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.

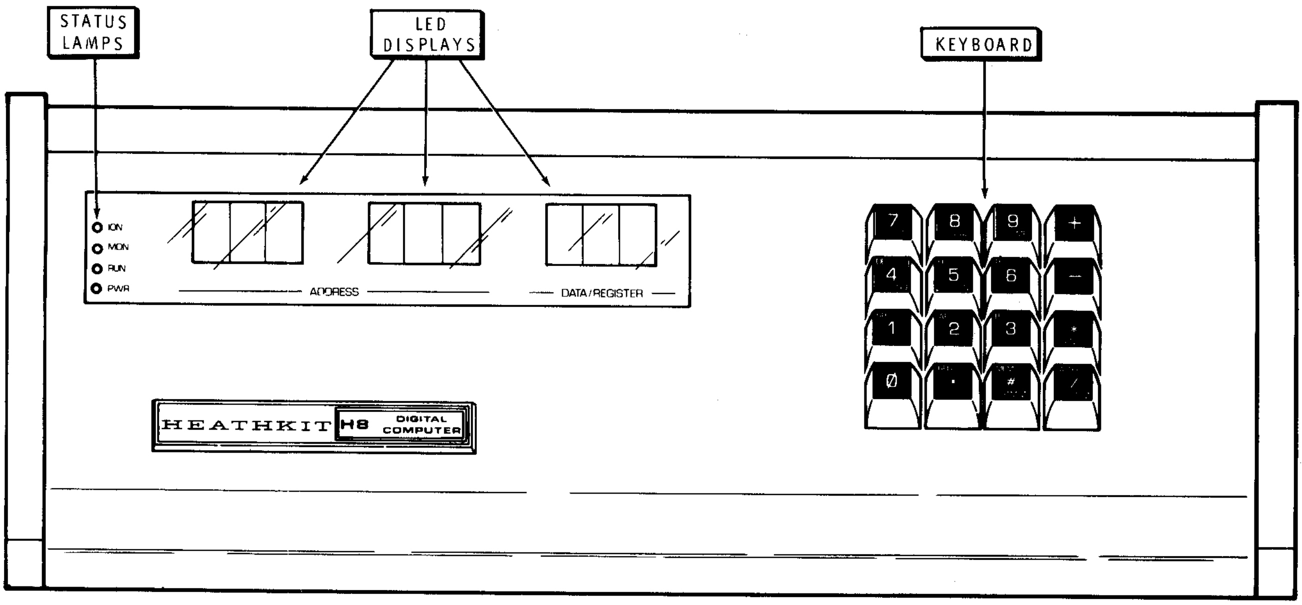

Figure 1-1

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.

$$\underbrace{00}_{\text{Most significant octal digit (0-3).}}\quad\underbrace{000}_{\text{Middle octal digit (0-7).}}\quad\underbrace{000}_{\text{Least significant octal digit (0-7),}}$$

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:

$$\underbrace{11}_{3}\,\underbrace{111}_{7}\,\underbrace{111}_{7}\quad\underbrace{11}_{3}\,\underbrace{111}_{7}\,\underbrace{111}_{7}$$

A 16-bit binary number

Offset octal representation (377 377)

$$\underbrace{1}_{1}\,\underbrace{111}_{7}\,\underbrace{111}_{7}\,\underbrace{111}_{7}\,\underbrace{111}_{7}\,\underbrace{111}_{7}$$

A 16-bit binary number

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:

$$\underbrace{377}_{\text{Hi Byte}}.\underbrace{377}_{\text{Lo Byte}}$$

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.

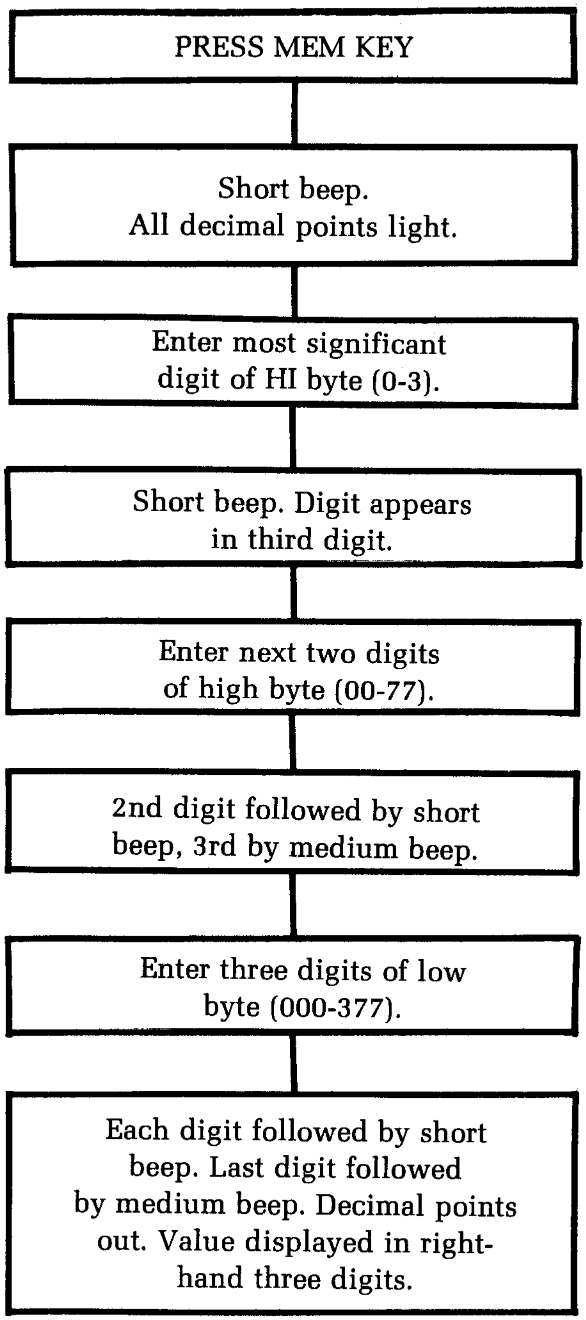

Figure 1-2
Entering a memory address through PAM-8.

