6-digit address (offset octal).

When you press the MEM key, all the decimal points will light. This indicates that the address may now be entered. Once the full 6-digit address is entered, the decimal points turn off, indicating that address entry is completed. After all 6 digits are entered, the address is displayed in the left-most six displays, and the contents of the addressed memory location are displayed in the right-hand 3 digits.

NOTE: As you press each key, including the MEM key, a short beep indicates successful entry. As each group of three octal digits is successfully entered, a medium beep is sounded. The sequence by which you specify a memory address is shown in Figure 1-2.

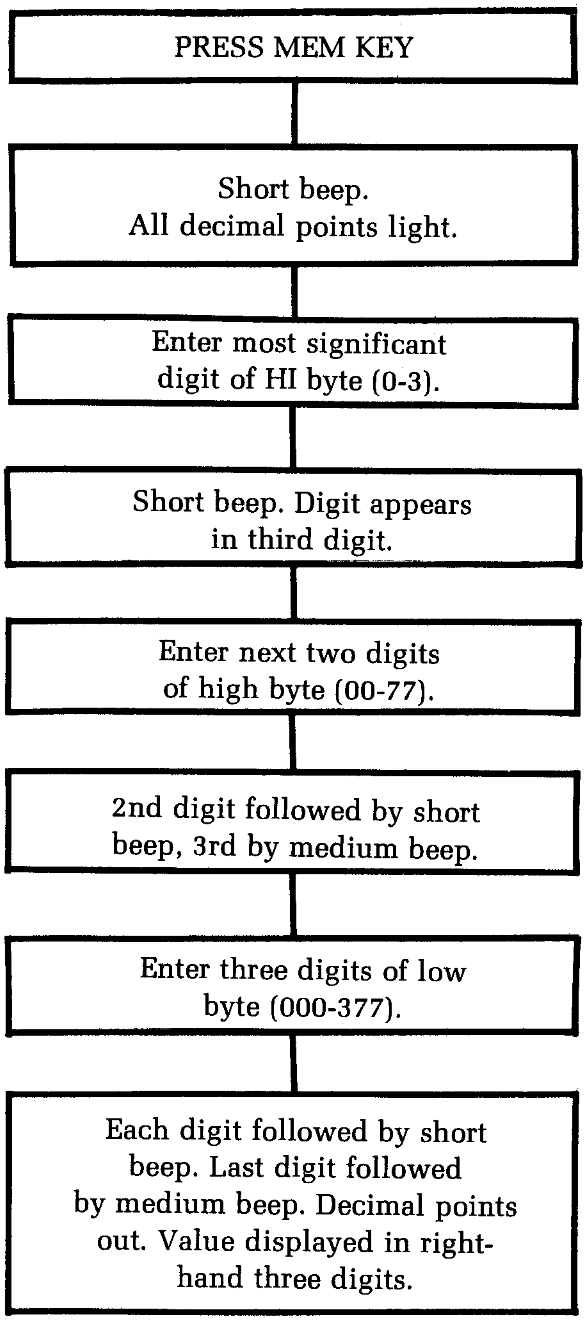


Figure 1-2
Entering a memory address through PAM-8.

NOTE: If you press a non-octal digit key as one of the six address digits, an error is flagged (a long beep). Once this error is flagged, the PAM-8 considers the address complete and extinguishes the decimal points. The entire sequence must be repeated.

Altering a Memory Location

Before you can alter a memory location, you must first display the contents of the memory location by specifying the memory address as described in the preceding paragraphs. After you specify the memory address, press the ALTER key. This will cause PAM-8 to enter the memory alter mode.

When PAM-8 enters the memory alter mode, a single decimal point rotates from right to left through all 9 digits. You can now alter the contents of the displayed location by entering the new octal value (three digits on the keypad). When the three digits have been entered, acoustical verification (a short beep) is given **and the memory address is incremented.** You can then alter this new location by entering three more digits or pressing one of the following keys, causing the monitor to perform the indicated function:

KEY	FUNCTION
+	Increment the address.
–	Decrement the address.
MEM	Specify a new memory address (leave memory alter mode).
REG	Specify a register for display (leave memory alter mode).
ALTER	Exit from the alter mode (into the display mode).

NOTE: PAM-8 automatically increments the memory address as each entry (3 octal digits) is complete. Therefore, you may load a program in sequential locations very rapidly. Each location is modified by simply entering the three octal digits.

The following example reviews each step as the H8 is turned on; the memory address mode is entered; and the location 040 123 is addressed, altered to 345, checked, and closed.

DISPLAY			COMMENTS
X X X	X X X	X X X	Random memory display at power up (X=random number.)
X.X.X.	X.X.X.	X.X.X.	MEM key pressed. (In memory address mode, a short beep.)
X.X.0.	X.X.X.	X.X.X.	0 key pressed. (Short beep.)
X.0.4.	X.X.X.	X.X.X.	4 key pressed. (Short beep.)
0.4.0.	X.X.X.	X.X.X.	0 key pressed. (Medium beep.) Contents of location 040 XXX displayed.)
0.4.0.	X.X.1.	X.X.X.	1 key pressed. (Short beep. Contents of 040 XX1 displayed.)
0.4.0.	X.1.2.	X.X.X.	2 key pressed. (Short beep. Contents of 040 X12 displayed.)
0 4 0	1 2 3	X X X	3 key pressed. (Medium beep. Contents of desired location 040 123 displayed, decimal points out.)
0.4.0	1.2.3	X.X.X	ALTER key pressed. (Short beep. Decimal points **rotate**.)
0.4.0.	1.2.3.	X.X.3.	3 key pressed. (Short beep. Decimal points **rotate**.)
0.4.0.	1.2.3.	X.3.4.	4 key pressed. (Short beep. Decimal points **rotate**.)
0.4.0.	1.2.4.	X.X.X.	5 key pressed. (Medium beep. Address increments one location. Decimal points **rotate**.)
0.4.0	1.2.3	3.4.5	−key pressed. (Short beep. Address decrements one location. Decimal points **rotate**.)
0 4 0	1 2 3	3 4 5	ALTER key pressed. (Short beep. Decimal points go out.)

Stepping Through Memory

When PAM-8 is either in the display memory or alter memory modes, the +and −keys increment and decrement the memory address. Each time you press the key, PAM-8 increments (or decrements) the memory address one location. If you hold the key down, the auto-repeat function of PAM-8 causes the memory address to increment or decrement repeatedly (approximately one location every second).

DISPLAYING AND ALTERING REGISTERS

PAM-8 can display and alter the contents of the 8080 CPU registers, just as it displays and alters the contents of H8 memory locations. Although the process is quite similar, a few special features should be noted.

Specifying a Register for Display

Press the REG key to specify that a register is to be displayed. After you press the REG key, press a second key (SP through PC, see the Table below) to specify the desired register or register pair.

When the REG key is pressed, six decimal points light, indicating that you must now select a register. NOTE: Simply pressing the REG key causes a register name to appear in the right-hand digits. However, you must select a register using the Register Select key before a register is definitely selected and its true contents are displayed. Once a register is selected, the decimal points are extinguished.

The contents of the selected register pair are displayed in the six left-most displays. The register name (or names) are displayed in the two right-most digits of the right-hand three displays. The registers are selected and displayed in accordance with the following table:

KEY	LEFT 3 DIGITS	MIDDLE 3 DIGITS	RIGHT PAIR	COMMENTS
SP (1)	000 to 377	000 to 377	SP	Stack pointer
AF (2)	000 to 377	000 to 377	AF	AF Register pair
BC (3)	000 to 377	000 to 377	bC	BC Register pair
DE (4)	000 to 377	000 to 377	dE	DE Register pair
HL (5)	000 to 377	000 to 377	HL	HL Register pair
PC (6)	000 to 377	000 to 377	Pc	Program counter

NOTE: The contents of any single eight-bit register may lie in the range of 000 to 377 octal. The stack pointer (SP) and the program counter (PC) are 16-bit registers and are displayed as two sets of three octal numbers. Each 3-digit grouping corresponds to one byte (8 bit number). When a register pair is displayed, the left three digits correspond to the left register and the middle three digits correspond to the right register. For example:

256 312 AF

Register A contains 256 and F contains 312.

Altering the Contents of a Selected Register

To alter the contents of a register (or register pair), you must first specify it as described in the preceding paragraphs. After you select the register or register pair, press the ALTER key. This will cause the six left-hand decimal points to rotate right to left, indicating that you may enter 6 digits to alter the contents of the indicated register or register pair.

Alternatively, you may press one of the following command keys:

KEY	FUNCTION
+	Changes the register pair being displayed.
–	Changes the register pair being displayed.
MEM	Specify a new memory address (leave the alter register mode).
REG	Specify a new register for display (leave alter register mode).
ALTER	Exit the register alter mode.

NOTE: Stack pointer register (SP) is not a direct display of the real stack pointer register, but simply a copy of the real stack pointer register and is used for display purposes only. The stack pointer cannot be altered from the front panel. To alter the stack pointer register, an SPHL (SPHL = 371) instruction must be written into memory. The desired new stack pointer value is then placed in the HL register pair. PAM-8's single instruction mode is used to execute the SPHL swap instructions, loading the stack pointer with the contents loaded in the HL register pair.

Stepping Through the Registers

Use + and – keys to change the register pair being displayed. For example, if the DE register pair is being displayed, press the + key causes the next sequential register pair to be displayed (the HL pair). In the same manner, pressing the – key causes the register to decrement to the preceding pair. For example, if the DE pair is being displayed, pressing the – key displays the BC register pair. NOTE: Holding down either the + key or the – key causes the display to continuously increment or decrement through all the six registers/register pairs.

PROGRAM EXECUTION CONTROL

PAM-8 supports three basic program execution control facilities:

- Beginning or starting execution.
- Breakpointing.
- Single instruction.

Each of these execution controls permits the programmer to execute the desired portions of a program and examine its effects. He may execute the entire program, or a small group of instructions, or a single program instruction.

Initiating Program Execution

To begin the execution of a program residing in H8 memory, place the address of the first instruction to be executed in the PC (program counter). Use the methods described in "Displaying and Altering Registers" (Page 1-14). Once the address of this first instruction is placed in the program counter, press the GO key and program execution will begin. NOTE: Unless the program disables the front panel, the display continues to be actively updated, although the front panel commands are no longer active (except for RST and RTM). If the program counter is displayed when you press the GO key, PAM-8 continuously monitors the program counter.

Breakpointing

Breakpointing permits the programmer to execute small portions of a program and then return to PAM-8. Breakpointing is especially useful when a program is being "debugged." Small portions of the program may be executed and their results observed. If there is an error, it may be corrected before an entire program is involved.

When the H8 executes a program and encounters a halt instruction, it re-enters PAM-8 and sounds the alarm. All of the registers are preserved and the program counter points to the address **following** the address of the halt instruction. Thus, you can breakpoint a program from the front panel by inserting halt instructions (HLT = 166) at the desired points throughout the program. When a particular section of the program is tested and the breakpoint feature is no longer required, you can change the halt to a NOP (NOP = 000). Once the halts are changed to NOPs, execution of the NOP simply passes control to the next successive instruction. Program execution for breakpointing uses the GO key as described above.

NOTE: If you temporarily replace an existing instruction with a halt, you must restore the instruction before resuming program execution. The contents of the program counter point to the address **following** the halt. Therefore, if the instruction which replaced the halt is to be executed, when the program continues, the contents of the program counter must be decremented one location before execution is resumed.

Single Instruction Operation

Any user program may be operated in the single instruction mode. This procedure is identical to the GO command, except that the SI key is pressed rather than the GO key. When the SI key is pressed, a single **instruction** (not a single machine cycle) is executed and then control is returned to PAM-8. Single instruction operation is available for careful inspection of program results and for executing special programs, such as swapping the HL register pair with the stack pointer as discussed in "Altering the Contents of a Selected Register" (Page 1-15).

Interrupting a Program During Execution

You can interrupt a running program (with all registers preserved at the point of interruption) by pressing RTM & 0. You can then examine and/or alter the contents of various memory locations and all the registers as required. Resume execution of the program at the next sequential instruction by simply pressing the GO key. NOTE: Although all registers and memory locations are preserved when RTM & 0 are pressed, it is very difficult to stop a program at an exact location. Therefore, use the breakpoint feature if you want to stop the program at an exact location.

LOAD/DUMP ROUTINES

PAM-8 contains a routine that lets you load and dump memory contents from or to a tape. This feature is especially important, as most computers require one or two successive "boot strap" routines to be hand-loaded before a desired program can be loaded into the main memory. All these "boot strap" routines are contained within the PAM-8 ROM, and use sophisticated error checking techniques. Thus, a program can be loaded or dumped by simply pressing a single key.

Loading From Tape

To load from a tape, ready the reader device with the tape to be loaded prior to executing the load command. Place PAM-8 in the display memory mode and press the LOAD key. Once the LOAD key is pressed, PAM-8 starts the tape transport and scans the tape for the first file record.

No change will be seen on the front panel displays until PAM-8 finds the first file. When the first file record is located, PAM-8 checks it to see if it is the first (or only) record in a sequence, and the record is a memory dump record. If it is not a memory dump record, a number two error is flagged (see "Tape Errors" on Page 1-20).

Once a correct record is found, loading proceeds. The loading procedure places the entry point address of the program being loaded in the H8 program counter. The H8 memory is then loaded. The displays continuously show the address being loaded and the data being loaded at these addresses. When the load is complete, PAM-8 sounds a long beep and displays the final memory address. If the load is faulty, a number one error is displayed and the audio alert continuously beeps. (See "Tape Errors," Page 1-20.)

NOTE: You may abort a partial load by using the CANCEL key. Naturally, the load image resulting from this action is incorrect, and should not be executed.

Dumping to Tape

Before dumping a memory image onto tape, the following three dump parameters are required:

- The entry point address (the program starting address).
- The dump starting address.
- The dump ending address.

Set the desired entry point address by placing this value in the program counter (PC). This value will be placed in the program counter whenever you load the program so execution will begin at this address when you press the GO key.

Place the dump starting address into the first two H8 RAM cells. These are: 040 000 (offset octal) and 040 001 (offset octal). NOTE: The low order byte of the address should be placed into location 040 000 and the high order byte of the starting address should be placed into location 040 001.

Enter the dump ending address as a memory address using the # (MEM) key. Then ready the tape transport and press the DUMP key. As the tape dump takes place, the number of bytes left to be dumped and the contents of the memory location being dumped are displayed on the front panel. You can abort a dump by using the CANCEL key. If the CANCEL key is used, an incomplete dump image is left on the tape. This cannot be loaded at a future date. NOTE: A successful load automatically sets up the following three dump parameters:

A. The program starting locations are stored in locations 040 000 and 040 001.
B. The program ending location is displayed.
C. The program counter contains the program entry point.

Figure 1-3A shows the steps of a typical dump sequence and Figure 1-3B shows the steps of a typical load sequence.

1. Set PC to 040 100; (040 100 = entry address).
2. Set 040 000 to 100 (100 = low byte of dump start).
3. Set 040 001 to 040 (040 = high byte of dump start).
4. Enter memory address 052 340 (052 340 = end address of dump).
5. Be sure tape is ready.
6. Press DUMP.

Figure 1-3A
The H8 memory image dump.

1. Be sure tape is ready.
2. Press LOAD.

Figure 1-3B
The H8 memory image load.

Copying a Tape

The beginning and final address of the load image are placed at the appropriate points. Thus, to copy a tape, simply load the tape as described in "Loading From Tape" (Page 1-18). Then ready the dump tape drive and press the DUMP key. A dump then takes place, including entry point, initial address, and final address.

In a similar manner, to load, alter, and then dump, enter only the ending address. The other paramters are unchanged from the load if locations 040 000, 040 001 or the program counter have not been modified during the altering procedure.

Tape Errors

PAM-8 detects two types of tape errors: record errors and checksum errors. In either case, when an error is detected, the tape transport is halted. The error number is then displayed in the center three digits (001 for a checksum error, 002 for a record error) and the alarm is repeatedly sounded. To halt the alarm and return to the command mode, press the CANCEL key.

RECORD ERRORS

The following are typical causes of record errors.

- Attempting to load a file which is not a memory image. For example, loading an editor text file or a BASIC program file.
- Attempting to start a load in the middle of a load image. Therefore missing the initialization information at the start of the file.
- A tape error which causes a portion of the load image to be missed so the next record read is not in the proper sequence.

CHECKSUM ERRORS

A checksum error is flagged when the CRC (Cyclical Redundancy Check) checksum following a record does not match the CRC calculated by PAM-8. This error means that the record is either incorrectly recorded or the load is faulty. In either case, the load should be attempted again. If successive loads result in repeated failures, the original tape must be suspected as faulty.

I/O FACILITIES

PAM-8 supports two commands that allow you to perform input and output functions on H8 I/O ports. These front panel instructions permit simple manipulation of the H8 I/O ports without your having to write extensive routines to perform these functions.

Inputting From a Port

To input from a port, press the # key. Then enter three zero digits and the three-digit address (octal) of the desired port. NOTE: The front panel should now display 000 AAA, where AAA is the port address and 000 is meaningless. Press the IN key to read the port, the value is displayed in the three left-most digits of the front panel display.

Outputting to a Port

To output to a specified port, press the # key. Then enter the value to be supplied to the port in the three left-most displays. The port address is entered into the middle three displays. The display is of the form VVV AAA, where V stands for value, and A for address. Pressing the OUT key causes the value to be outputted to the indicated port.

Addressing Port Pairs

Frequently, ports are assigned in pairs, where one of the two port addresses is the control and status register and the other port is the data port. Address port pairs by using the + and – key to change ports. Once the initial port has been defined, the + key increments the port address to a new higher numbered port, and the – key is used to decrement to a lower numbered port.

ADVANCED CONTROL

One of the advanced features of PAM-8 is its provisions allowing sophisticated users to augment or replace PAM-8's functions. Augmenting or replacing PAM-8 functions is usually done in conjunction with assembly language programs. Sometimes it is possible to implement these features by using the POKE and PEEK commands in BASIC. The sample exercise in "Appendix B" (Page 1-64) uses several PAM-8 functions, including the clock, I/O, and the audio alarm.

The following discussion refers to symbols and locations defined in the PAM-8 program listing, given in its complete form as "Appendix A." It is recommended that you review the PAM-8 listing in order to become familiar with its various features. This can be done in conjunction with reading the following section, or independently. In either case, a first overview followed by a detailed analysis of the listing is probably necessary for a complete understanding.

16-Bit Tick Counter (TICCNT)

PAM-8 maintains a 16-bit (2 byte) tick counter known as TICCNT. The value of this counter is incremented each time a clock interrupt is processed. As an interrupt occurs once every 2 mS, the counter is incremented once every 2 mS. As long as clock interrupts are not disabled, this value can be used by any program to compute elapsed time. The tick counter may be set to any desired value, but it should not be frequently reset, as this interferes with the front panel refresh cycle. The contents of the tick counter are contained in memory locations 040 033 (the least significant byte) and 040 034 (the most significant byte).

Using the Keypad

When your program is running, PAM-8 does not recognize any single key command. Thus, all single key patterns are available for your program. To read keypad patterns, you can use one of two routines. First, you may take an input from port IP. PAD; or second, your program may use PAM-8's RCK routine. The input port IP. PAD is permanently assigned to port location 360. Inputting a binary number from this port detects which of the 16 keys are depressed. These results are shown in the table on Page 1-57 of "Appendix A."

A far more sophisticated keypad routine is available to you in the RCK (read Console Keypad) routine. This is also described in "Appendix A" (see Page 1-57). RCK provides keypad decoding, keypad debounce routines, auto-repeat routines, and acoustical feedback.

NOTE: If you use two key combinations, each key must reside in a separate bank. The first bank includes keys 0-7 and the second bank includes keys 8-#. RCK cannot decode two key combinations.

Display Usage

When a user program is running, PAM-8 normally displays the contents of the selected register or memory location. However, you may disable this process and display any arbitrary segment pattern, or completely disable the display to provide greater computational through-put. The display usage is primarily controlled by setting various bits in the .MFLAG memory cell. This memory cell is found at location 040 010.

MANUAL UPDATING

By setting the UO.DDU (see "Appendix A," Page 1-25, for an explanation of the user option bits, UO.XXX) bit in the .MFLAG memory location, you can instruct PAM-8 to continue refreshing the front panel displays and to disable updating. When this is done, PAM-8 continues to refresh the LED's from a 9-byte block of RAM cells found at locations 040 013 through 040 023. A description of these front panel LED's (FPLEDS) is found in "Appendix A" (see Page 1-60). When the UO.DDU bit is set in .MFLAG, the contents of these bytes are not altered in any manner by PAM-8.

You can use this technique to display numbers, letters, or arbitrary bar patterns (see Page 1-58) on the front panel displays. For instance, your program may alter the display by inserting any value into FPLEDS. The front panel LED segments will display a decimal integer if you use the octal to 7-segment pattern (DODA) display.

MANUAL DISPLAY REFRESHING

By setting the UO.NFR (User Option.No Front Panel Refresh) bit in the .MFLAG memory cell, you can instruct PAM-8 to stop refreshing the front panel displays. Setting the UO.NFR bit does not disable the clock interrupts; therefore, the tick counter (TICCNT) is still incremented. But PAM-8 does not refresh the displays from the information contained in the FPLEDS bytes.

NOTE: If you desire, you may write a program to refresh the front panel LED displays. Usually this is done using the clock interrupts. If you undertake an independent front panel refresh program, take extreme care to avoid burning the displays due to excessive refreshing. **The total power dissipated in the LEDs is determined by the refresh cycle, and too frequent refreshing will result in excessive display heating.**

Using Interrupts

All H-8 interrupts cause control to be transferred into the low 64 bytes of memory. PAM-8 occupies this memory space so all interrupts are first processed by PAM-8. Except for level zero interrupts, which are used as master clears, you can supply an interrupt processing routine for each of the seven additional interrupts. The following sections explain the use of each of these interrupts.

I/O INTERRUPTS

Interrupts numbered 3 through 7 are I/O interrupts. PAM-8 does not process these interrupts in any way. When a level 3 through level 7 interrupt is received, PAM-8 immediately transfers to the user interrupt vectors contained in memory locations 040 037 through 040 064. These locations are listed in "Appendix A" (see Page 1-60). Each location must contain a jump instruction pointing to the appropriate program location which processes these interrupts.

NOTE: If any of these interrupts occur, you must supply a processing routine for them. This routine must be complete including both entry and exit processing. When you use H8 interrupts, you must use only the available vector which is 6 to insure compatability with future H8 products. You may also use 2 if you will not be using BUG-8.

CLOCK INTERRUPTS

The level one interrupts are generated by the front panel hardware every 2 mS. PAM-8 normally processes these interrupts. However, by setting a processing vector in UIVEC and setting the UO.INT bit in the MFLAG cell, PAM-8 enters the users routine each time a clock interrupt is generated. "Appendix A" (see Page 1-31) gives the required entry and exit conditions for processing clock interrupts.

SINGLE INSTRUCTION AND BREAKPOINT INTERRUPTS

Level two interrupts are generated by the single instruction hardware contained on the CPU card. When a single instruction is requested, the result of the interrupt is processed by PAM-8. If the single instruction interrupt was generated by PAM-8 in response to a Monitor Mode Single Instruction register condition, PAM-8 processes it. Otherwise, PAM-8 jumps to the user level two interrupt vector (UIVEC). Since the level two interrupt does not affect PAM-8, a level two restart instruction can be used as a breakpoint instruction by the user programs.

APPENDIX A

Panel Monitor Listing

This appendix contains a complete listing of the PAM-8 front panel monitor program. PAM-8 resides in the low 1,024 bytes of the H8 computer. It provides all the control for front panel operation, and cassette or paper tape load and dump facilities. It also provides for master clear and front panel interrupt processing. PAM-8 presumes RAM cells are available for its use in locations 040 000 through 040 077 and 80 bytes are available in high memory for a stack. The use of these RAM cells is described on Page 1-60 of this Appendix and in the memory map on Page 0-36.