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  #01.00.00.                    HEATH X8ASM V1.1  06/21/77
 INTRODUCTION.                                                  15:43:50  01-APR-77  PAGE     1

***     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)
```

```
PAM/8 - H8 FRONT PANEL MONITOR  #01.00.00.              HEATH X8ASM V1.1  06/21/77
 INTRODUCTION.                                            15:43:51  01-APR-77  PAGE      2

*               (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
```

```
PAM/8 - H8 FRONT PANEL MONITOR  #01.00.00.                HEATH XBASM V1.1  06/21/77
ASSEMBLY CONSTANTS.                                         15:43:56  01-APR-77  PAGE    4

                         **       MACHINE INSTRUCTIONS.
     000.166             MI.HLT   EQU      01110110B       HALT
     000.311             MI.RET   EQU      11001001B       RETURN
     000.333             MI.IN    EQU      11011011B       INPUT
     000.323             MI.OUT   EQU      11010011B       OUTPUT
     000.072             MI.LDA   EQU      00111010B       LDA
     000.346             MI.ANI   EQU      11100110B       ANI
     000.021             MI.LXID  EQU      00010001B       LXI D

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

     000.000                      XTEXT    U8251           DEFINE 8251 USART BITS
```

```
PAM/8 - H8 FRONT PANEL MONITOR  #01.00.00.                 HEATH X8ASM V1.0  02/18/77
8251 USART BIT DEFINITIONS.                                   13:23:23  01-APR-77  PAGE     5

                           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
```

```
PAM/8 - H8 FRONT PANEL MONITOR  #01.00.00.                   HEATH X8ASM V1.0  02/18/77
HARDWARE INTERRUPT VECTORS                                      13:23:25  01-APR-77  PAGE      6

                              ***     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,FRSROM          (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             INTO 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                         ORG    30A
000.030  303 045 040    INT3    JMP    UIVEC+6          JUMP TO USER ROUTINE

000.033  064 064 064            DB     '44413'          HEATH PART NUMBER 444-13


000.040                         ORG    40A
000.040  303 050 040    INT4    JMP    UIVEC+9          JUMP TO USER ROUTINE

000.043  100 112 107            DB     100Q,112Q,107Q,114Q,100Q        SUPPORT CODE


000.050                         ORG    50A
000.050  303 053 040    INT5    JMP    UIVEC+12         JUMP TO USER ROUTINE


                        **      DLY - DELAY TIME INTERVAL.
                        *
                        *       ENTRY  (A) = MILLISECOND DELAY COUNT/2
                        *       EXIT   NONE
                        *       USES   A,F

000.053  365            DLY     PUSH   PSW              SAVE COUNT
000.054  257                    XRA    A                DONT SOUND HORN
000.055  303 143 002            JMP    HRNO             PROCESS AS HORN


000.060                         ORG    60A
000.060  303 056 040    INT6    JMP    UIVEC+15         JUMP TO USER ROUTINE


000.063  076 320        GO.     MVI    A,CB.SSI+CB.CLI+CB.SPK  OFF MONITOR MODE LIGHT
000.065  303 235 001            JMP    SST1             RETURN TO USER PROGRAM