Pages 1-61, 1-62, and 1-63 of this Appendix are a symbolic reference table. Use this table to find the program locations where each symbolic address is used. Symbolic addresses are listed in alphabetical sequence.

```
***     PAM/8 - H8 FRONT PANEL MONITOR.
*
*       JGL, 05/01/76.
*
*       FOR *WINTEK* INC.
*
*       COPYRIGHT  05/1976, WINTEK CORPORATION,
*                           902 N. 9TH ST.
*                           LAFAYETTE, IND.

***     PAM/8 - H8 FRONT PANEL MONITOR.
*
*       THIS PROGRAM RESIDES (IN ROM) IN THE LOW 1024 BYTES OF THE HEATH
*       H8 COMPUTER. IT ACTUALLY CONSISTS OF TWO VIRTUALLY INDEPENDENT
*       ROUTINES: A TASK-TIME PROGRAM WHICH PROVIDES SOPHISTICATED
*       FRONT PANEL MONITOR SERVICE, AND AN INTERRUPT-TIME PROGRAM WHICH
*       PROVIDES BOTH A REAL-TIME CLOCK AND EMULATES AN EFFECTIVE
*       HARDWARE FRONT PANEL.

***     INTERRUPTS.
*
*       PAM/8 IS THE PRIMARY PROCESSOR FOR ALL INTERRUPTS.
*       THEY ARE PROCESSED AS FOLLOWS:
*
*       RST     USE
*
*       0       MASTER CLEAR. (NEVER USED FOR I/O OR RST)
*
*       1       CLOCK INTERRUPT. NORMALLY TAKEN BY PAM/8.
*               SETTING BIT *UO.CLK* IN BYTE *.MFLAG* ALLOWS
*               USER PROCESSING (VIA A JUMP THROUGH *UIVEC*).
*               UPON ENTRY OF THE USER ROUTINE, THE STACK
*               CONTAINS:
*               (STACK+0)  = RETURN ADDRESS (TO PAM/8)
*               (STACK+2)  = (STACKPTR+14)
*               (STACK+4)  = (AF)
*               (STACK+6)  = (BC)
*               (STACK+8)  = (DE)
*               (STACK+10) = (HL)
*               (STACK+12) = (PC)
*               THE USER'S ROUTINE SHOULD RETURN TO PAM/8 VIA
*               A *RET* WITHOUT ENABLING INTERRUPTS.
*
*       2       SINGLE STEP. SINGLE STEP INTERRUPTS GENERATED
*               BY PAM/8 ARE PROCESSED BY PAM/8.
*               ANY SINGLE STEP INTERRUPT RECEIVED WHEN IN
*               USER MODE CAUSES A JUMP THROUGH *UIVEC*+3.
*               STACK UPON USER ROUTINE ENTRY:
*               (STACK+0)  = (STACKPTR+12)
*               (STACK+2)  = (AF)
*               (STACK+4)  = (BC)
```

```
*               (STACK+6)  = (DE)
*               (STACK+8)  = (HL)
*               (STACK+10) = (PC)
*               THE USER'S ROUTINE SHOULD HANDLE ITS OWN RETURN
*               FROM THE INTERRUPT.
*
*
*       THE FOLLOWING INTERRUPTS ARE VECTORED DIRECTLY THROUGH *UIVEC*.
*       THE USER ROUTINE MUST HAVE SETUP A JUMP IN *UIVEC* BEFORE ANY
*       OF THESE INTERRUPTS MAY OCCUR.
*
*       3       I/O 3. CAUSES A DIRECT JUMP THROUGH *UIVEC*+6
*
*       4       I/O 4. CAUSES A DIRECT JUMP THROUGH *UIVEC*+9
*
*       5       I/O 5. CAUSES A DIRECT JUMP THROUGH *UIVEC*+12
*
*       6       I/O 6. CAUSES A DIRECT JUMP THROUGH *UIVEC*+15
*
*       7       I/O 7. CAUSES A DIRECT JUMP THROUGH *UIVEC*+18
```

```
PAM/8 - H8 FRONT PANEL MONITOR  #01.00.00.                         HEATH X8ASM V1.1  06/21/77
ASSEMBLY CONSTANTS.                                                  15:43:52  01-APR-77  PAGE     3

                     **     ASSEMBLY CONSTANTS

                     **     I/O PORTS

000.360              IP.PAD  EQU     360Q                PAD INPUT PORT
000.360              OP.CTL  EQU     360Q                CONTROL OUTPUT PORT
000.360              OP.DIG  EQU     360Q                DIGIT SELECT OUTPUT PORT
000.361              OP.SEG  EQU     361Q                SEGMENT SELECT OUTPUT PORT
000.371              IP.TPC  EQU     371Q                TAPE CONTROL IN
000.371              OP.TPC  EQU     371Q                TAPE CONTROL OUT
000.370              IP.TPD  EQU     370Q                TAPE DATA IN
000.370              OP.TPD  EQU     370Q                TAPE DATA OUT

                     **     ASCII CHARACTERS.

000.026              A.SYN   EQU     026Q                SYNC CHARACTER
000.002              A.STX   EQU     002Q                STX CHARACTER

                     **     FRONT PANEL HARDWARE CONTROL BITS.

000.020              CB.SSI  EQU     00010000B           SINGLE STEP INTERRUPT
000.040              CB.MTL  EQU     00100000B           MONITOR LIGHT
000.100              CB.CLI  EQU     01000000B           CLOCK INTERRUPT ENABLE
000.200              CB.SPK  EQU     10000000B           SPEAKER ENABLE

                     **     DISPLAY MODE FLAGS (IN *DSPMOD*)

000.000              DM.MR   EQU     0                   MEMORY READ
000.001              DM.MW   EQU     1                   MEMORY WRITE
000.002              DM.RR   EQU     2                   REGISTER READ
000.003              DM.RW   EQU     3                   REGISTER WRITE
000.000                      XTEXT   TAPE                TAPE DEFINITIONS

                     **     TAPE EQUIVALENCES.

000.001              RT.MI   EQU     1                   RECORD TYPE - MEMORY DUMP IMAGE
000.002              RT.BP   EQU     2                   RECORD TYPE - BASIC PROGRAM
000.003              RT.CT   EQU     3                   RECORD TYPE - COMPRESSED TEXT

                     **     BLOCK SIZE FOR INTER-PRODUCT COMMUNICATION.

002.000              BLKSIZ  EQU     512
```

```
                          121 **      MACHINE INSTRUCTIONS.
                          122
    000.166               123 MI.HLT  EQU     01110110B       HALT
    000.311               124 MI.RET  EQU     11001001B       RETURN
    000.333               125 MI.IN   EQU     11011011B       INPUT
    000.323               126 MI.OUT  EQU     11010011B       OUTPUT
    000.072               127 MI.LDA  EQU     00111010B       LDA
    000.346               128 MI.ANI  EQU     11100110B       ANI
    000.021               129 MI.LXID EQU     00010001B       LXI D


                          131 **      USER OPTION BITS.
                          132 *
                          133 *       THESE BITS ARE SET IN CELL .MFLAG.
                          134
    000.200               135 UO.HLT  EQU     10000000B       DISABLE HALT PROCESSING
    000.100               136 UO.NFR  EQU     CB.CLI          NO REFRESH OF FRONT PANEL
    000.002               137 UO.DDU  EQU     00000010B       DISABLE DISPLAY UPDATE
    000.001               138 UO.CLK  EQU     00000001B       ALLOW CLOCK INTERRUPT PROCESSING


    000.000               140         XTEXT   U8251           DEFINE 8251 USART BITS
```

```
                     143X **      8251 USART BIT DEFINITIONS.
                     144X *
                     145X
                     146X **      MODE INSTRUCTION CONTROL BITS.
                     147X
     000.100         148X UMI.1B  EQU    01000000B       1 STOP BIT
     000.200         149X UMI.HB  EQU    10000000B       1 1/2 STOP BITS
     000.300         150X UMI.2B  EQU    11000000B       2 STOP BITS
     000.040         151X UMI.PE  EQU    00100000B       EVEN PARITY
     000.020         152X UMI.PA  EQU    00010000B       USE PARITY
     000.000         153X UMI.L5  EQU    00000000B       5 BIT CHARACTERS
     000.004         154X UMI.L6  EQU    00000100B       6 BIT CHARACTERS
     000.010         155X UMI.L7  EQU    00001000B       7 BIT CHARACTERS
     000.014         156X UMI.L8  EQU    00001100B       8 BIT CHARACTERS
     000.001         157X UMI.1X  EQU    00000001B       CLOCK X 1
     000.002         158X UMI.16X EQU    00000010B       CLOCK X 16
     000.003         159X UMI.64X EQU    00000011B       CLOCK X 64
                     160X
                     161X **      COMMAND INSTRUCTION BITS.
                     162X
     000.100         163X UCI.IR  EQU    01000000B       INTERNAL RESET
     000.040         164X UCI.RO  EQU    00100000B       READER-ON CONTROL FLAG
     000.020         165X UCI.ER  EQU    00010000B       ERROR RESET
     000.004         166X UCI.RE  EQU    00000100B       RECEIVE ENABLE
     000.002         167X UCI.IE  EQU    00000010B       ENABLE INTERRUPTS FLAG
     000.001         168X UCI.TE  EQU    00000001B       TRANSMIT ENABLE
                     169X
                     170X **      STATUS READ COMMAND BITS.
                     171X
     000.040         172X USR.FE  EQU    00100000B       FRAMING ERROR
     000.020         173X USR.OE  EQU    00010000B       OVERRUN ERROR
     000.010         174X USR.PE  EQU    00001000B       PARITY ERROR
     000.004         175X USR.TXE EQU    00000100B       TRANSMITTER EMPTY
     000.002         176X USR.RXR EQU    00000010B       RECEIVER READY
     000.001         177X USR.TXR EQU    00000001B       TRANSMITTER READY
```

```
                              ***    INTERRUPT VECTORS.
                              *


                              **     LEVEL 0 - RESET
                              *
                              *      THIS 'INTERRUPT' MAY NOT BE PROCESSED BY A USER PROGRAM.

   000.000                           ORG     00A

   000.000  021 371 003       INIT0  LXI     D,PRSROM          (DE) = ROM COPY OF PRS CODE
   000.003  041 012 040              LXI     H,PRSRAM+PRSL-1   (HL) = RAM DESTINATION FOR CODE
   000.006  303 073 000              JMP     INIT              INITIALIZE
   377.073                           ERRPL   INIT-1000A        BYTE IN WORD 10A MUST BE 0


                              **     LEVEL 1 - CLOCK

   000.010                    INT1   EQU     10Q               INTERRUPT ENTRY POINT

   000.000                           ERRNZ   *-11Q             INT0 TAKES UP ONE BYTE
   000.011  315 132 000              CALL    SAVALL            SAVE USER REGISTERS
   000.014  026 000                  MVI     D,0
   000.016  303 201 000              JMP     CLOCK             PROCESS CLOCK INTERRUPT
   377.201                           ERRPL   CLOCK-1000A       EXTRA BYTE MUST BE 0


                              **     LEVEL 2 - SINGLE STEP
                              *
                              *      IF THIS INTERRUPT IS RECEIVED WHEN NOT IN MONITOR MODE,
                              *      THEN IT IS ASSUMED TO BE GENERATED BY A USER PROGRAM
                              *      (SINGLE STEPPING OR BREAKPOINTING). IN SUCH CASE, THE
                              *      USER PROGRAM IS ENTERED THROUGH (UIVEC+3

   000.020                    INT2   EQU     20A               LEVEL 2 ENTRY

   000.000                           ERRNZ   *-21A             INT1 TAKES EXTRA BYTE
   000.021  315 132 000              CALL    SAVALL            SAVE REGISTERS
   000.024  032                      LDAX    D                 (A) = (CTLFLG)
   040.011                           SET     CTLFLG
   000.025  303 244 001              JMP     STPRTN            STEP RETURN


                              ***    I/O INTERRUPT VECTORS.
                              *
                              *      INTERRUPTS 3 THROUGH 7 ARE AVAILABLE FOR GENERAL I/O USE.
                              *
                              *      THESE INTERRUPTS ARE NOT SUPPORTED BY PAM/8, AND SHOULD
                              *      NEVER OCCUR UNLESS THE USER HAS SUPPLIED HANDLER ROUTINES
                              *      (THROUGH UIVEC)
```

```
PAM/8 - H8 FRONT PANEL MONITOR  #01.00.00.                          HEATH X8ASM V1.0  02/18/77
HARDWARE INTERRUPT VECTORS                                            13:23:26  01-APR-77  PAGE      7

        000.030                   228          ORG      30A
        000.030  303 045 040      229  INT3    JMP      UIVEC+6            JUMP TO USER ROUTINE
                                  230
        000.033  064 064 064      231          DB       '44413'            HEATH PART NUMBER 444-13

        000.040                   233          ORG      40A
        000.040  303 050 040      234  INT4    JMP      UIVEC+9            JUMP TO USER ROUTINE
                                  235
        000.043  100 112 107      236          DB       100Q,112Q,107Q,114Q,100Q         SUPPORT CODE

        000.050                   238          ORG      50A
        000.050  303 053 040      239  INT5    JMP      UIVEC+12           JUMP TO USER ROUTINE
                                  240
                                  241
                                  242  **      DLY - DELAY TIME INTERVAL.
                                  243  *
                                  244  *       ENTRY    (A) = MILLISECOND DELAY COUNT/2
                                  245  *       EXIT     NONE
                                  246  *       USES     A,F
                                  247
        000.053  365              248  DLY     PUSH     PSW                SAVE COUNT
        000.054  257              249          XRA      A                  DONT SOUND HORN
        000.055  303 143 002      250          JMP      HRN0               PROCESS AS HORN

        000.060                   252          ORG      60A
        000.060  303 056 040      253  INT6    JMP      UIVEC+15           JUMP TO USER ROUTINE
                                  254
                                  255
        000.063  076 320          256  GO.     MVI      A,CB.SSI+CB.CLI+CB.SPK  OFF MONITOR MODE LIGHT
        000.065  303 235 001      257          JMP      SST1               RETURN TO USER PROGRAM

        000.070                   259          ORG      70A
        000.070  303 061 040      260  INT7    JMP      UIVEC+18           JUMP TO USER ROUTINE
```

```
                       **      INIT - INITIALIZE SYSTEM
                       *
                       *       INIT IS CALLED WHENEVER A HARDWARE MASTER-CLEAR IS INITIATED.
                       *
                       *       SETUP PAM/8 CONTROL CELLS IN RAM.
                       *       DECODE HOW MUCH MEMORY EXISTS, SETUP STACKPOINTER, AND
                       *       ENTER THE MONITOR LOOP.
                       *
                       *       ENTRY   FROM MASTER CLEAR
                       *       EXIT    INTO PAM/8 MAIN LOOP


000.073  032           INIT    LDAX    D               COPY *PRSROM* INTO RAM
000.074  167                   MOV     M,A             MOVE BYTE
000.075  053                   DCX     H               DECREMENT DESTINATION
000.076  034                   INR     E               INCREMENT SOURCE
000.077  302 073 000           JNZ     INIT            IF NOT DONE

004.000                SINCR   EQU     4000A           SEARCH INCREMENT

000.102  026 004               MVI     D,SINCR/256     (DE) = SEARCH INCREMENT
000.104  041 000 034           LXI     H,START-SINCR   (HL) = FIRST RAM - SEARCH INCREMENT

                       *       DETERMINE MEMORY LIMIT.

000.107  167           INIT1   MOV     M,A             RESTORE VALUE READ
000.110  031                   DAD     D               INCREMENT TRIAL ADDRESS
000.111  176                   MOV     A,M             (A) = CURRENT MEMORY VALUE
000.112  065                   DCR     M               TRY TO CHANGE IT
000.113  276                   CMP     M
000.114  302 107 000           JNE     INIT1           IF MEMORY CHANGED

000.117  053           INIT2   DCX     H
000.120  371                   SPHL                    SET STACKPOINTER = MEMORY LIMIT -1
000.121  345                   PUSH    H               SET *PC* VALUE ON STACK
000.122  041 322 000           LXI     H,ERROR
000.125  345                   PUSH    H               SET 'RETURN ADDRESS'

                       *       CONFIGURE LOAD/DUMP UART

000.126  076 116               MVI     A,UMI.1B+UMI.L8+UMI.16X
000.130  323 371               OUT     OP.TPC          SET 8 BIT, NO PARITY, 1 STOP, X16
```

```
                        **      SAVALL - SAVE ALL REGISTERS ON STACK.
                        *
                        *       SAVALL IS CALLED WHEN AN INTERRUPT IS ACCEPTED, IN ORDER TO
                        *       SAVE THE CONTENTS OF THE REGISTERS ON THE STACK.
                        *
                        *       ENTRY   CALLED DIRECTLY FROM INTERRUPT ROUTINE.
                        *       EXIT    ALL REGISTERS PUSHED ON STACK,
                        *               IF NOT YET IN MONITOR MODE, REGPTR = ADDRESS OF REGISTERS
                        *               ON STACK.
                        *               (DE) = ADDRESS OF CTLFLG


000.132  343            SAVALL  XTHL                    SET H,L ON STACK TOP
000.133  325                    PUSH    D
000.134  305                    PUSH    B
000.135  365                    PUSH    PSW
000.136  353                    XCHG                    (D,E) = RETURN ADDRESS
000.137  041 012 000            LXI     H,10
000.142  071                    DAD     SP              (H,L) = ADDRESS OF USERS SP
000.143  345                    PUSH    H               SET ON STACK AS 'REGISTER'
000.144  325                    PUSH    D               SET RETURN ADDRESS
000.145  021 011 040            LXI     D,CTLFLG
000.150  032                    LDAX    D               (A) = CTLFLG
000.151  057                    CMA
000.152  346 060                ANI     CB.MTL+CB.SSI   SAVE REGISTER ADDR IF USER OR SINGLE-STEP
000.154  310                    RZ                      RETURN IF WAS INTERRUPT OF MONITOR LOOP
000.155  041 002 000            LXI     H,2
000.160  071                    DAD     SP              (H,L) = ADDRESS OF 'STACKPTR' ON STACK
000.161  042 035 040            SHLD    REGPTR
000.164  311                    RET


                        **      CUI - CHECK FOR USER INTERRUPT PROCESSING.
                        *
                        *       CUI IS CALLED TO SEE IF THE USER HAS SPECIFIED PROCESSING
                        *       FOR THE CLOCK INTERRUPT.


040.010                 .       SET     .MFLAG          REFERENCE TO MFLAG
000.165  012            CUI1    LDAX    B               (A) = .MFLAG
000.000                         ERRNZ   UO.CLK-1        CODE ASSUMED = 01
000.166  017                    RRC
000.167  334 037 040            CC      UIVEC           IF SPECIFIED, TRANSFER TO USER

                        *       RETURN TO PROGRAM FROM INTERRUPT.

000.172  361            INTXIT  POP     PSW             REMOVE FAKE 'STACK REGISTER'
000.173  361                    POP     PSW
000.174  301                    POP     B
000.175  321                    POP     D
000.176  341                    POP     H
000.177  373                    EI
000.200  311                    RET
```

```
                        ***     CLOCK - PROCESS CLOCK INTERRUPT
                        *
                        *       CLOCK IS ENTERED WHENEVER A MILLISECOND CLOCK INTERRUPT IS
                        *       PROCESSED.
                        *
                        *       TICCNT IS INCREMENTED EVERY INTERRUPT.


000.201  052 033 040    CLOCK   LHLD    TICCNT
000.204  043                    INX     H
000.205  042 033 040            SHLD    TICCNT          INCREMENT TICCOUNT

                        **      REFRESH FRONT PANEL.
                        *
                        *       THIS CODE DISPLAYS THE APPROPRIATE PATTERN ON THE
                        *       FRONT PANEL LEDS. THE LEDS ARE PAINTED IN REVERSE ORDER,
                        *       ONE PER INTERRUPT. FIRST, NUMBER 9 IS LIT, THEN NUMBER 8,
                        *       ETC.


000.210  041 010 040            LXI     H,.MFLAG
000.213  176                    MOV     A,M
000.214  107                    MOV     B,A             (B) = CURRENT FLAG
000.215  346 100                ANI     UO.NFR          SEE IF FRONT PANEL REFRESH WANTED
000.217  043                    INX     H
000.000                         ERRNZ   CTLFLG-.MFLAG-1
000.220  176                    MOV     A,M             (A) = CTLFLG
000.221  112                    MOV     C,D             (C) = 0 IN CASE NO PANEL DISPLAY
000.222  302 237 000            JNZ     CLK3            IF NOT
000.225  043                    INX     H               (H,L) = (REFIND)
000.000                         ERRNZ   REFIND-CTLFLG-1
000.226  065                    DCR     M               DECREMENT DIGIT INDEX
000.227  302 234 000            JNZ     CLK2            IF NOT WRAP-AROUND
000.232  066 011                MVI     M,9             WRAP DISPLAY AROUND
000.234  136            CLK2    MOV     E,M
000.235  031                    DAD     D               (H,L) = ADDRESS OF PATTERN
000.236  113                    MOV     C,E
000.237                 CLK3    EQU     *               (A) = CTLNLG
000.237  261                    ORA     C               (A) = INDEX + FIXED BITS