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

```
PAM/8 - H8 FRONT PANEL MONITOR  #01.00.00.                HEATH X8ASM V1.0  02/18/77
MASTER CLEAR PROCESSING                                     13:23:28  01-APR-77  PAGE     8

                               263  **      INIT - INITIALIZE SYSTEM
                               264  *
                               265  *       INIT IS CALLED WHENEVER A HARDWARE MASTER-CLEAR IS INITIATED.
                               266  *
                               267  *       SETUP PAM/8 CONTROL CELLS IN RAM.
                               268  *       DECODE HOW MUCH MEMORY EXISTS, SETUP STACKPOINTER, AND
                               269  *       ENTER THE MONITOR LOOP.
                               270  *
                               271  *       ENTRY   FROM MASTER CLEAR
                               272  *       EXIT    INTO PAM/8 MAIN LOOP
                               273
                               274
  000.073  032                 275  INIT    LDAX    D                   COPY *PRSROM* INTO RAM
  000.074  167                 276          MOV     M,A                 MOVE BYTE
  000.075  053                 277          DCX     H                   DECREMENT DESTINATION
  000.076  034                 278          INR     E                   INCREMENT SOURCE
  000.077  302 073 000         279          JNZ     INIT                IF NOT DONE
                               280
  004.000                      281  SINCR   EQU     4000A               SEARCH INCREMENT
                               282
  000.102  026 004             283          MVI     D,SINCR/256         (DE) = SEARCH INCREMENT
  000.104  041 000 034         284          LXI     H,START-SINCR       (HL) = FIRST RAM - SEARCH INCREMENT
                               285
                               286  *       DETERMINE MEMORY LIMIT.
                               287
  000.107  167                 288  INIT1   MOV     M,A                 RESTORE VALUE READ
  000.110  031                 289          DAD     D                   INCREMENT TRIAL ADDRESS
  000.111  176                 290          MOV     A,M                 (A) = CURRENT MEMORY VALUE
  000.112  065                 291          DCR     M                   TRY TO CHANGE IT
  000.113  276                 292          CMP     M
  000.114  302 107 000         293          JNE     INIT1               IF MEMORY CHANGED
                               294
  000.117  053                 295  INIT2   DCX     H
  000.120  371                 296          SPHL                        SET STACKPOINTER = MEMORY LIMIT -1
  000.121  345                 297          PUSH    H                   SET *PC* VALUE ON STACK
  000.122  041 322 000         298          LXI     H,ERROR
  000.125  345                 299          PUSH    H                   SET 'RETURN ADDRESS'
                               300
                               301  *       CONFIGURE LOAD/DUMP UART
                               302
  000.126  076 116             303          MVI     A,UMI.1B+UMI.L8+UMI.16X
  000.130  323 371             304          OUT     OP.TPC              SET 8 BIT, NO PARITY, 1 STOP, X16
```

```
PAM/8 - H8 FRONT PANEL MONITOR  #01.00.00.                HEATH X8ASM V1.0  02/18/77
INTERRUPT TIME SUBROUTINES                                  13:23:29  01-APR-77  PAGE     9

                         **      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
```

```
PAM/8 - H8 FRONT PANEL MONITOR  #01.00.00.                    HEATH X8ASM V1.0  02/18/77
PROCESS CLOCK INTERRUPTS                                        13:23:31  01-APR-77  PAGE    10

                         361  ***     CLOCK - PROCESS CLOCK INTERRUPT
                         362  *
                         363  *       CLOCK IS ENTERED WHENEVER A MILLISECOND CLOCK INTERRUPT IS
                         364  *       PROCESSED.
                         365  *
                         366  *       TICCNT IS INCREMENTED EVERY INTERRUPT.
                         367
                         368
000.201  052 033 040     369  CLOCK   LHLD    TICCNT
000.204  043             370          INX     H
000.205  042 033 040     371          SHLD    TICCNT           INCREMENT TICCOUNT
                         372
                         373  **      REFRESH FRONT PANEL.
                         374  *
                         375  *       THIS CODE DISPLAYS THE APPROPRIATE PATTERN ON THE
                         376  *       FRONT PANEL LEDS. THE LEDS ARE PAINTED IN REVERSE ORDER,
                         377  *       ONE PER INTERRUPT. FIRST, NUMBER 9 IS LIT, THEN NUMBER 8,
                         378  *       ETC.
                         379
                         380
000.210  041 010 040     381          LXI     H,.MFLAG
000.213  176             382          MOV     A,M
000.214  107             383          MOV     B,A              (B) = CURRENT FLAG
000.215  346 100         384          ANI     UO.NFR           SEE IF FRONT PANEL REFRESH WANTED
000.217  043             385          INX     H
000.000                  386          ERRNZ   CTLFLG-.MFLAG-1
000.220  176             387          MOV     A,M              (A) = CTLFLG
000.221  112             388          MOV     C,D              (C) = 0 IN CASE NO PANEL DISPLAY
000.222  302 237 000     389          JNZ     CLK3             IF NOT
000.225  043             390          INX     H                (H,L) = (REFIND)
000.000                  391          ERRNZ   REFIND-CTLFLG-1
000.226  065             392          DCR     M                DECREMENT DIGIT INDEX
000.227  302 234 000     393          JNZ     CLK2             IF NOT WRAP-AROUND
000.232  066 011         394          MVI     M,9              WRAP DISPLAY AROUND
000.234  136             395  CLK2    MOV     E,M
000.235  031             396          DAD     D                (H,L) = ADDRESS OF PATTERN
000.236  113             397          MOV     C,E
000.237                  398  CLK3    EQU     *                (A) = CTLNLG
000.237  261             399          ORA     C                (A) = INDEX + FIXED BITS
000.240  323 360         400          OUT     OP.DIG           SELECT DIGIT
000.242  176             401          MOV     A,M
000.243  323 361         402          OUT     OP.SEG           SELECT SEGMENT
                         403
                         404  *       SEE IF TIME TO DECODE DISPLAY VALUES.
                         405
000.245  056 033         406          MVI     L,#TICCNT
000.247  176             407          MOV     A,M
000.250  346 037         408          ANI     37Q              EVERY 32 INTERRUPTS
000.252  314 161 003     409          CZ      UFD              UPDATE FRONT PANEL DISPLAYS
                         410
                         411  *       EXIT CLOCK INTERRUPT.
                         412
000.255  001 011 040     413          LXI     B,CTLFLG
000.260  012             414          LDAX    B                (A) = CTLFLG
000.261  346 040         415          ANI     CB.MTL
000.263  302 172 000     416          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                      DCX     B
000.000                           ERRNZ   CTLFLG-.MFLAG-1
000.267  012                      LDAX    B                (A) = .MFLAG
000.000                           ERRNZ   UO.HLT-200Q      ASSUME HIGH-ORDER
000.270  027                      RAL
000.271  332 313 000              JC      CLK4             SKIP IT

                          *       NOT IN MONITOR MODE. CHECK FOR HALT

000.274  076 012                  MVI     A,10             (A) = INDEX OF *P* REG
000.276  315 052 003              CALL    LRA.             LOCATE REGISTER ADDRESS
000.301  136                      MOV     E,M
000.302  043                      INX     H
000.303  126                      MOV     D,M              (D,E) = PC CONTENTS
000.304  033                      DCX     D
000.305  032                      LDAX    D
000.306  376 166                  CPI     MI.HLT           CHECK FOR HALT
000.310  312 322 000              JE      ERROR            IF HALT, BE IN MONITOR MODE

                          *       CHECK FOR 'RETURN TO MONITOR' KEY ENTRY.

000.313                   CLK4    EQU     *
000.313  333 360                  IN      IP.PAD
000.315  376 056                  CPI     56Q              SEE IF '0' AND '#'
000.317  302 165 000              JNE     CUI1             IF NOT, ALLOW USER PROCESSING OF CLOCK
```

```
PAM/8 - H8 FRONT PANEL MONITOR  #01.00.00.                 HEATH X8ASM V1.1  06/21/77
MTR - MAIN EXECUTIVE LOOP.                                   15:44:09  01-APR-77  PAGE    12

                              445  ***    ERROR - COMMAND ERROR.
                              446  *
                              447  *      ERROR IS CALLED AS A 'BAIL-OUT' ROUTINE.
                              448  *
                              449  *      IT RESETS THE OPERATIONAL MODE, AND RESTORES THE STACKPOINTER.
                              450  *
                              451  *      ENTRY   NONE
                              452  *      EXIT    TO MTR LOOP
                              453  *              CTLFLG SET
                              454  *              .MFLAG CLEARED
                              455  *      USES    ALL
                              456
                              457
000.322                       458  ERROR  EQU     *
000.322  041 010 040          459         LXI     H,.MFLAG
000.325  176                  460         MOV     A,M             (A) = .MFLAG
000.326  346 275              461         ANI     377Q-UO.DDU-UO.NFR     RE-ENABLE DISPLAYS
000.330  167                  462         MOV     M,A             REPLACE
000.331  043                  463         INX     H
000.332  066 360              464         MVI     M,CB.SSI+CB.MTL+CB.CLI+CB.SPK    RESTORE *CTLFLG*
000.000                       465         ERRNZ   CTLFLG-.MFLAG-1
000.334  373                  466         EI
000.335  052 035 040          467         LHLD    REGPTR
000.340  371                  468         SPHL                    RESTORE STACK POINTER TO EMPTY STATE
000.341  315 136 002          469         CALL    ALARM           ALARM FOR 200 MS


                              471  **     MTR - MONITOR LOOP.
                              472  *
                              473  *      THIS IS THE MAIN EXECUTIVE LOOP FOR THE FRONT PANEL EMULATOR.
                              474
                              475
000.344                       476  MTR    EQU     *
000.344  373                  477         EI
                              478
000.345  041 345 000          479  MTR1   LXI     H,MTR1
000.350  345                  480         PUSH    H               SET 'MTR1' AS RETURN ADDRESS
000.351  001 007 040          481         LXI     B,DSPMOD        (BC) = #DSPMOD
000.354  012                  482         LDAX    B
000.355  346 001              483         ANI     1               (A) = 1 IF ALTER
000.357  057                  484         CMA
000.360  062 006 040          485         STA     DSPROT          ROTATE LED PERIODS IF ALTER
                              486
                              487  *      READ KEY
                              488
000.363  315 260 003          489         CALL    RCK             READ CONSOLE KEYPAD
000.366  052 024 040          490         LHLD    ABUSS
000.371  376 012              491         CPI     10
000.373  322 005 001          492         JNC     MTR4            IF IN 'ALWAYS VALID' GROUP
000.376  137                  493         MOV     E,A             SAVE VALUE
040.007                       494  .      SET     DSPMOD
000.377  012                  495         LDAX    B               (A) = DSPMOD
001.000  017                  496         RRC
001.001  332 051 001          497         JC      MTR5            IF IN ALTER MODE
```

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PAM/8 - H8 FRONT PANEL MONITOR  #01.00.00.                 HEATH X8ASM V1.0  02/18/77
MTR - MAIN EXECUTIVE LOOP.                                   13:23:37  01-APR-77  PAGE    13

001.004  173            498          MOV     A,E          (A) = CODE
                        499
                        500  *       HAVE A COMMAND (NOT A VALUE)
                        501
001.005  326 004        502  MTR4    SUI     4            (A) = COMMAND
001.007  332 322 000    503          JC      ERROR        IF BAD
001.012  137            504          MOV     E,A
001.013  345            505          PUSH    H            SAVE ABUSS VALUE
001.014  041 035 001    506          LXI     H,MTRA
001.017  026 000        507          MVI     D,0
001.021  031            508          DAD     D            (H,L) = ADDRESS OF TABLE ENTRY
001.022  136            509          MOV     E,M
001.023  031            510          DAD     D            (H,L) = ADDRESS OF PROCESSOR
001.024  343            511          XTHL                 SET ADDRESS, (H,L) = (ABUSS)
001.025  021 005 040    512          LXI     D,REGI       (D,E) = ADDRESS OF REG INDEX
040.007                 513          SET     DSPMOD
001.030  012            514          LDAX    B            (A) = DSPMOD
001.031  346 002        515          ANI     2            SET 'Z' IF MEMORY
001.033  012            516          LDAX    B            (A) = DSPMOD
001.034  311            517          RET                  JUMP TO PROCESSOR
                        518
                        519
001.035                 520  MTRA    EQU     *            JUMP TABLE
001.035  165            521          DB      GO-*         4 - GO
001.036  141            522          DB      IN-*         5 - INPUT
001.037  143            523          DB      OUT-*        6 - OUTPUT
001.040  165            524          DB      SSTEP-*      7 - SINGLE STEP
001.041  220            525          DB      RMEM-*       8 - CASSETTE LOAD
001.042  332            526          DB      WMEM-*       9 - CASSETTE DUMP
001.043  067            527          DB      NEXT-*       + - NEXT
001.044  104            528          DB      LAST-*       - - LAST
001.045  102            529          DB      ABORT-*      * - ABORT
001.046  060            530          DB      R$W-*        / - DISPLAY/ALTER
001.047  116            531          DB      MEMM-*       # - MEMORY MODE
001.050  034            532          DB      REGM-*       . - REGISTER MODE


                        534  **      PROCESS MEMORY/REGISTER ALTERATIONS.
                        535  *
                        536  *       THIS CODE IS ENTERED IF
                        537  *
                        538  *       1) AM IN ALTER MODE, AND
                        539  *       2) A KEY FROM 0-7 WAS ENTERED.
                        540
001.051  017            541  MTR5    RRC
001.052  173            542          MOV     A,E          (A) = VALUE
001.053  332 067 001    543          JC      MTR6         IS REGISTER
001.056  067            544          STC                  INDICATE 1ST DIGIT IS IN (A)
001.057  315 066 003    545          CALL    IOB          INPUT OCTAL BYTE
001.062  043            546          INX     H            DISPLAY NEXT LOCATION
```

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PAM/8 - H8 FRONT PANEL MONITOR  #01.00.00.                         HEATH X8ASM V1.0  02/18/77
MTR - MAIN EXECUTIVE LOOP.                                           13:23:39  01-APR-77  PAGE    14

                              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
```

```
PAM/8 - H8 FRONT PANEL MONITOR  #01.00.00.                  HEATH X8ASM V1.1  06/21/77
MONITOR TASK SUBROUTINES.                                      15:44:14  01-APR-77  PAGE    15

                          569  **      REGM - ENTER REGISTER DISPLAY MODE.
                          570  *
                          571  *       ENTRY   (A) = DSPMOD
                          572  *               (BC) = #DSPMOD
                          573
  001.104  076 002        574  REGM    MVI     A,2                 SET DISPLAY REGISTER MODE
  040.007                 575          SET     DSPMOD
  001.106  002            576          STAX    B                   SET DISPLAY REGISTER MODE
  000.000                 577          ERRNZ   DSPMOD-DSPROT-1
  001.107  013            578          DCX     B                   (BC) = #DSPROT
  001.110  257            579          XRA     A
  001.111  002            580          STAX    B                   SET ALL PERIODS ON
  001.112  315 260 003    581          CALL    RCK                 READ KEY ENTRY
  001.115  075            582          DCR     A                   DISPLACE
  001.116  376 006        583          CPI     6
  001.120  322 322 000    584          JNC     ERROR               NOT 1-6
  001.123  007            585          RLC
  001.124  022            586          STAX    D                   SET NEW REG IND
  040.005                 587          SET     REGI
  001.125  311            588          RET


                          590  **      R$W - TOGGLE DISPLAY/ALTER MODE.
                          591  *
                          592  *       ENTRY   (A) = DSPMOD
                          593  *               (BC) = ADDRESS OF DSPMOD
                          594
  040.007                 595  .       SET     DSPMOD
  001.126  356 001        596  R$W     XRI     1
  001.130  002            597          STAX    B
  001.131  311            598          RET


                          600  **      NEXT - INCREMENT DISPLAY ELEMENT.
                          601  *
                          602  *       ENTRY   (HL) = (ABUSS)
                          603  *               (DE) = ADDRESS OF REGIND
                          604
  001.132  043            605  NEXT    INX     H
  001.133  312 063 001    606          JZ      SAE                 IF MEMORY, STORE ABUSS AND EXIT
                          607
                          608  *       IS REGISTER MODE.
                          609
  040.005                 610  .       SET     REGI
  001.136  032            611          LDAX    D                   (A) = REGI
  001.137  306 002        612          ADI     2                   INCREMENT REG INNEX
  001.141  022            613          STAX    D                   WRAP TO *SP*
  001.142  376 014        614          CPI     12
  001.144  330            615          RC                          IF NOT TOO LARGE, EXIT
  001.145  257            616          XRA     A                   OVERFLOW
  001.146  022            617          STAX    D
  001.147  311            618  ABORT   RET
```

```
PAM/8 - H8 FRONT PANEL MONITOR  #01.00.00.                   HEATH X8ASM V1.1  06/21/77
MONITOR TASK SUBROUTINES.                                      15:44:16  01-APR-77  PAGE    16

                            **      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
```

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PAM/8 - H8 FRONT PANEL MONITOR  #01.00.00.                 HEATH X8ASM V1.0  02/18/77
*GO* AND *STEP* FUNCTIONS                                   13:23:43  01-APR-77  PAGE    18

                           675  **      GO - RETURN TO USER MODE
                           676  *
                           677  *       ENTRY   NONE
                           678
001.222  303 063 000       679  GO      JMP     GO.             ROUTINE IS IN WASTE SPACE