000.240  323 360                OUT     OP.DIG          SELECT DIGIT
000.242  176                    MOV     A,M
000.243  323 361                OUT     OP.SEG          SELECT SEGMENT

                        *       SEE IF TIME TO DECODE DISPLAY VALUES.

000.245  056 033                MVI     L,#TICCNT
000.247  176                    MOV     A,M
000.250  346 037                ANI     37Q             EVERY 32 INTERRUPTS
000.252  314 161 003            CZ      UFD             UPDATE FRONT PANEL DISPLAYS

                        *       EXIT CLOCK INTERRUPT.

000.255  001 011 040            LXI     B,CTLFLG
000.260  012                    LDAX    B               (A) = CTLFLG
000.261  346 040                ANI     CB.MTL
000.263  302 172 000            JNZ     INTXIT          IF IN MONITOR MODE
```

```
PAM/8 - H8 FRONT PANEL MONITOR  #01.00.00.                  HEATH X8ASM V1.0  02/18/77
PROCESS CLOCK INTERRUPTS                                     13:23:34  01-APR-77  PAGE    11

   000.266  013           417          DCX     B
   000.000                418          ERRNZ   CTLFLG-.MFLAG-1
   000.267  012           419          LDAX    B                  (A) = .MFLAG
   000.000                420          ERRNZ   UO.HLT-200Q        ASSUME HIGH-ORDER
   000.270  027           421          RAL
   000.271  332 313 000   422          JC      CLK4               SKIP IT
                          423
                          424  *       NOT IN MONITOR MODE. CHECK FOR HALT
                          425
   000.274  076 012       426          MVI     A,10               (A) = INDEX OF *P* REG
   000.276  315 052 003   427          CALL    LRA.               LOCATE REGISTER ADDRESS
   000.301  136           428          MOV     E,M
   000.302  043           429          INX     H
   000.303  126           430          MOV     D,M                (D,E) = PC CONTENTS
   000.304  033           431          DCX     D
   000.305  032           432          LDAX    D
   000.306  376 166       433          CPI     MI.HLT             CHECK FOR HALT
   000.310  312 322 000   434          JE      ERROR              IF HALT, BE IN MONITOR MODE
                          435
                          436  *       CHECK FOR 'RETURN TO MONITOR' KEY ENTRY.
                          437
   000.313                438  CLK4    EQU     *
   000.313  333 360       439          IN      IP.PAD
   000.315  376 056       440          CPI     56Q                SEE IF '0' AND '#'
   000.317  302 165 000   441          JNE     CUI1               IF NOT, ALLOW USER PROCESSING OF CLOCK
```

```
                             ***     ERROR - COMMAND ERROR.
                             *
                             *       ERROR IS CALLED AS A 'BAIL-OUT' ROUTINE.
                             *
                             *       IT RESETS THE OPERATIONAL MODE, AND RESTORES THE STACKPOINTER.
                             *
                             *       ENTRY   NONE
                             *       EXIT    TO MTR LOOP
                             *               CTLFLG SET
                             *               .MFLAG CLEARED
                             *       USES    ALL


000.322                      ERROR   EQU     *
000.322  041 010 040                 LXI     H,.MFLAG
000.325  176                         MOV     A,M             (A) = .MFLAG
000.326  346 275                     ANI     377Q-UO.DDU-UO.NFR      RE-ENABLE DISPLAYS
000.330  167                         MOV     M,A             REPLACE
000.331  043                         INX     H
000.332  066 360                     MVI     M,CB.SSI+CB.MTL+CB.CLI+CB.SPK   RESTORE *CTLFLG*
000.000                              ERRNZ   CTLFLG-.MFLAG-1
000.334  373                         EI
000.335  052 035 040                 LHLD    REGPTR
000.340  371                         SPHL                    RESTORE STACK POINTER TO EMPTY STATE
000.341  315 136 002                 CALL    ALARM           ALARM FOR 200 MS


                             **      MTR - MONITOR LOOP.
                             *
                             *       THIS IS THE MAIN EXECUTIVE LOOP FOR THE FRONT PANEL EMULATOR.


000.344                      MTR     EQU     *
000.344  373                         EI

000.345  041 345 000         MTR1    LXI     H,MTR1
000.350  345                         PUSH    H               SET 'MTR1' AS RETURN ADDRESS
000.351  001 007 040                 LXI     B,DSPMOD        (BC) = #DSPMOD
000.354  012                         LDAX    B
000.355  346 001                     ANI     1               (A) = 1 IF ALTER
000.357  057                         CMA
000.360  062 006 040                 STA     DSPROT          ROTATE LED PERIODS IF ALTER

                             *       READ KEY

000.363  315 260 003                 CALL    RCK             READ CONSOLE KEYPAD
000.366  052 024 040                 LHLD    ABUSS
000.371  376 012                     CPI     10
000.373  322 005 001                 JNC     MTR4            IF IN 'ALWAYS VALID' GROUP
000.376  137                         MOV     E,A             SAVE VALUE
040.007                      .       SET     DSPMOD
000.377  012                         LDAX    B               (A) = DSPMOD
001.000  017                         RRC
001.001  332 051 001                 JC      MTR5            IF IN ALTER MODE
```

```
001.004  173                       MOV   A,E          (A) = CODE

                            *      HAVE A COMMAND (NOT A VALUE)

001.005  326 004            MTR4   SUI   4            (A) = COMMAND
001.007  332 322 000               JC    ERROR        IF BAD
001.012  137                       MOV   E,A
001.013  345                       PUSH  H            SAVE ABUSS VALUE
001.014  041 035 001               LXI   H,MTRA
001.017  026 000                   MVI   D,0
001.021  031                       DAD   D            (H,L) = ADDRESS OF TABLE ENTRY
001.022  136                       MOV   E,M
001.023  031                       DAD   D            (H,L) = ADDRESS OF PROCESSOR
001.024  343                       XTHL               SET ADDRESS, (H,L) = (ABUSS)
001.025  021 005 040               LXI   D,REGI       (D,E) = ADDRESS OF REG INDEX
040.007                            SET   DSPMOD
001.030  012                       LDAX  B            (A) = DSPMOD
001.031  346 002                   ANI   2            SET 'Z' IF MEMORY
001.033  012                       LDAX  B            (A) = DSPMOD
001.034  311                       RET                JUMP TO PROCESSOR

001.035                     MTRA   EQU   *            JUMP TABLE
001.035  165                       DB    GO-*         4 - GO
001.036  141                       DB    IN-*         5 - INPUT
001.037  143                       DB    OUT-*        6 - OUTPUT
001.040  165                       DB    SSTEP-*      7 - SINGLE STEP
001.041  220                       DB    RMEM-*       8 - CASSETTE LOAD
001.042  332                       DB    WMEM-*       9 - CASSETTE DUMP
001.043  067                       DB    NEXT-*       + - NEXT
001.044  104                       DB    LAST-*       - - LAST
001.045  102                       DB    ABORT-*      * - ABORT
001.046  060                       DB    R$W-*        / - DISPLAY/ALTER
001.047  116                       DB    MEMM-*       # - MEMORY MODE
001.050  034                       DB    REGM-*       . - REGISTER MODE


                            **     PROCESS MEMORY/REGISTER ALTERATIONS.
                            *
                            *      THIS CODE IS ENTERED IF
                            *
                            *      1) AM IN ALTER MODE, AND
                            *      2) A KEY FROM 0-7 WAS ENTERED.

001.051  017                MTR5   RRC
001.052  173                       MOV   A,E          (A) = VALUE
001.053  332 067 001               JC    MTR6         IS REGISTER
001.056  067                       STC                INDICATE 1ST DIGIT IS IN (A)
001.057  315 066 003               CALL  IOB          INPUT OCTAL BYTE
001.062  043                       INX   H            DISPLAY NEXT LOCATION
```

```
                             548  **       SAE - STORE ABUSS AND EXIT.
                             549  *
                             550  *        ENTRY   (HL) = ABUSS VALUE
                             551  *        EXIT    TO (RET)
                             552  *        USES    NONE
                             553
001.063  042 024 040         554  SAE      SHLD    ABUSS
001.066  311                 555           RET
                             556
                             557  *        ALTER REGISTER
                             558
001.067  365                 559  MTR6     PUSH    PSW             SAVE CODE
001.070  315 047 003         560           CALL    LRA             LOCATE REGISTER ADDRESS
001.073  247                 561           ANA     A
001.074  312 322 000         562           JZ      ERROR           NOT ALLOWED TO ALTER STACKPOINTER
001.077  043                 563           INX     H
001.100  361                 564           POP     PSW             RESTORE VALUE AND CARRY FLAG
001.101  303 062 003         565           JMP     IOA             INPUT OCTAL ADDRESS
```

```
                          **      REGM - ENTER REGISTER DISPLAY MODE.
                          *
                          *       ENTRY   (A) = DSPMOD
                          *               (BC) = #DSPMOD

001.104  076 002          REGM    MVI     A,2             SET DISPLAY REGISTER MODE
040.007                           SET     DSPMOD
001.106  002                      STAX    B               SET DISPLAY REGISTER MODE
000.000                           ERRNZ   DSPMOD-DSPROT-1
001.107  013                      DCX     B               (BC) = #DSPROT
001.110  257                      XRA     A
001.111  002                      STAX    B               SET ALL PERIODS ON
001.112  315 260 003              CALL    RCK             READ KEY ENTRY
001.115  075                      DCR     A               DISPLACE
001.116  376 006                  CPI     6
001.120  322 322 000              JNC     ERROR           NOT 1-6
001.123  007                      RLC
001.124  022                      STAX    D               SET NEW REG IND
040.005                           SET     REGI
001.125  311                      RET


                          **      R$W - TOGGLE DISPLAY/ALTER MODE.
                          *
                          *       ENTRY   (A) = DSPMOD
                          *               (BC) = ADDRESS OF DSPMOD

040.007                   .       SET     DSPMOD
001.126  356 001          R$W     XRI     1
001.130  002                      STAX    B
001.131  311                      RET


                          **      NEXT - INCREMENT DISPLAY ELEMENT.
                          *
                          *       ENTRY   (HL) = (ABUSS)
                          *               (DE) = ADDRESS OF REGIND

001.132  043              NEXT    INX     H
001.133  312 063 001              JZ      SAE             IF MEMORY, STORE ABUSS AND EXIT

                          *       IS REGISTER MODE.

040.005                   .       SET     REGI
001.136  032                      LDAX    D               (A) = REGI
001.137  306 002                  ADI     2               INCREMENT REG INNEX
001.141  022                      STAX    D               WRAP TO *SP*
001.142  376 014                  CPI     12
001.144  330                      RC                      IF NOT TOO LARGE, EXIT
001.145  257                      XRA     A               OVERFLOW
001.146  022                      STAX    D
001.147  311              ABORT   RET
```

```
                          **      LAST - DECREMENT DISPLAY ELEMENT.
                          *
                          *       ENTRY   (HL) = (ABUSS)
                          *               (DE) = ADDRESS OF REGIND

001.150  053              LAST    DCX     H
001.151  312 063 001              JZ      SAE                IF MEMORY, STORE AND EXIT

                          *       IS REGISTER MODE.

040.005                   .       SET     REGI
001.154  032              LST2    LDAX    D                  (A) = REGI
001.155  326 002                  SUI     2
001.157  022                      STAX    D
001.160  320                      RNC                        IF OK
001.161  076 012                  MVI     A,10               UNDERFLOW TO *PC*
001.163  022                      STAX    D
001.164  311                      RET


                          **      MEMM - ENTER DISPLAY MEMORY MODE.
                          *
                          *       ENTRY   (BC) = ADDRESS OF DSPMOD

001.165  257              MEMM    XRA     A                  (A) = 0
040.007                   .       SET     DSPMOD
001.166  002                      STAX    B                  SET DISPLAY MEMORY MODE
000.000                           ERRNZ   DSPMOD-DSPROT-1
001.167  013                      DCX     B                  (BC) = #DSPROT
001.170  002                      STAX    B                  SET ALL PERIODS ON
001.171  041 025 040              LXI     H,ABUSS+1
001.174  303 062 003              JMP     IOA                INPUT OCTAL ADDRESS


                          **      IN - INPUT DATA BYTE.
                          *

                          **      OUT - OUTPUT DATA BYTE.
                          *
                          *       ENTRY   (HL) = (ABUSS)

001.177  006 333          IN      MVI     B,MI.IN
001.201  021                      DB      MI.LXID            SKIP NEXT INSTRUCTION
001.202  006 323          OUT     MVI     B,MI.OUT
001.204  174                      MOV     A,H                (A) = VALUE
001.205  145                      MOV     H,L                (H) = PORT
001.206  150                      MOV     L,B                (L) = IN/OUT INSTRUCTION
001.207  042 002 040              SHLD    IOWRK
001.212  315 002 040              CALL    IOWRK              PERFORM IO
001.215  154                      MOV     L,H                (L) = PORT
001.216  147                      MOV     H,A                (H) = VALUE
001.217  303 063 001              JMP     SAE                STORE ABUSS AND EXIT
```

```
                          **      GO - RETURN TO USER MODE
                          *
                          *       ENTRY   NONE

001.222  303 063 000      GO      JMP     GO.                  ROUTINE IS IN WASTE SPACE


                          **      SSTEP - SINGLE STEP INSTRUCTION.
                          *
                          *       ENTRY   NONE

001.225                   SSTEP   EQU     *                    SINGLE STEP
001.225  363                      DI                           DISABLE INTERRUPTS UNTIL THE RIGHT TIME
001.226  072 011 040              LDA     CTLFLG
001.231  356 020                  XRI     CB.SSI               CLEAR SINGLE STEP INHIBIT
001.233  323 360                  OUT     OP.CTL               PRIME SINGLE STEP INTERRUPT
001.235  062 011 040      SST1    STA     CTLFLG               SET NEW FLAG VALUES
001.240  341                      POP     H                    CLEAN STACK
001.241  303 172 000              JMP     INTXIT               RETURN TO USER ROUTINE FOR STEP


                          **      STPRTN - SINGLE STEP RETURN

001.244                   STPRTN  EQU     *
001.244  366 020                  ORI     CB.SSI               DISABLE SINGLE STEP INTERRUPTION
001.246  323 360                  OUT     OP.CTL               TURN OFF SINGLE STEP ENABLE
040.011                           SET     CTLFLG
001.250  022                      STAX    D
001.251  346 040                  ANI     CB.MTL               SEE IF IN MONITOR MODE
001.253  302 344 000              JNZ     MTR
001.256  303 042 040              JMP     UIVEC+3              TRANSFER TO USER'S ROUTINE


                          **      RMEM - LOAD MEMORY FROM TAPE.
                          *

001.261  041 244 002      RMEM    LXI     H,TPABT
001.264  042 031 040              SHLD    TPERRX               SETUP ERROR EXIT ADDRESS
                          *       JMP     LOAD
```

```
                           712  ***     LOAD - LOAD MEMORY FROM TAPE.
                           713  *
                           714  *       READ THE NEXT RECORD FROM THE CASSETTE TAPE.
                           715  *
                           716  *       USE THE LOAD ADDRESS IN THE TAPE RECORD.
                           717  *
                           718  *       ENTRY   (HL) = ERROR EXIT ADDRESS
                           719  *       EXIT    USER P-REG (IN STACK) SET TO ENTRY ADDRESS
                           720  *               TO CALLER IF ALL OK
                           721  *               TO ERROR EXIT IF TAPE ERRORS DETECTED.
                           722
                           723
001.267                    724  LOAD    EQU     *
001.267  001 000 376       725          LXI     B,1000A-RT.MI*256-256   (BC) = - REQUIRED TYPE AND #
001.272  315 265 002       726  LOA0    CALL    SRS             SCAN FOR RECORD START
001.275  157               727          MOV     L,A             (HL) = COUNT
001.276  353               728          XCHG                    (DE) = COUNT, (HL) = TYPE AND #
001.277  015               729          DCR     C               (C) = - NEXT #
001.300  011               730          DAD     B
001.301  174               731          MOV     A,H
001.302  305               732          PUSH    B               SAVE TYPE AND #
001.303  365               733          PUSH    PSW             SAVE TYPE CODE
001.304  346 177           734          ANI     177Q            CLEAR END FLAG BIT
001.306  265               735          ORA     L
001.307  076 002           736          MVI     A,2             SEQUENCE ERROR
001.311  302 205 002       737          JNE     TPERR           IF NOT RIGHT TYPE OR SEQUENCE
001.314  315 325 002       738          CALL    RNP             READ ADDR
001.317  104               739          MOV     B,H
001.320  117               740          MOV     C,A             (BC) = P-REG ADDRESS
001.321  076 012           741          MVI     A,10
001.323  325               742          PUSH    D               SAVE (DE)
001.324  315 052 003       743          CALL    LRA.            LOCATE REG ADDRESS
001.327  321               744          POP     D               RESTORE (DE)
001.330  161               745          MOV     M,C             SET P-REG IN MEM
001.331  043               746          INX     H
001.332  160               747          MOV     M,B
001.333  315 325 002       748          CALL    RNP             READ ADDRESS
001.336  157               749          MOV     L,A             (HL) = ADDRESS, (DE) = COUNT
001.337  042 000 040       750          SHLD    START
                           751
001.342  315 331 002       752  LOA1    CALL    RNB             READ BYTE
001.345  167               753          MOV     M,A
001.346  042 024 040       754          SHLD    ABUSS           SET ABUSS FOR DISPLAY
001.351  043               755          INX     H
001.352  033               756          DCX     D
001.353  172               757          MOV     A,D
001.354  263               758          ORA     E
001.355  302 342 001       759          JNZ     LOA1            IF MORE TO GO
                           760
001.360  315 172 002       761          CALL    CTC             CHECK  TAPE CHECKSUM
                           762
                           763  *       READ NEXT BLOCK
                           764
001.363  361               765          POP     PSW             (A) = FILE TYPE BYTE
001.364  301               766          POP     B               (BC) = -(LAST TYPE, LAST #)
001.365  007               767          RLC
```

```
001.366  332 133 002    768         JC      TFT         ALL DONE - TURN OFF TAPE
001.371  303 272 001    769         JMP     LOAD        READ ANOTHER RECORD
```

```
                          ***     DUMP - DUMP MEMORY TO MAG TAPE.
                          *
                          *       DUMP SPECIFIED MEMORY RANGE TO MAG TAPE.
                          *
                          *       ENTRY   (START) = START ADDRESS
                          *               (ABUSS) = END ADDRESS