                           681  **      SSTEP - SINGLE STEP INSTRUCTION.
                           682  *
                           683  *       ENTRY   NONE
                           684
001.225                    685  SSTEP   EQU     *               SINGLE STEP
001.225  363               686          DI                      DISABLE INTERRUPTS UNTIL THE RIGHT TIME
001.226  072 011 040       687          LDA     CTLFLG
001.231  356 020           688          XRI     CB.SSI          CLEAR SINGLE STEP INHIBIT
001.233  323 360           689          OUT     OP.CTL          PRIME SINGLE STEP INTERRUPT
001.235  062 011 040       690  SST1    STA     CTLFLG          SET NEW FLAG VALUES
001.240  341               691          POP     H               CLEAN STACK
001.241  303 172 000       692          JMP     INTXIT          RETURN TO USER ROUTINE FOR STEP

                           694  **      STPRTN - SINGLE STEP RETURN
                           695
001.244                    696  STPRTN  EQU     *
001.244  366 020           697          ORI     CB.SSI          DISABLE SINGLE STEP INTERRUPTION
001.246  323 360           698          OUT     OP.CTL          TURN OFF SINGLE STEP ENABLE
040.011                    699          SET     CTLFLG
001.250  022               700          STAX    D
001.251  346 040           701          ANI     CB.MTL          SEE IF IN MONITOR MODE
001.253  302 344 000       702          JNZ     MTR
001.256  303 042 040       703          JMP     UIVEC+3         TRANSFER TO USER'S ROUTINE

                           705  **      RMEM - LOAD MEMORY FROM TAPE.
                           706  *
                           707
001.261  041 244 002       708  RMEM    LXI     H,TPABT
001.264  042 031 040       709          SHLD    TPERRX          SETUP ERROR EXIT ADDRESS
                           710  *       JMP     LOAD
```

```
PAM/8 - H8 FRONT PANEL MONITOR  #01.00.00.                  HEATH X8ASM V1.1  06/21/77
LOAD - LOAD MEMORY FROM TAPE                                   15:44:19  01-APR-77  PAGE    19

                      ***     LOAD - LOAD MEMORY FROM TAPE.
                      *
                      *       READ THE NEXT RECORD FROM THE CASSETTE TAPE.
                      *
                      *       USE THE LOAD ADDRESS IN THE TAPE RECORD.
                      *
                      *       ENTRY   (HL) = ERROR EXIT ADDRESS
                      *       EXIT    USER P-REG (IN STACK) SET TO ENTRY ADDRESS
                      *               TO CALLER IF ALL OK
                      *               TO ERROR EXIT IF TAPE ERRORS DETECTED.


001.267               LOAD    EQU     *
001.267  001 000 376          LXI     B,1000A-RT.MI*256-256    (BC) = - REQUIRED TYPE AND #
001.272  315 265 002  LOA0    CALL    SRS               SCAN FOR RECORD START
001.275  157                  MOV     L,A               (HL) = COUNT
001.276  353                  XCHG                      (DE) = COUNT, (HL) = TYPE AND #
001.277  015                  DCR     C                 (C) = - NEXT #
001.300  011                  DAD     B
001.301  174                  MOV     A,H
001.302  305                  PUSH    B                 SAVE TYPE AND #
001.303  365                  PUSH    PSW               SAVE TYPE CODE
001.304  346 177              ANI     177Q              CLEAR END FLAG BIT
001.306  265                  ORA     L
001.307  076 002              MVI     A,2               SEQUENCE ERROR
001.311  302 205 002          JNE     TPERR             IF NOT RIGHT TYPE OR SEQUENCE
001.314  315 325 002          CALL    RNP               READ ADDR
001.317  104                  MOV     B,H
001.320  117                  MOV     C,A               (BC) = P-REG ADDRESS
001.321  076 012              MVI     A,10
001.323  325                  PUSH    D                 SAVE (DE)
001.324  315 052 003          CALL    LRA.              LOCATE REG ADDRESS
001.327  321                  POP     D                 RESTORE (DE)
001.330  161                  MOV     M,C               SET P-REG IN MEM
001.331  043                  INX     H
001.332  160                  MOV     M,B
001.333  315 325 002          CALL    RNP               READ ADDRESS
001.336  157                  MOV     L,A               (HL) = ADDRESS, (DE) = COUNT
001.337  042 000 040          SHLD    START

001.342  315 331 002  LOA1    CALL    RNB               READ BYTE
001.345  167                  MOV     M,A
001.346  042 024 040          SHLD    ABUSS             SET ABUSS FOR DISPLAY
001.351  043                  INX     H
001.352  033                  DCX     D
001.353  172                  MOV     A,D
001.354  263                  ORA     E
001.355  302 342 001          JNZ     LOA1              IF MORE TO GO

001.360  315 172 002          CALL    CTC               CHECK  TAPE CHECKSUM

                      *       READ NEXT BLOCK

001.363  361                  POP     PSW               (A) = FILE TYPE BYTE
001.364  301                  POP     B                 (BC) = -(LAST TYPE, LAST #)
001.365  007                  RLC
```

```
PAM/8 - H8 FRONT PANEL MONITOR  #01.00.00.                  HEATH X8ASM V1.1  06/21/77
LOAD - LOAD MEMORY FROM TAPE                                    15:44:21  01-APR-77  PAGE    20

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

```
PAM/8 - H8 FRONT PANEL MONITOR  #01.00.00.                HEATH X8ASM V1.0  02/18/77
DUMP - DUMP MEMORY TO MAG/PAPER TAPE                         13:23:47  01-APR-77  PAGE    21

                          772  ***     DUMP - DUMP MEMORY TO MAG TAPE.
                          773  *
                          774  *       DUMP SPECIFIED MEMORY RANGE TO MAG TAPE.
                          775  *
                          776  *       ENTRY   (START) = START ADDRESS
                          777  *               (ABUSS) = END ADDRESS
                          778  *               USER PC = ENTRY POINT ADDRESS
                          779  *       EXIT    TO CALLER.
                          780
                          781
001.374                   782  WMEM    EQU     *
001.374  041 244 002      783          LXI     H,TPABT
001.377  042 031 040      784          SHLD    TPERRX          SETUP ERROR EXIT
                          785
002.002  076 001          786  DUMP    MVI     A,UCI.TE
002.004  323 371          787          OUT     OP.TPC          SETUP TAPE CONTROL
002.006  076 026          788          MVI     A,A.SYN
002.010  046 040          789          MVI     H,32            (H) = # OF SYNC CHARACTERS
002.012  315 024 003      790  WME1    CALL    WNB
002.015  045              791          DCR     H
002.016  302 012 002      792          JNZ     WME1            WRITE SYN HEADER
002.021  076 002          793          MVI     A,A.STX
002.023  315 024 003      794          CALL    WNB             WRITE STX
002.026  154              795          MOV     L,H             (HL) = 00
002.027  042 027 040      796          SHLD    CRCSUM          CLEAR CRC 16
002.032  041 001 201      797          LXI     H,RT.MI+80H*256+1        FIRST AND LAST MI RECORD
002.035  315 017 003      798          CALL    WNP             WRITE HEADER
002.040  052 000 040      799          LHLD    START
002.043  353              800          XCHG                    (D,E) = START ADDRESS
002.044  052 024 040      801          LHLD    ABUSS           (H,L) = STOP ADDR
002.047  043              802          INX     H               COMPUTE WITH STOP+1
002.050  175              803          MOV     A,L
002.051  223              804          SUB     E
002.052  157              805          MOV     L,A
002.053  174              806          MOV     A,H
002.054  232              807          SBB     D
002.055  147              808          MOV     H,A             (HL) = COUNT
002.056  315 017 003      809          CALL    WNP             WRITE COUNT
002.061  345              810          PUSH    H
002.062  076 012          811          MVI     A,10
002.064  325              812          PUSH    D               SAVE (DE)
002.065  315 052 003      813          CALL    LRA.            LOCATE P-REG ADDRESS
002.070  176              814          MOV     A,M
002.071  043              815          INX     H
002.072  146              816          MOV     H,M
002.073  157              817          MOV     L,A             (HL) = CONTENTS OF PC
002.074  315 017 003      818          CALL    WNP             WRITE HEADER
002.077  341              819          POP     H               (HL) = ADDRESS
002.100  321              820          POP     D               (DE) = COUNT
002.101  315 017 003      821          CALL    WNP
                          822
002.104  176              823  WME2    MOV     A,M
002.105  315 024 003      824          CALL    WNB             WRITE BYTE
002.110  042 024 040      825          SHLD    ABUSS           SET ADDRESS FOR DISPLAY
002.113  043              826          INX     H
002.114  033              827          DCX     D
```

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PAM/8 - H8 FRONT PANEL MONITOR  #01.00.00.                 HEATH X8ASM V1.0  02/18/77
DUMP - DUMP MEMORY TO MAG/PAPER TAPE                         13:23:49  01-APR-77  PAGE    22

     002.115  172            828          MOV     A,D
     002.116  263            829          ORA     E
     002.117  302 104 002    830          JNZ     WME2              IF MORE TO GO
                             831
                             832  *        WRITE CHECKSUM
                             833
     002.122  052 027 040    834          LHLD    CRCSUM
     002.125  315 017 003    835          CALL    WNP               WRITE IT
     002.130  315 017 003    836          CALL    WNP               FLUSH CHECKSUM
                             837  *       JMP     TFT


                             839  **      TFT - TURN OFF TAPE.
                             840  *
                             841  *       STOP THE TAPE TRANSPORT.
                             842  *
                             843
     002.133  257            844  TFT     XRA     A
     002.134  323 371        845          OUT     OP.TPC            TURN OFF TAPE


                             847  **      HORN - MAKE NOISE.
                             848  *
                             849  *       ENTRY   (A) = (MILLISECOND COUNT)/2
                             850  *       EXIT    NONE
                             851  *       USES    A,F
                             852
                             853
     002.136  076 144        854  ALARM   MVI     A,200/2           200 MS BEEP
     002.140  365            855  HORN    PUSH    PSW
     002.141  076 200        856          MVI     A,CB.SPK          TURN ON SPEAKER
                             857
     002.143  343            858  HRN0    XTHL                      SAVE (HL), (H)  = COUNT
     002.144  325            859          PUSH    D                 SAVE (DE)
     002.145  353            860          XCHG                      (D) = LOOP COUNT
     002.146  041 011 040    861          LXI     H,CTLFLG
     002.151  256            862          XRA     M
     002.152  136            863          MOV     E,M               (E) = OLD CTLFLG VALUE
     002.153  167            864          MOV     M,A               TURN ON HORN
     002.154  056 033        865          MVI     L,#TICCNT
                             866
     002.156  172            867          MOV     A,D               (A) = CYCLE COUNT
     002.157  206            868          ADD     M
     002.160  276            869  HRN2    CMP     M                 WAIT REQUIRED TICCOUNTS
     002.161  302 160 002    870          JNE     HRN2
     002.164  056 011        871          MVI     L,#CTLFLG
     002.166  163            872          MOV     M,E               TURN HORN OFF
     002.167  321            873          POP     D
     002.170  341            874          POP     H
     002.171  311            875          RET
```

```
PAM/8 - H8 FRONT PANEL MONITOR  #01.00.00.                  HEATH X8ASM V1.1  06/21/77
TAPE PROCESSING SUBROUTINES                                   15:44:25  01-APR-77  PAGE    23

                          **      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
```

```
PAM/8 - H8 FRONT PANEL MONITOR  #01.00.00.                  HEATH X8ASM V1.0  02/18/77
TAPE PROCESSING SUBROUTINES                                   13:23:52  01-APR-77  PAGE    24

                        929  **      TPABT - ABORT TAPE LOAD OR DUMP.
                        930  *
                        931  *       ENTERED WHEN LOADING OR DUMPING, AND THE '*' KEY
                        932  *       IS STRUCK.
                        933
                        934
  002.244  257          935  TPABT   XRA     A
  002.245  323 371      936          OUT     OP.TPC           OFF TAPE
  002.247  303 322 000  937          JMP     ERROR



                        939  **      TPXIT - CHECK FOR USER FORCED EXIT.
                        940  *
                        941  *       TPXIT CHECKS FOR AN '*' KEYPAD ENTRY. IF SO, TAKE
                        942  *       THE TAPE DRIVER ABNORMAL EXIT.
                        943  *
                        944  *       ENTRY   NONE
                        945  *       EXIT    TO *RET* IF NOT '*'
                        946  *                (A) = PORT STATUS
                        947  *               TO (TPERRX) IF '*' DOWN
                        948  *       USES    A,F
                        949
                        950
  002.252  333 360      951  TPXIT   IN      IP.PAD
  002.254  376 157      952          CPI     01101111B        *
  002.256  333 371      953          IN      IP.TPC           READ TAPE STATUS
  002.260  300          954          RNE                      NOT '*', RETURN WITH STATUS
  002.261  052 031 040  955          LHLD    TPERRX
  002.264  351          956          PCHL                     ENTER (TPERRX)