                          *               USER PC = ENTRY POINT ADDRESS
                          *       EXIT    TO CALLER.


001.374                   WMEM    EQU     *
001.374  041 244 002              LXI     H,TPABT
001.377  042 031 040              SHLD    TPERRX          SETUP ERROR EXIT

002.002  076 001          DUMP    MVI     A,UCI.TE
002.004  323 371                  OUT     OP.TPC          SETUP TAPE CONTROL
002.006  076 026                  MVI     A,A.SYN
002.010  046 040                  MVI     H,32            (H) = # OF SYNC CHARACTERS
002.012  315 024 003      WME1    CALL    WNB
002.015  045                      DCR     H
002.016  302 012 002              JNZ     WME1            WRITE SYN HEADER
002.021  076 002                  MVI     A,A.STX
002.023  315 024 003              CALL    WNB             WRITE STX
002.026  154                      MOV     L,H             (HL) = 00
002.027  042 027 040              SHLD    CRCSUM          CLEAR CRC 16
002.032  041 001 201              LXI     H,RT.MI+80H*256+1       FIRST AND LAST MI RECORD
002.035  315 017 003              CALL    WNP             WRITE HEADER
002.040  052 000 040              LHLD    START
002.043  353                      XCHG                    (D,E) = START ADDRESS
002.044  052 024 040              LHLD    ABUSS           (H,L) = STOP ADDR
002.047  043                      INX     H               COMPUTE WITH STOP+1
002.050  175                      MOV     A,L
002.051  223                      SUB     E
002.052  157                      MOV     L,A
002.053  174                      MOV     A,H
002.054  232                      SBB     D
002.055  147                      MOV     H,A             (HL) = COUNT
002.056  315 017 003              CALL    WNP             WRITE COUNT
002.061  345                      PUSH    H
002.062  076 012                  MVI     A,10
002.064  325                      PUSH    D               SAVE (DE)
002.065  315 052 003              CALL    LRA.            LOCATE P-REG ADDRESS
002.070  176                      MOV     A,M
002.071  043                      INX     H
002.072  146                      MOV     H,M
002.073  157                      MOV     L,A             (HL) = CONTENTS OF PC
002.074  315 017 003              CALL    WNP             WRITE HEADER
002.077  341                      POP     H               (HL) = ADDRESS
002.100  321                      POP     D               (DE) = COUNT
002.101  315 017 003              CALL    WNP

002.104  176              WME2    MOV     A,M
002.105  315 024 003              CALL    WNB             WRITE BYTE
002.110  042 024 040              SHLD    ABUSS           SET ADDRESS FOR DISPLAY
002.113  043                      INX     H
002.114  033                      DCX     D
```

```
002.115  172                    MOV     A,D
002.116  263                    ORA     E
002.117  302 104 002            JNZ     WME2            IF MORE TO GO

                 *      WRITE CHECKSUM

002.122  052 027 040            LHLD    CRCSUM
002.125  315 017 003            CALL    WNP             WRITE IT
002.130  315 017 003            CALL    WNP             FLUSH CHECKSUM
                 *      JMP     TFT


                 **     TFT - TURN OFF TAPE.
                 *
                 *      STOP THE TAPE TRANSPORT.
                 *

002.133  257     TFT    XRA     A
002.134  323 371        OUT     OP.TPC          TURN OFF TAPE


                 **     HORN - MAKE NOISE.
                 *
                 *      ENTRY   (A) = (MILLISECOND COUNT)/2
                 *      EXIT    NONE
                 *      USES    A,F


002.136  076 144 ALARM  MVI     A,200/2         200 MS BEEP
002.140  365     HORN   PUSH    PSW
002.141  076 200        MVI     A,CB.SPK        TURN ON SPEAKER

002.143  343     HRN0   XTHL                    SAVE (HL), (H)  = COUNT
002.144  325            PUSH    D               SAVE (DE)
002.145  353            XCHG                    (D) = LOOP COUNT
002.146  041 011 040    LXI     H,CTLFLG
002.151  256            XRA     M
002.152  136            MOV     E,M             (E) = OLD CTLFLG VALUE
002.153  167            MOV     M,A             TURN ON HORN
002.154  056 033        MVI     L,#TICCNT

002.156  172            MOV     A,D             (A) = CYCLE COUNT
002.157  206            ADD     M
002.160  276     HRN2   CMP     M               WAIT REQUIRED TICCOUNTS
002.161  302 160 002    JNE     HRN2
002.164  056 011        MVI     L,#CTLFLG
002.166  163            MOV     M,E             TURN HORN OFF
002.167  321            POP     D
002.170  341            POP     H
002.171  311            RET
```

```
                                **      CTC - VERIFY CHECKSUM.
                                *
                                *       ENTRY   TAPE JUST BEFORE CRC
                                *       EXIT    TO CALLER IF OK
                                *               TO *TPERR* IF BAD
                                *       USES    A,F,H,L


002.172  315 325 002            CTC     CALL    RNP                READ NEXT PAIR
002.175  052 027 040                    LHLD    CRCSUM
002.200  174                            MOV     A,H
002.201  265                            ORA     L
002.202  310                            RZ                         RETURN OF OK
002.203  076 001                        MVI     A,1                CHECKSUM ERROR
                                *       JMP     TPERR              (B) = CODE


                                **      TPERR - PROCESS TAPE ERROR.
                                *
                                *       DISPLAY ERR NUMBER IN LOW BYTE OF ABUSS
                                *
                                *       IF ERROR NUMBER EVEN, DONT ALLOW #
                                *       IF ERROR NUMBER ODD, ALLOW #
                                *
                                *       ENTRY   (A) = NUMBER


002.205  062 024 040            TPERR   STA     ABUSS
002.210  107                            MOV     B,A                (B) = CODE
002.211  315 133 002                    CALL    TFT                TURN OFF TAPE

                                *       IS #, RETURN (IF PARITY ERROR)

002.214  346                            DB      MI.ANI             FALL THROUGH WITH CARRY CLEAR
002.215  170                    TER3    MOV     A,B

002.216  017                            RRC
002.217  330                            RC                         RETURN IF OK

                                *       BEEP AND FLASH ERROR NUMBER

002.220  334 136 002            TER1    CC      ALARM              ALARM IF PROPER TIME
002.223  315 252 002                    CALL    TPXIT              SEE IF *
002.226  333 360                        IN      IP.PAD
002.230  376 057                        CPI     00101111B          CHECK FOR #
002.232  312 215 002                    JE      TER3               IF #
002.235  072 034 040                    LDA     TICCNT+1
002.240  037                            RAR                        'C' SET IF 1/2 SECOND
002.241  303 220 002                    JMP     TER1
```

```
                      **       TPABT - ABORT TAPE LOAD OR DUMP.
                      *
                      *        ENTERED WHEN LOADING OR DUMPING, AND THE '*' KEY
                      *        IS STRUCK.


002.244  257          TPABT    XRA     A
002.245  323 371               OUT     OP.TPC           OFF TAPE
002.247  303 322 000           JMP     ERROR



                      **       TPXIT - CHECK FOR USER FORCED EXIT.
                      *
                      *        TPXIT CHECKS FOR AN '*' KEYPAD ENTRY. IF SO, TAKE
                      *        THE TAPE DRIVER ABNORMAL EXIT.
                      *
                      *        ENTRY   NONE
                      *        EXIT    TO *RET* IF NOT '*'
                      *                 (A) = PORT STATUS
                      *                TO (TPERRX) IF '*' DOWN
                      *        USES    A,F


002.252  333 360      TPXIT    IN      IP.PAD
002.254  376 157               CPI     01101111B        *
002.256  333 371               IN      IP.TPC           READ TAPE STATUS
002.260  300                   RNE                      NOT '*', RETURN WITH STATUS
002.261  052 031 040           LHLD    TPERRX
002.264  351                   PCHL                     ENTER (TPERRX)



                      **       SRS - SCAN RECORD START
                      *
                      *        SRS READS BYTES UNTIL IT RECOGNIZES THE START OF A RECORD.
                      *
                      *        THIS REQUIRES
                      *        AT LEAST 10 SYNC CHARACTERS
                      *        1 STX CHARACTER.
                      *
                      *        THE CRC-16 IS THEN INITIALIZED.
                      *
                      *        ENTRY   NONE
                      *        EXIT    TAPE POSITIONED (AND MOVING), CRCSUM =0
                      *                (DE) = HEADER BYTES
                      *                (HA) = RECORD COUNT
                      *        USES    A,F,D,E,H,L


002.265               SRS      EQU     *
002.265  026 000      SRS1     MVI     D,0
002.267  142                   MOV     H,D
002.270  152                   MOV     L,D              (HL) = 0
```

```
002.271  315 331 002  SRS2   CALL   RNB              READ NEXT BYTE
002.274  024                 INR    D
002.275  376 026             CPI    A,SYN
002.277  312 271 002         JE     SRS2             HAVE SYN
002.302  376 002             CPI    A,STX
002.304  302 265 002         JNE    SRS1             NOT STX - START OVER

002.307  076 012             MVI    A,10
002.311  272                 CMP    D                SEE IF ENOUGH SYN CHARACTERS
002.312  322 265 002         JNC    SRS1             NOT ENOUGH
002.315  042 027 040         SHLD   CRCSUM           CLEAR CRC-16
002.320  315 325 002         CALL   RNP              READ LEADER
002.323  124                 MOV    D,H
002.324  137                 MOV    E,A
                      *      JMP    RNP              READ COUNT


                      **     RNP - READ NEXT PAIR.
                      *
                      *      RNP READS THE NEXT TWO BYTES FROM THE INPUT DEVICE.
                      *
                      *      ENTRY  NONE
                      *      EXIT   (H,A) = BYTE PAIR
                      *      USES   A,F,H


002.325  315 331 002  RNP    CALL   RNB              READ NEXT BYTE
002.330  147                 MOV    H,A
                      *      JMP    RNB              READ NEXT BYTE


                      **     RNB - READ NEXT BYTE
                      *
                      *      RNB READS THE NEXT SINGLE BYTE FROM THE INPUT DEVICE.
                      *      THE CHECKSUM IS TAKEN FOR THE CHARACTER.
                      *
                      *      ENTRY  NONE
                      *      EXIT   (A) = CHARACTER
                      *      USES   A,F


002.331  076 064      RNB    MVI    A,UCI.RO+UCI.ER+UCI.RE  TURN ON READER FOR NEXT BYTE
002.333  323 371             OUT    OP.TPC
002.335  315 252 002  RNB1   CALL   TPXIT            CHECK FOR *, READ STATUS
002.340  346 002             ANI    USR.RXR
002.342  312 335 002         JZ     RNB1             IF NOT READY
002.345  333 370             IN     IP.TPD           INPUT DATA
                      *      JMP    CRC              CHECKSUM
```

```
                            **      CRC - COMPUTE CRC-16
                            *
                            *       CRC COMPUTES A CRC-16 CHECKSUM FROM THE POLYNOMIAL
                            *
                            *       (X + 1) * (X^15 + X + 1)
                            *
                            *       SINCE THE CHECKSUM GENERATED IS A DIVISION REMAINDER,
                            *       A CHECKSUMED DATA SEQUENCE CAN BE VERIFIED BY RUNNING
                            *       THE DATA THROUGH CRC, AND THEN RUNNING THE PREVIOUSLY OBTAINED
                            *       CHECKSUM THROUGH CRC. THE RESULTANT CHECKSUM SHOULD BE 0.
                            *
                            *       ENTRY   (CRCSUM) = CURRENT CHECKSUM
                            *               (A) = BYTE
                            *       EXIT    (CRCSUM) UPDATED
                            *               (A) UNCHANGED.
                            *       USES    F


002.347  305                CRC     PUSH    B                       SAVE (BC)
002.350  006 010                    MVI     B,8                     (B) = BIT COUNT
002.352  345                        PUSH    H
002.353  052 027 040                LHLD    CRCSUM
002.356  007                CRC1    RLC
002.357  117                        MOV     C,A                     (C) = BIT
002.360  175                        MOV     A,L
002.361  207                        ADD     A
002.362  157                        MOV     L,A
002.363  174                        MOV     A,H
002.364  027                        RAL
002.365  147                        MOV     H,A
002.366  027                        RAL
002.367  251                        XRA     C
002.370  017                        RRC
002.371  322 004 003                JNC     CRC2                    IF NOT TO XOR
002.374  174                        MOV     A,H
002.375  356 200                    XRI     200Q
002.377  147                        MOV     H,A
003.000  175                        MOV     A,L
003.001  356 005                    XRI     5Q
003.003  157                        MOV     L,A
003.004  171                CRC2    MOV     A,C
003.005  005                        DCR     B
003.006  302 356 002                JNZ     CRC1                    IF MORE TO GO
003.011  042 027 040                SHLD    CRCSUM
003.014  341                        POP     H                       RESTORE (HL)
003.015  301                        POP     B                       RESTORE (BC)
003.016  311                        RET                             EXIT
```

```
                           **       WNP - WRITE NEXT PAIR.
                           *
                           *        WPT WRITES THE NEXT TWO BYTES TO THE CASSETTE DRIVE.
                           *
                           *        ENTRY   (H,L) = BYTES
                           *        EXIT    WRITTEN.
                           *        USES    A,F


003.017  174               WNP      MOV     A,H
003.020  315 024 003                CALL    WNB
003.023  175                        MOV     A,L
                           *        JMP     WNB                WRITE NEXT BYTE


                           **       WNB - WRITE BYTE
                           *
                           *        WNB WRITES THE NEXT BYTE TO THE CASSETTE TAPE.
                           *
                           *        ENTRY   (A) = BYTE
                           *        EXIT    NONE.
                           *        USES    F


003.024  365               WNB      PUSH    PSW
003.025  315 252 002       WNB1     CALL    TPXIT              CHECK FOR *, READ STATUS
003.030  346 001                    ANI     USR.TXR
003.032  312 025 003                JZ      WNB1               IF MORE TO GO
003.035  076 021                    MVI     A,UCI.ER+UCI.TE ENABLE TRANSMITTER
003.037  323 371                    OUT     OP.TPC             TURN ON TAPE
003.041  361                        POP     PSW
003.042  323 370                    OUT     OP.TPD             OUTPUT DATA
003.044  303 347 002                JMP     CRC                COMPUTE CRC
```

```
                                **      LRA - LOCATE REGISTER ADDRESS.
                                *
                                *       ENTRY   NONE.
                                *       EXIT    (A) = REGISTER INDEX
                                *               (H,L) = STORAGE ADDRESS
                                *               (D,E) = (0,A)
                                *       USES    A,D,E,H,L,F



003.047  072 005 040            LRA     LDA     REGI
003.052  137                    LRA.    MOV     E,A
003.053  026 000                        MVI     D,0
003.055  052 035 040                    LHLD    REGPTR
003.060  031                            DAD     D               (DE) = (REGPTR)+(REGI)
003.061  311                            RET


                                **      IOA - INPUT OCTAL ADDRESS.
                                *
                                *       ENTRY   (H,L) = ADDRESS OF RECEPTION DOUBLE BYTE.
                                *       EXIT    TO *RET* IF ERROR.
                                *               TO *RET*+1 IF OK, VALUE IN MEMORY.
                                *       USES    A,D,E,H,L,F


003.062  315 066 003            IOA     CALL    IOB             INPUT BYTE
003.065  053                            DCX     H


                                **      IOB - INPUT OCTAL BYTE.
                                *
                                *       READ ONE OCTAL BYTE FROM THE KEYSET.
                                *
                                *       ENTRY   (H,L) = ADDRESS OF BYTE TO HOLD VALUE
                                *               'C' SET IF FIRST DIGIT IN (A)
                                *       EXIT    TO *RET* IF ALL OK
                                *               TO *ERROR* IF ERROR
                                *       USES    A,D,E,H,L,F



003.066  026 003                IOB     MVI     D,3             (D) = DIGIT COUNT
003.070  324 260 003            IOB1    CNC     RCK             READ CONSOLE KEYSET

003.073  376 010                        CPI     8
003.075  322 322 000                    JNC     ERROR           IF ILLEGAL DIGIT

003.100  137                            MOV     E,A             (E) = VALUE
003.101  176                            MOV     A,M
003.102  007                            RLC                     SHIFT 3
003.103  007                            RLC
```

```
003.104  007          1159          RLC
003.105  346 370      1160          ANI     370Q
003.107  263          1161          ORA     E
003.110  167          1162          MOV     M,A              REPLACE
003.111  025          1163          DCR     D
003.112  302 070 003  1164          JNZ     IOB1             IF NOT DONE
003.115  076 017      1165          MVI     A,30/2           BEEP FOR 30 MS
003.117  303 140 002  1166          JMP     HORN


                      1168   **     DOD - DECODE FOR OCTAL DISPLAY.
                      1169   *
                      1170   *      ENTRY   (H,L) = ADDRESS OF LED REFRESH AREA
                      1171   *              (B) = *OR* PATTERN TO FORCE ON BARS OR PERIODS
                      1172   *              (A) = OCTAL VALUE
                      1173   *      EXIT    (H,L) = NEX DIGIT ADDRESS
                      1174   *      USES    A,B,C,D,H,L
                      1175
                      1176
003.122  325          1177   DOD    PUSH    D
003.123  026 003      1178          MVI     D,DODA/256
003.125  016 003      1179          MVI     C,3
003.127  027          1180   DOD1   RAL                      LEFT 3 PLACES
003.130  027          1181          RAL
003.131  027          1182          RAL
003.132  365          1183          PUSH    PSW              SAVE FOR NEXT DIGIT
003.133  346 007      1184          ANI     7
003.135  306 356      1185          ADI     #DODA
003.137  137          1186          MOV     E,A              (D) = INDEX
003.140  032          1187          LDAX    D                (A) = PATTERN
003.141  250          1188          XRA     B
003.142  346 177      1189          ANI     177Q
003.144  250          1190          XRA     B
003.145  167          1191          MOV     M,A              SET IN MEMORY
003.146  043          1192          INX     H
003.147  170          1193          MOV     A,B
003.150  007          1194          RLC
003.151  107          1195          MOV     B,A
003.152  361          1196          POP     PSW              (A) = VALUE
003.153  015          1197          DCR     C
003.154  302 127 003  1198          JNZ     DOD1             IF MORE TO GO
003.157  321          1199          POP     D
003.160  311          1200          RET                      RETURN
```