                        958  **      SRS - SCAN RECORD START
                        959  *
                        960  *       SRS READS BYTES UNTIL IT RECOGNIZES THE START OF A RECORD.
                        961  *
                        962  *       THIS REQUIRES
                        963  *       AT LEAST 10 SYNC CHARACTERS
                        964  *       1 STX CHARACTER.
                        965  *
                        966  *       THE CRC-16 IS THEN INITIALIZED.
                        967  *
                        968  *       ENTRY   NONE
                        969  *       EXIT    TAPE POSITIONED (AND MOVING), CRCSUM =0
                        970  *               (DE) = HEADER BYTES
                        971  *               (HA) = RECORD COUNT
                        972  *       USES    A,F,D,E,H,L
                        973
                        974
  002.265               975  SRS     EQU     *
  002.265  026 000      976  SRS1    MVI     D,0
  002.267  142          977          MOV     H,D
  002.270  152          978          MOV     L,D              (HL) = 0
```

```
PAM/8 - H8 FRONT PANEL MONITOR  #01.00.00.                    HEATH X8ASM V1.0  02/18/77
TAPE PROCESSING SUBROUTINES                                     13:23:54  01-APR-77  PAGE    25

     002.271  315 331 002   979  SRS2    CALL    RNB              READ NEXT BYTE
     002.274  024           980          INR     D
     002.275  376 026       981          CPI     A,SYN
     002.277  312 271 002   982          JE      SRS2             HAVE SYN
     002.302  376 002       983          CPI     A,STX
     002.304  302 265 002   984          JNE     SRS1             NOT STX - START OVER
                            985
     002.307  076 012       986          MVI     A,10
     002.311  272           987          CMP     D                SEE IF ENOUGH SYN CHARACTERS
     002.312  322 265 002   988          JNC     SRS1             NOT ENOUGH
     002.315  042 027 040   989          SHLD    CRCSUM           CLEAR CRC-16
     002.320  315 325 002   990          CALL    RNP              READ LEADER
     002.323  124           991          MOV     D,H
     002.324  137           992          MOV     E,A
                            993  *       JMP     RNP              READ COUNT



                            995  **      RNP - READ NEXT PAIR.
                            996  *
                            997  *       RNP READS THE NEXT TWO BYTES FROM THE INPUT DEVICE.
                            998  *
                            999  *       ENTRY   NONE
                           1000  *       EXIT    (H,A) = BYTE PAIR
                           1001  *       USES    A,F,H
                           1002
                           1003
     002.325  315 331 002  1004  RNP     CALL    RNB              READ NEXT BYTE
     002.330  147          1005          MOV     H,A
                           1006  *       JMP     RNB              READ NEXT BYTE



                           1008  **      RNB - READ NEXT BYTE
                           1009  *
                           1010  *       RNB READS THE NEXT SINGLE BYTE FROM THE INPUT DEVICE.
                           1011  *       THE CHECKSUM IS TAKEN FOR THE CHARACTER.
                           1012  *
                           1013  *       ENTRY   NONE
                           1014  *       EXIT    (A) = CHARACTER
                           1015  *       USES    A,F
                           1016
                           1017
     002.331  076 064      1018  RNB     MVI     A,UCI.RO+UCI.ER+UCI.RE  TURN ON READER FOR NEXT BYTE
     002.333  323 371      1019          OUT     OP.TPC
     002.335  315 252 002  1020  RNB1    CALL    TPXIT            CHECK FOR *, READ STATUS
     002.340  346 002      1021          ANI     USR.RXR
     002.342  312 335 002  1022          JZ      RNB1             IF NOT READY
     002.345  333 370      1023          IN      IP.TPD           INPUT DATA
                           1024  *       JMP     CRC              CHECKSUM
```

```
PAM/8 - H8 FRONT PANEL MONITOR  #01.00.00.                          HEATH XBASM V1.0  02/18/77
TAPE PROCESSING SUBROUTINES                                            13:23:56  01-APR-77  PAGE    26

                         **     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
```

```
PAM/8 - H8 FRONT PANEL MONITOR  #01.00.00.                    HEATH X8ASM V1.0  02/18/77
TAPE PROCESSING SUBROUTINES                                     13:23:58  01-APR-77  PAGE    27

                          1074  **      WNP - WRITE NEXT PAIR.
                          1075  *
                          1076  *       WPT WRITES THE NEXT TWO BYTES TO THE CASSETTE DRIVE.
                          1077  *
                          1078  *       ENTRY   (H,L) = BYTES
                          1079  *       EXIT    WRITTEN.
                          1080  *       USES    A,F
                          1081
                          1082
003.017  174              1083  WNP     MOV     A,H
003.020  315 024 003      1084          CALL    WNB
003.023  175              1085          MOV     A,L
                          1086  *       JMP     WNB               WRITE NEXT BYTE


                          1088  **      WNB - WRITE BYTE
                          1089  *
                          1090  *       WNB WRITES THE NEXT BYTE TO THE CASSETTE TAPE.
                          1091  *
                          1092  *       ENTRY   (A) = BYTE
                          1093  *       EXIT    NONE.
                          1094  *       USES    F
                          1095
                          1096
003.024  365              1097  WNB     PUSH    PSW
003.025  315 252 002      1098  WNB1    CALL    TPXIT             CHECK FOR *, READ STATUS
003.030  346 001          1099          ANI     USR.TXR
003.032  312 025 003      1100          JZ      WNB1              IF MORE TO GO
003.035  076 021          1101          MVI     A,UCI.ER+UCI.TE ENABLE TRANSMITTER
003.037  323 371          1102          OUT     OP.TPC            TURN ON TAPE
003.041  361              1103          POP     PSW
003.042  323 370          1104          OUT     OP.TPD            OUTPUT DATA
003.044  303 347 002      1105          JMP     CRC               COMPUTE CRC
```

```
PAM/8 - H8 FRONT PANEL MONITOR  #01.00.00.                    HEATH X8ASM V1.0  02/18/77
SUBROUTINES                                                     13:23:59  01-APR-77  PAGE    28

                            1109  **     LRA - LOCATE REGISTER ADDRESS.
                            1110  *
                            1111  *      ENTRY   NONE.
                            1112  *      EXIT    (A) = REGISTER INDEX
                            1113  *              (H,L) = STORAGE ADDRESS
                            1114  *              (D,E) = (0,A)
                            1115  *      USES    A,D,E,H,L,F
                            1116
                            1117
                            1118
003.047  072 005 040        1119  LRA    LDA     REGI
003.052  137                1120  LRA.   MOV     E,A
003.053  026 000            1121         MVI     D,0
003.055  052 035 040        1122         LHLD    REGPTR
003.060  031                1123         DAD     D                 (DE) = (REGPTR)+(REGI)
003.061  311                1124         RET


                            1126  **     IOA - INPUT OCTAL ADDRESS.
                            1127  *
                            1128  *      ENTRY   (H,L) = ADDRESS OF RECEPTION DOUBLE BYTE.
                            1129  *      EXIT    TO *RET* IF ERROR.
                            1130  *              TO *RET*+1 IF OK, VALUE IN MEMORY.
                            1131  *      USES    A,D,E,H,L,F
                            1132
                            1133
003.062  315 066 003        1134  IOA    CALL    IOB               INPUT BYTE
003.065  053                1135         DCX     H