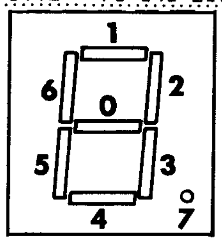
```
                         **    UFD - UPDATE FRONT PANEL DISPLAYS.
                         *
                         *
                         *     UFD IS CALLED BY THE CLOCK INTERRUPT PROCESSOR WHEN IT IS
                         *     TIME TO UPDATE THE DISPLAY CONTENTS. CURRENTLY, THIS IS DONE
                         *     EVERY 32 INTERRUPTS, OR ABOUT 32 TIMES A SECOND.
                         *
                         *     ENTRY   (H,L) = ADDRESS OF REFCNT
                         *     EXIT    NONE
                         *     USES    ALL
003.161                  UFD   EQU     *
003.161  076 002               MVI     A,UO.DDU
003.163  240                   ANA     B
003.164  300                   RNZ                     IF NOT TO HANDLE UPDATE
003.165  056 006               MVI     L,#DSPROT
003.167  176                   MOV     A,M
003.170  007                   RLC
003.171  167                   MOV     M,A             ROTATE PATTERN
003.172  107                   MOV     B,A
003.173  043                   INX     H
000.000                        ERRNZ   DSPMOD-DSPROT-1
003.174  176                   MOV     A,M             (A) = DSPMOD
003.175  346 002               ANI     2
003.177  052 024 040           LHLD    ABUSS
003.202  312 227 003           JZ      UFD1            IF MEMORY
                         *     AM DISPLAYING REGISTERS.
003.205  315 047 003           CALL    LRA             LOCATE REGISTER ADDRESS
003.210  345                   PUSH    H
003.211  041 342 003           LXI     H,DSPA
003.214  031                   DAD     D               (H,L) = ADDRESS OF REG NAME PATTERNS
003.215  176                   MOV     A,M
003.216  043                   INX     H
003.217  146                   MOV     H,M
003.220  157                   MOV     L,A             (H,L) = REG NAME PATTERN
003.221  343                   XTHL
003.222  264                   ORA     H               CLEAR 'Z'
003.223  176                   MOV     A,M
003.224  043                   INX     H
003.225  146                   MOV     H,M
003.226  157                   MOV     L,A             (HL) = ADDRESS OF REGISTER PAIR CONTENTS
                         *     SETUP DISPLAY
003.227  365             UFD1  PUSH    PSW
003.230  353                   XCHG
003.231  041 013 040           LXI     H,ALEDS
003.234  172                   MOV     A,D
003.235  315 122 003           CALL    DOD             FORMAT ABANK HIGH HALF
003.240  173                   MOV     A,E
003.241  315 122 003           CALL    DOD             FORMAT ABANK LOW HALF
003.244  361                   POP     PSW
```

```
003.245  032                 LDAX   D
003.246  312 122 003         JZ     DOD             IF MEMORY, DECODE BYTE VALUE

                     *       IS REGISTER. SET REGISTER NAME.

003.251  066 377             MVI    M,377Q          CLEAR DIGIT
003.253  341                 POP    H
003.254  042 022 040         SHLD   DLEDS+1
003.257  311                 RET
```

```
PAM/8 - H8 FRONT PANEL MONITOR  #01.00.00.                    HEATH X8ASM V1.1  06/21/77
RCK - READ CONSOLE KEYPAD.                                      15:44:39  01-APR-77  PAGE    32

                           **       RCK - READ CONSOLE KEYPAD.
                           *
                           *        RCK IS CALLED TO READ A KEYSTROKE FROM THE CONSOLE KEYPAD.
                           *        WHENEVER A KEY IS ACCEPTED.
                           *        RCK PERFORMS DEBOUNCING, AND AUTO-REPEAT. A *BIP* IS SOUNDED
                           *        WHEN A VALUE IS ACCEPTED.
                           *
                           *        KEY PAD VALUES:
                           *
                           *        1111 1110  -  0
                           *        1111 1100  -  1
                           *        1111 1010  -  2
                           *        1111 1000  -  3
                           *        1111 0110  -  4
                           *        1111 0100  -  5
                           *        1111 0010  -  6
                           *        1111 0000  -  7
                           *        1110 1111  -  8
                           *        1100 1111  -  9
                           *        1010 1111  -  +
                           *        1000 1111  -  -
                           *        0110 1111  -  *
                           *        0100 1111  -  /
                           *        0010 1111  -  #
                           *        0000 1111  -  .
                           *
                           *
                           *        ENTRY    NONE
                           *        EXIT     TO CALLER WHEN A KEY IS HIT
                           *                 (A) =  0 - '0'
                           *                        1 - '1'
                           *                        2 - '2'
                           *                        3 - '3'
                           *                        4 - '4'
                           *                        5 - '5'
                           *                        6 - '6'
                           *                        7 - '7'
                           *                        8 - '8'
                           *                        9 - '9'
                           *                       10 - '+'
                           *                       11 - '-'
                           *                       12 - '*'
                           *                       13 - '/'
                           *                       14 - '#'
                           *                       15 - '.'
                           *        USES     A,F


003.260                    RCK      EQU      *
003.260  345                        PUSH     H
003.261  305                        PUSH     B
003.262  016 024                    MVI      C,400/20         WAIT 400 MS
003.264  041 026 040                LXI      H,RCKA

003.267  333 360           RCK1     IN       IP.PAD           INPUT PAD VALUE
003.271  107                        MOV      B,A              (B) = VALUE
```

```
003.272  076 012             MVI     A,20/2
003.274  315 053 000         CALL    DLY             WAIT 20 MS
003.277  170                 MOV     A,B
003.300  276                 CMP     M
003.301  302 310 003         JNE     RCK2            HAVE A CHANGE
003.304  015                 DCR     C
003.305  302 267 003         JNZ     RCK1            WAIT N CYCLES

                     *       HAVE KEY VALUE

003.310  167         RCK2    MOV     M,A             UPDATE RCKA
003.311  356 376             XRI     376Q            INVERT ALL BUT GROUP 0 FLAG
003.313  017                 RRC
003.314  322 326 003         JNC     RCK3            HIT BANK 0
003.317  017                 RRC
003.320  017                 RRC
003.321  017                 RRC
003.322  017                 RRC
003.323  322 267 003         JNC     RCK1            NO HIT AT ALL
003.326  107         RCK3    MOV     B,A             (B) = CODE
003.327  076 002             MVI     A,4/2
003.331  315 140 002         CALL    HORN            MAKE BIP
003.334  170                 MOV     A,B
003.335  346 017             ANI     17Q
003.337  301                 POP     B
003.340  341                 POP     H
003.341  311                 RET                     RETURN
```

```
                        **      DISPLAY SEGMENT CODING:
                        *
                        *       BYTE = 76 543 210
                        *
                        *
                        *
                        *
                        *
                        *
                        *
```




```
                        **      REGISTER INDEX TO 7-SEGMENT PATTERN

003.342                 DSPA    DS      0
003.342  244 230                DW      1001100010100100B    SP
003.344  220 234                DW      1001110010010000B    AF
003.346  206 215                DW      1000110110000110B    BC
003.350  302 214                DW      1000110011000010B    DE
003.352  222 217                DW      1000111110010010B    HL
003.354  230 316                DW      1100111010011000B    PC


                        **      OCTAL TO 7-SEGMENT PATTERN

003.356                 DODA    DS      0
003.356  001                    DB      00000001B       0
003.357  163                    DB      01110011B       1
003.360  110                    DB      01001000B       2
003.361  140                    DB      01100000B       3
003.362  062                    DB      00110010B       4
003.363  044                    DB      00100100B       5
003.364  004                    DB      00000100B       6
003.365  161                    DB      01110001B       7
003.366  000                    DB      00000000B       8
003.367  040                    DB      00100000B       9


                        **      I/O ROUTINES TO BE COPIED INTO AND USED IN RAM.
                        *
                        *       MUST CONTINUE TO 3777A FOR PROPER COPY.
                        *       THE TABLE MUST ALSO BE BACKWARDS TO THE FINAL RAM

003.371                         ORG     4000A-7

003.371                 PRSROM  EQU     *
003.371  001                    DB      1               REFIND
003.372  000                    DB      0               CTLFLG
003.373  000                    DB      0               .MFLAG
```

```
003.374  000        1405        DB      0             DSPMOD
003.375  000        1406        DB      0             DSPROT
003.376  012        1407        DB      10            REGI
003.377  311        1408        DB      MI.RET
                    1409
000.000             1410        ERRNZ *-4000A
```

```
PAM/8 - H8 FRONT PANEL MONITOR  #01.00.00.                HEATH X8ASM V1.1  06/21/77
RAM CELLS                                                   15:44:44  01-APR-77  PAGE    36

                    1413
                    1414  **       THE FOLLOWING ARE CONTROL CELLS AND FLAGS USED BY THE KEYPAD
                    1415  *        MONITOR.
                    1416
     040.000        1417           ORG     40000A             8192
     040.000        1418  START    DS      2                  DUMP STARTING ADDRESS
     040.002        1419  IOWRK    DS      2                  IN OR OUT INSTRUCTION
     040.004        1420  PRSRAM   EQU     *                  FOLLOWING CELLS INITIALIZED FROM ROM
     040.004        1421           DS      1                  RET
                    1422
     040.005        1423  REGI     DS      1                  INDEX OF REGISTER UNDER DISPLAY
     040.006        1424  DSPROT   DS      1                  PERIOD FLAG BYTE
     040.007        1425  DSPMOD   DS      1                  DISPLAY MODE
                    1426
     040.010        1427  .MFLAG   DS      1                  USER FLAG OPTIONS
                    1428  *                                   SEE *UO.XXX* BITS DESCRIBED AT FRONT
                    1429
     040.011        1430  CTLFLG   DS      1                  FRONT PANEL CONTROL BITS
     040.012        1431  REFIND   DS      1                  REFRESH INDEX (0 TO 7)
     000.007        1432  PRSL     EQU     *-PRSRAM           END OF AREA INITIALIZED FROM ROM
                    1433
     040.013        1434  FPLEDS   EQU     *                  FRONT PANEL LED PATTERNS
     040.013        1435  ALEDS    DS      1                  ADDR 0
     040.014        1436           DS      1                  ADDR 1
     040.015        1437           DS      1                  ADDR 2
                    1438
     040.016        1439           DS      1                  ADDR 3
     040.017        1440           DS      1                  ADDR 4
     040.020        1441           DS      1                  ADDR 5
                    1442
     040.021        1443  DLEDS    DS      1                  DATA 0
     040.022        1444           DS      1                  DATA 1
     040.023        1445           DS      1                  DATA 2
                    1446
     040.024        1447  ABUSS    DS      2                  ADDRESS BUS
     040.026        1448  RCKA     DS      1                  RCK SAVE AREA
     040.027        1449  CRCSUM   DS      2                  CRC-16 CHECKSUM
     040.031        1450  TPERRX   DS      2                  TAPE ERROR EXIT ADDRESS
     040.033        1451  TICCNT   DS      2                  CLOCK TIC COUNTER
                    1452
     040.035        1453  REGPTR   DS      2                  REGISETR CONTENTS POINTER
                    1454
     040.037        1455  UIVEC    DS      0                  USER INTERRUPT VECTORS
     040.037        1456           DS      3                  JUMP TO CLOCK PROCESSOR
     040.042        1457           DS      3                  JUMP TO SINGLE STEP PROCESSOR
     040.045        1458           DS      3                  JUMP TO I/O 3
     040.050        1459           DS      3                  JUMP TO I/O 4
     040.053        1460           DS      3                  JUMP TO I/O 5
     040.056        1461           DS      3                  JUMP TO I/O 6
     040.061        1462           DS      3                  JUMP TO I/O 7
                    1463
     040.064        1464           END
ASSEMBLY COMPLETE
 1464 STATEMENTS
    0 ERRORS DETECTED
22310 BYTES FREE
```