                            1137  **     IOB - INPUT OCTAL BYTE.
                            1138  *
                            1139  *      READ ONE OCTAL BYTE FROM THE KEYSET.
                            1140  *
                            1141  *      ENTRY   (H,L) = ADDRESS OF BYTE TO HOLD VALUE
                            1142  *              'C' SET IF FIRST DIGIT IN (A)
                            1143  *      EXIT    TO *RET* IF ALL OK
                            1144  *              TO *ERROR* IF ERROR
                            1145  *      USES    A,D,E,H,L,F
                            1146
                            1147
                            1148
003.066  026 003            1149  IOB    MVI     D,3               (D) = DIGIT COUNT
003.070  324 260 003        1150  IOB1   CNC     RCK               READ CONSOLE KEYSET
                            1151
003.073  376 010            1152         CPI     8
003.075  322 322 000        1153         JNC     ERROR             IF ILLEGAL DIGIT
                            1154
003.100  137                1155         MOV     E,A               (E) = VALUE
003.101  176                1156         MOV     A,M
003.102  007                1157         RLC                       SHIFT 3
003.103  007                1158         RLC
```

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


                          **    DOD - DECODE FOR OCTAL DISPLAY.
                          *
                          *     ENTRY   (H,L) = ADDRESS OF LED REFRESH AREA
                          *             (B) = *OR* PATTERN TO FORCE ON BARS OR PERIODS
                          *             (A) = OCTAL VALUE
                          *     EXIT    (H,L) = NEX DIGIT ADDRESS
                          *     USES    A,B,C,D,H,L


003.122  325              DOD   PUSH    D
003.123  026 003                MVI     D,DODA/256
003.125  016 003                MVI     C,3
003.127  027              DOD1  RAL                     LEFT 3 PLACES
003.130  027                    RAL
003.131  027                    RAL
003.132  365                    PUSH    PSW             SAVE FOR NEXT DIGIT
003.133  346 007                ANI     7
003.135  306 356                ADI     #DODA
003.137  137                    MOV     E,A             (D) = INDEX
003.140  032                    LDAX    D               (A) = PATTERN
003.141  250                    XRA     B
003.142  346 177                ANI     177Q
003.144  250                    XRA     B
003.145  167                    MOV     M,A             SET IN MEMORY
003.146  043                    INX     H
003.147  170                    MOV     A,B
003.150  007                    RLC
003.151  107                    MOV     B,A
003.152  361                    POP     PSW             (A) = VALUE
003.153  015                    DCR     C
003.154  302 127 003            JNZ     DOD1            IF MORE TO GO
003.157  321                    POP     D
003.160  311                    RET                     RETURN
```

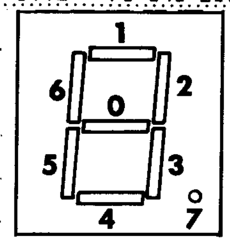
```
PAM/8 - H8 FRONT PANEL MONITOR  #01.00.00.                    HEATH X8ASM V1.0  02/18/77
UFD - UPDATE FRONT PANEL DISPLAYS.                              13:24:02  01-APR-77  PAGE    30

                       **     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
```

```
PAM/8 - H8 FRONT PANEL MONITOR  #01.00.00.                  HEATH X8ASM V1.0  02/18/77
UFD - UPDATE FRONT PANEL DISPLAYS.                            13:24:04  01-APR-77  PAGE    31

      003.245  032            1259          LDAX    D
      003.246  312 122 003    1260          JZ      DOD            IF MEMORY, DECODE BYTE VALUE
                              1261
                              1262   *      IS REGISTER. SET REGISTER NAME.
                              1263
      003.251  066 377        1264          MVI     M,377Q         CLEAR DIGIT
      003.253  341            1265          POP     H
      003.254  042 022 040    1266          SHLD    DLEDS+1
      003.257  311            1267          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
```

```
PAM/8 - H8 FRONT PANEL MONITOR  #01.00.00.                  HEATH X8ASM V1.1  06/21/77
RCK - READ CONSOLE KEYPAD.                                     15:44:41  01-APR-77  PAGE    33

003.272  076 012      1327           MVI    A,20/2
003.274  315 053 000  1328           CALL   DLY             WAIT 20 MS
003.277  170          1329           MOV    A,B
003.300  276          1330           CMP    M
003.301  302 310 003  1331           JNE    RCK2            HAVE A CHANGE
003.304  015          1332           DCR    C
003.305  302 267 003  1333           JNZ    RCK1            WAIT N CYCLES
                      1334
                      1335  *        HAVE KEY VALUE
                      1336
003.310  167          1337  RCK2     MOV    M,A             UPDATE RCKA
003.311  356 376      1338           XRI    376Q            INVERT ALL BUT GROUP 0 FLAG
003.313  017          1339           RRC
003.314  322 326 003  1340           JNC    RCK3            HIT BANK 0
003.317  017          1341           RRC
003.320  017          1342           RRC
003.321  017          1343           RRC
003.322  017          1344           RRC
003.323  322 267 003  1345           JNC    RCK1            NO HIT AT ALL
003.326  107          1346  RCK3     MOV    B,A             (B) = CODE
003.327  076 002      1347           MVI    A,4/2
003.331  315 140 002  1348           CALL   HORN            MAKE BIP
003.334  170          1349           MOV    A,B
003.335  346 017      1350           ANI    17Q
003.337  301          1351           POP    B
003.340  341          1352           POP    H
003.341  311          1353           RET                    RETURN
```

```
PAM/8 - H8 FRONT PANEL MONITOR  #01.00.00.                  HEATH XBASM V1.1  06/21/77
SEGMENT PATTERNS AND CONSTANTS.                               15:44:42  01-APR-77  PAGE    34

                          **      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
```

```
PAM/8 - H8 FRONT PANEL MONITOR  #01.00.00.                  HEATH X8ASM V1.1  06/21/77
CONSTANTS AND TABLES.                                          15:44:44  01-APR-77  PAGE     35

        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
```

```
FAM/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
```

```
CROSS REFERENCE TABLE.                  XREF V1.0  PAGE   37

 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
```

```
CROSS REFERENCE TABLE.                    XREF V1.0  PAGE   39

  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.

```
                                                    HEATH ASM #104.01.00.
                                                    PAGE  1

                          ***  **************************************************
                          *
                          *      DEMO: PAMB
                          *
                          *      SYSTEM DEFINITIONS
                          *

  040.100                        ORG     40100A
  000.322                 ERROR  EQU     322A    RESET PAMB
  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        PAMB   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!
```

```
                                                     HEATH ASM 04.01.00.
                                                     PAGE  2

                              *
 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
```

INDEX