CTLFLG	040011	217S	344S	494S	513S	574S	586S	594S	609S	630S	645S	699S	
.MFLAG	040010	344	381	386	418	459	465	1427L					
A.STX	000002	93E	793	983									
A.SYN	000026	92E	788	981									
ABORT	001147	529	617L										
ABUSS	040024	490	554	650	754	801	825	906	1229	1447L			
ALARM	002136	469	854L	920									
ALEDS	040013	1253	1435L										
BLKSIZ	002000	118E											
CB.CLI	000100	99E	136	256	464								
CB.MTL	000040	98E	331	415	464	701							
CB.SPK	000200	100E	256	464	856								
CB.SSI	000020	97E	256	331	464	688	697						
CLK2	000234	393	395L										
CLK3	000237	389	398E										
CLK4	000313	422	438E										
CLOCK	000201	202	203	369L									
CRC	002347	1044L	1105										
CRC1	002356	1048L	1068										
CRC2	003004	1059	1066L										
CRCSUM	040027	796	834	889	989	1047	1069	1449L					
CTC	002172	761	888L										
CTLFLG	040011	217	328	386	391	413	418	465	687	690	699	861	871
		1430L											
CUI1	000165	345L	441										
DLEDS	040021	1266	1443L										
DLY	000053	248L	1328										
DM.MR	000000	104E											
DM.MW	000001	105E											
DM.RR	000002	106E											
DM.RW	000003	107E											
DOD	003122	1177L	1255	1257	1260								
DOD1	003127	1180L	1198										
DODA	003356	1178	1185	1382L									
DSPA	003342	1236	1372L										
DSPMOD	040007	481	494	513	574	576	594	645	647	1226	1425L		
DSPROT	040006	485	576	647	1220	1226	1424L						
DUMP	002002	786L											
ERROR	000322	298	434	458E	503	562	583	937	1153				
FPLEDS	040013	1434E											
GO	001222	521	679L										
GO.	000063	256L	679										
HORN	002140	855L	1166	1348									
HRN0	002143	250	858L										
HRN2	002160	869L	870										
IN	001177	522	660L										
INIT	000073	192	193	275L	279								
INIT0	000000	190L											
INIT1	000107	288L	293										
INIT2	000117	295L											
INT1	000010	197E											
INT2	000020	212E											
INT3	000030	229L											
INT4	000040	234L											
INT5	000050	239L											
INT6	000060	253L											
INT7	000070	260L											
INTXIT	000172	352L	416	692									

CROSS REFERENCE TABLE. XREF V1.0 PAGE 38

IOA	003062	565	651	1134L			
IOB	003066	545	1134	1149L			
IOB1	003070	1150L	1164				
IOWRK	040002	666	667	1419L			
IP.PAD	000360	81E	439	922	951	1325	
IP.TPC	000371	85E	953				
IP.TPD	000370	87E	1023				
LAST	001150	528	625L				
LOA0	001272	726L	769				
LOA1	001342	752L	759				
LOAD	001267	724E					
LRA	003047	560	1119L	1234			
LRA.	003052	427	743	813	1120L		
LST2	001154	631L					
MEMM	001165	531	644L				
MI.ANI	000346	128E	912				
MI.HLT	000166	123E	433				
MI.IN	000333	125E	660				
MI.LDA	000072	127E					
MI.LXID	000021	129E	661				
MI.OUT	000323	126E	662				
MI.RET	000311	124E	1408				
MTR	000344	476E	702				
MTR1	000345	479	479L				
MTR4	001005	492	502L				
MTR5	001051	497	541L				
MTR6	001067	543	559L				
MTRA	001035	506	520E				
NEXT	001132	527	604L				
OP.CTL	000360	82E	689	698			
OP.DIG	000360	83E	400				
OP.SEG	000361	84E	402				
OP.TPC	000371	86E	304	787	845	936	1019	1102
OP.TPD	000370	88E	1104				
OUT	001202	523	662L				
PRSL	000007	191	1432E				
PRSRAM	040004	191	1420E	1432			
PRSROM	003371	190	1401E				
R$W	001126	530	595L				
RCK	003260	489	580	1150	1319E		
RCK1	003267	1325L	1333	1345			
RCK2	003310	1331	1337L				
RCK3	003326	1340	1346L				
RCKA	040026	1323	1448L				
REFIND	040012	391	1431L				
REGI	040005	512	586	609	630	1119	1423L
REGM	001104	532	573L				
REGPTR	040035	335	467	1122	1453L		
RMEM	001261	525	708L				
RNB	002331	752	979	1004	1018L		
RNB1	002335	1020L	1022				
RNP	002325	738	748	888	990	1004L	
RT.BP	000002	113E					
RT.CT	000003	114E					
RT.MI	000001	112E	725	797			
SAE	001063	554L	605	626	670		
SAVALL	000132	200	215	319L			
SINCR	004000	281E	283	284			

```
SRS      002265    726      975E
SRS1     002265    976L     984     988
SRS2     002271    979L     982
SST1     001235    257      690L
SSTEP    001225    524      685E
START    040000    284      750     799     1418L
STPRTN   001244    218      696E
TER1     002220    920L     927
TER3     002215    913L     924
TFT      002133    768      844L    908
TICCNT   040033    369      371     406     865     925     1451L
TPABT    002244    708      783     935L
TPERR    002205    737      906L
TPERRX   040031    709      784     955     1450L
TPXIT    002252    921      951L    1020    1098
UCI.ER   000020    165E     1018    1101
UCI.IE   000002    167E
UCI.IR   000100    163E
UCI.RE   000004    166E     1018
UCI.RO   000040    164E     1018
UCI.TE   000001    168E     786     1101
UFD      003161    409      1215E
UFD1     003227    1230     1251L
UIVEC    040037    229      234     239     253     260     348     703     1455L
UMI.16X  000002    158E     303
UMI.1R   000100    148E     303
UMI.1X   000001    157E
UMI.2B   000300    150E
UMI.64X  000003    159E
UMI.HB   000200    149E
UMI.L5   000000    153E
UMI.L6   000004    154E
UMI.L7   000010    155E
UMI.L8   000014    156E     303
UMI.PA   000020    152E
UMI.PE   000040    151E
UO.CLK   000001    138E     346
UO.DDU   000002    137E     461     1216
UO.HLT   000200    135E     420
UO.NFR   000100    136E     384     461
USR.FE   000040    172E
USR.OE   000020    173E
USR.PE   000010    174E
USR.RXR  000002    176E     1021
USR.TXE  000004    175E
USR.TXR  000001    177E     1099
WME1     002012    790L     792
WME2     002104    823L     830
WMEM     001374    526      782E
WNB      003024    790      794     824     1084    1097L
WNB1     003025    1098L    1100
WNP      003017    798      809     818     821     835     836     1083L

25434 BYTES FREE
```

APPENDIX B

Demo: PAM-8

This program shows the advanced features of PAM-8 and, as such, should not be evaluated as either an efficient or useful routine. The program uses the H8 clock, keyboard, display and interrupt capabilities to create an accurate interval timer that lets you enter an integer value from zero through nine seconds. When the program has counted down to zero, an audio alert is sounded, ending the program and returning control to PAM-8.

Use the H8 keypad to enter the machine code, set the program counter, and execute the program. While the program is being executed, the front panel display will be turned off and the computer will wait for you to enter a digit from the keypad. A single digit corresponding to the integer you selected is displayed and decremented until control is returned to PAM-8.

The timer is typical of a program you might create. An interval timer, a clock, or even a game requires that you communicate with the H8. The keypad lets you communicate with the CPU, and the CPU uses the LED display to communicate with you. The computer understands the selected time interval when you press a decimal key on the front panel. The job status, or decremented time interval, is relayed to you by the front panel displays. This interaction between you and the machine is characteristic of most software applications.

The program uses the PAM-8 firmware. Although it appears simple enough, you must study both the program and the PAM-8 listing ("Appendix A") in order to understand what happens when the program is operating. We suggest that you take a course in assembly language programming, such as the Heath EC-1108, if you have difficulty understanding the program.

The program source listing was prepared on an H8 computer system using the text editor (TED-8) and the assembler (HASL-8). NOTE: Your programs can be handwritten and assembled if you have only an H8.

The Sample Program

This program initially blanks the LED display and waits for you to enter an integer value. The computer verifies that the value you selected is permissible and then increments and stores the integer. The value was incremented because the display routine always decrements the count by one when it is called.

The most subtle part of this program is the interrupt service routine.* The H8 requires that you initialize the interrupt service routine by loading an instruction and address into the user interrupt vector (UIVEC) before executing the interrupt. After UIVEC is initialized, the program will jump to the service routine after the next interrupt signal is generated.

The main body of the program is a "do-nothing" loop that holds the program in a wait status until the interval timer has reached zero. You could replace the loop with another program which would execute simultaneously with the clock counter. When the countdown is complete, the program returns the H8 computer to its original status before halting.

*NOTE: Basically, an interrupt is a CPU response to a control signal. This signal directs the software to automatically save the current CPU status and transfers program control to a specified routine, called an interrupt handler. When the interrupt handler completes the routine, program control returns to its original status and normal program execution continues.

```
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                         ***  ******************************************
                         *
                         *       DEMO: PAM8
                         *
                         *       SYSTEM DEFINITIONS
                         *

040.100                          ORG     40100A
000.322                  ERROR   EQU     322A     RESET PAM8
002.140                  HORN    EQU     2140A    MAKE NOISE
003.260                  RCK     EQU     3260A    READ CONSOLE KEYPAD
003.356                  DODA    EQU     3356A    OCTAL TO 7-SEGMENT PATTERN
040.010                  .MFLAG  EQU     40010A   USER FLAG OPTIONS
040.013                  FPLEDS  EQU     40013A   FRONT PANEL L.E.D. PATTERNS
040.037                  UIVEC   EQU     40037A   USER INTERRUPT VECTOR
000.001                  UO.CLK  EQU     1A       ALLOW CLOCK INTERRUPT PROCESSING
000.002                  UO.DDU  EQU     2A       DISABLE DISPLAY UPDATE
000.303                  MI.JMP  EQU     303A     MACHINE INSTRUCTION (8080) JUMP
000.377                  LEDOFF  EQU     377A     BLANK L.E.D. DISPLAY
                         ***  ******************************************
                         *
                         *       DISABLE UPDATING OF L.E.D. DISPLAY
                         *       AND TURN OFF L.E.D.'S
                         *
040.100  076 002         PAM8    MVI     A,UO.DDU          DISABLE NORMAL UPDATING
040.102  062 010 040             STA     .MFLAG               DONE
040.105  041 013 040             LXI     H,FPLEDS          L.E.D. DISPLAY ADDRESS
040.110  006 011                 MVI     B,9               COUNT L.E.D.'S
040.112  076 377                 MVI     A,LEDOFF          TURN OFF L.E.D.
040.114  167             BLANK   MOV     M,A                  O.K. - GO
040.115  043                     INX     H                 NEXT L.E.D. ADDRESS
040.116  005                     DCR     B                 ALL DONE - ??
040.117  302 114 040             JNZ     BLANK                NO - DO AGAIN!
                         ***  ******************************************
                         *
                         *       READ A DECIMAL INTEGER FROM H8 FRONT PANEL
                         *          IF NOT DECIMAL -- RETURN TO PAM-8.
                         *          INCREMENT THE INTEGER (A PROGRAM REQUIREMENT)
                         *          STORE THE DIGIT.
                         *
040.122  315 260 003             CALL    RCK               READ CONSOLE KEYPAD
040.125  376 012                 CPI     10D               TEST IF ZERO THRU NINE
040.127  322 322 000             JNC     ERROR             ABORT TO PAM-8
040.132  074                     INR     A                 <A>=<A>+1
040.133  062 254 040             STA     DIGIT             STORE INTEGER
                         ***  ******************************************
                         *
                         *       INITIALIZE CLOCK COUNTER.
                         *          PROGRAM REQUIRES ONE INTERRUPT BEFORE DISPLAY
                         *
040.136  041 001 000             LXI     H,1               H=0 & L=1
040.141  042 252 040             SHLD    TICK              INITIALIZE COUNT
                         ***  ******************************************
                         *
                         *       INITIALIZE SERVICE INTERRUPT ROUTINE
                         *          LOAD THE USER INTERRUPT VECTOR (UIVEC) WITH A
                         *          JUMP INSTRUCTION AND THE ADDRESS OF THE SERVICE
                         *          ROUTINE.  ENABLE USER CLOCK INTERRUPT!
```

```
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                          *
040.144  076 303                 MVI     A,MI.JMP           SET-UP JUMP INSTRUCTION
040.146  062 037 040             STA     UIVEC         STORE 'JMP' INSTRUCTION
040.151  041 207 040             LXI     H,INTRP         USER INTERRUPT ADDRESS
040.154  042 040 040             SHLD    UIVEC+1            POSITIONED
040.157  076 003                 MVI     A,UO.DDU+UO.CLK
040.161  062 010 040             STA     .MFLAG        DISABLE UPDATE & ENABLE CLOCK INT.
                          ***   ***************************************************************
                          *
                          *      WAIT FOR CLOCK TO REACH ZERO
                          *
040.164  072 254 040 LOOP        LDA     DIGIT         DO NOTHING LOOP.
040.167  376 000                 CPI     0               WAIT FOR END
040.171  302 164 040             JNZ     LOOP            OF COUNT DOWN.
                          ***   ************************************************************
                          *
                          *      RETURN TO NORMAL INTERRUPT STATUS & HALT.
                          *         DISABLE INTERRUPT & TURN ON SPEAKER
                          *
040.174  076 002                 MVI     A,UO.DDU
040.176  062 010 040             STA     .MFLAG        DISABLE UPDATE & CLOCK INTERRUPT
040.201  076 372                 MVI     A,500/2       250 MS BEEP
040.203  315 140 002             CALL    HORN
040.206  166                     HLT
                          ***   *******************************************************
                          *
                          *      INTERRUPT ROUTINE
                          *         CLOCK AND DISPLAY INTERRUPT
                          *
040.207  052 252 040 INTRP       LHLD    TICK          GET COUNT (BETWEEN 0 & 500)
040.212  053                     DCX     H             TICK=TICK-1
040.213  042 252 040             SHLD    TICK          STORE COUNT
040.216  175                     MOV     A,L           TEST FOR ZERO
040.217  264                     ORA     H               COMPARE WITH 'H'
040.220  300                     RNE                     EXIT IF .NE. 0
                          ***   *********************************************************
                          *
                          *      UPDATE L.E.D. DISPLAY FOR 'NEW' DIGIT.
                          *
040.221  072 254 040             LDA     DIGIT         GET INTEGER
040.224  075                     DCR     A             DIGIT=DIGIT-1
040.225  062 254 040             STA     DIGIT         SAVE INTEGER
040.230  041 356 003             LXI     H,DODA        DECODE DISPLAY ADDRESS
040.233  205                     ADD     L             POSITION DISPLAY
040.234  157                     MOV     L,A           ALL SET -- GO
040.235  176                     MOV     A,M             DISPLAY SET
040.236  366 200                 ORI     200Q            MASK - TURN OFF D.P.
040.240  062 017 040             STA     FPLEDS+4        TURN-ON-THE-LIGHTS
040.243  041 364 001             LXI     H,500         RESTORE COUNT
040.246  042 252 040             SHLD    TICK            WITH 500
040.251  311                     RET
                          *              STORAGE AREA & END ASSEMBLY
040.252                   TICK   DS      2
040.254  001              DIGIT  DB      1
040.255  000                     END     PAM8

 00130 STATEMENTS ASSEMBLED
 12275 BYTES FREE
  NO ERRORS DETECTED
```

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