Section 1

PANEL MONITOR

PAM-8

TABLE OF CONTENTS

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.

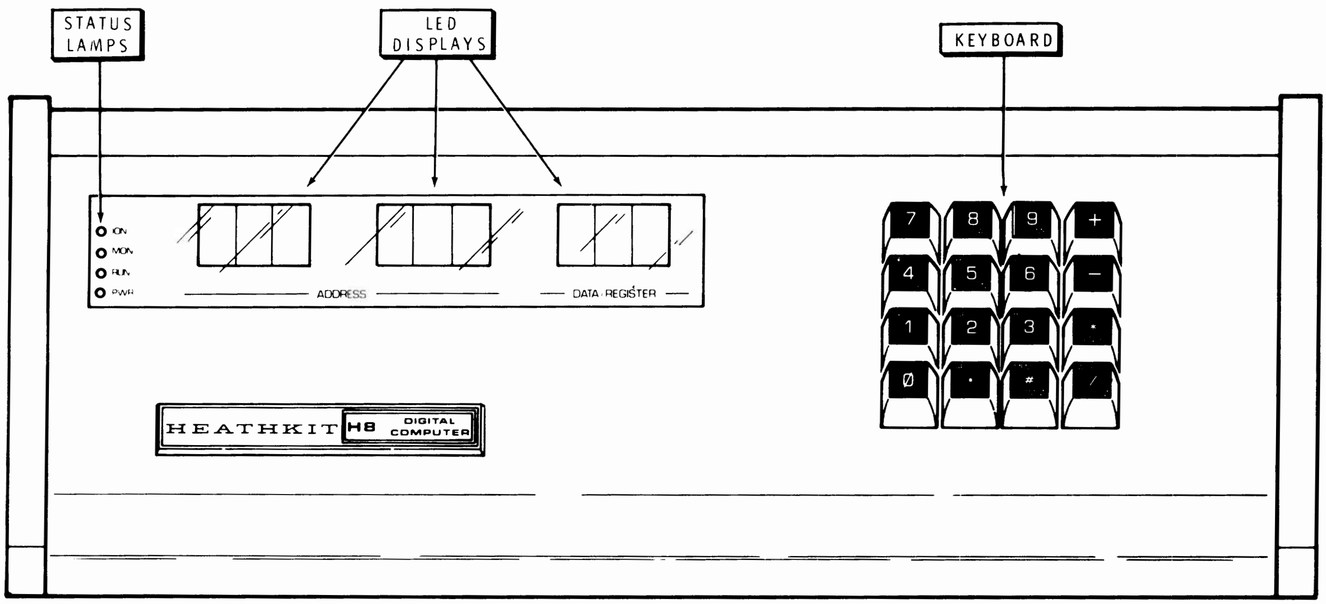


Figure 1-1

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.

$$\underbrace{00}\quad\underbrace{000}\quad\underbrace{000}$$

Least significant octal digit (0-7).

Middle octal digit (0-7).

Most significant octal digit (0-3).

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

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

$$\underbrace{1\,1}_{3}\,\underbrace{1\,1\,1}_{7}\,\underbrace{1\,1\,1}_{7}\quad\underbrace{1\,1}_{3}\,\underbrace{1\,1\,1}_{7}\,\underbrace{1\,1\,1}_{7}$$

A 16-bit binary number

Offset octal representation (377 377)

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

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.

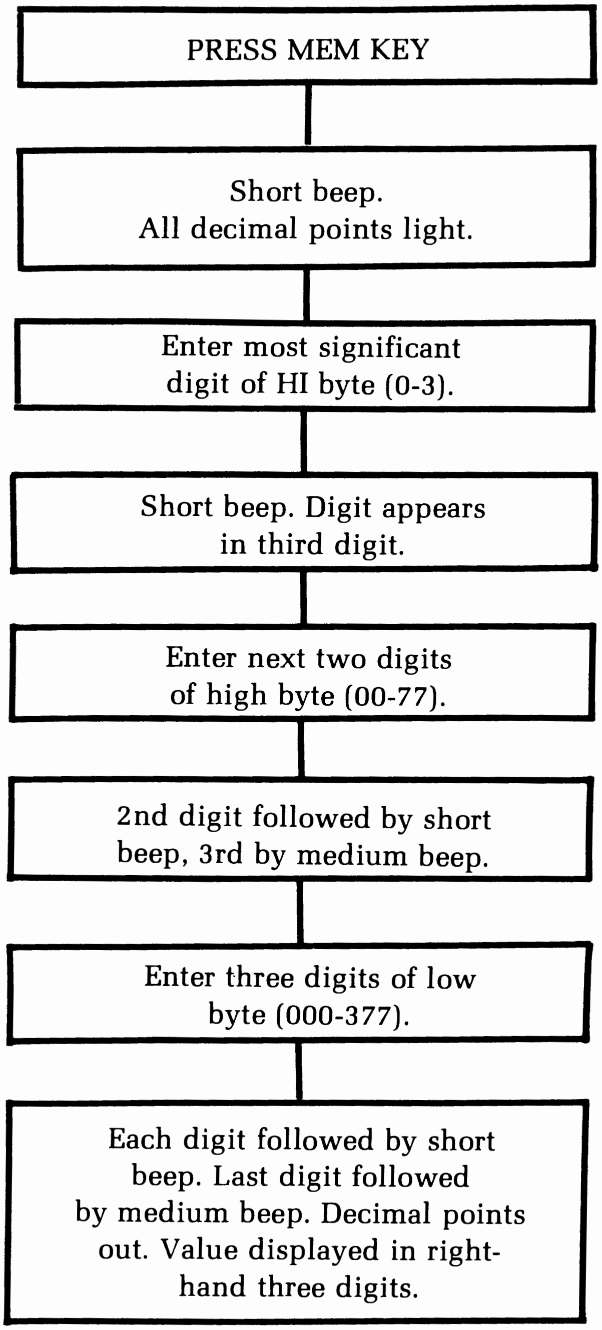


Figure 1-2
Entering a memory address through PAM-8.

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	5P	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 1-29, 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 but 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 1-61). 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

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 0-47.

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)
```

HEATHKIT®


```
*              (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 X8ASM V1.1  06/21/77
ASSEMBLY CONSTANTS.                                            15:43:56  01-APR-77  PAGE     4

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

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

        000.000               140          XTEXT   U8251           DEFINE 8251 USART BITS
```

```
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

                    **      8251 USART BIT DEFINITIONS.
                    *

                    **      MODE INSTRUCTION CONTROL BITS.

000.100             UMI.1B  EQU     01000000B       1 STOP BIT
000.200             UMI.HB  EQU     10000000B       1 1/2 STOP BITS
000.300             UMI.2B  EQU     11000000B       2 STOP BITS
000.040             UMI.PE  EQU     00100000B       EVEN PARITY
000.020             UMI.PA  EQU     00010000B       USE PARITY
000.000             UMI.L5  EQU     00000000B       5 BIT CHARACTERS
000.004             UMI.L6  EQU     00000100B       6 BIT CHARACTERS
000.010             UMI.L7  EQU     00001000B       7 BIT CHARACTERS
000.014             UMI.L8  EQU     00001100B       8 BIT CHARACTERS
000.001             UMI.1X  EQU     00000001B       CLOCK X 1
000.002             UMI.16X EQU     00000010B       CLOCK X 16
000.003             UMI.64X EQU     00000011B       CLOCK X 64

                    **      COMMAND INSTRUCTION BITS.

000.100             UCI.IR  EQU     01000000B       INTERNAL RESET
000.040             UCI.RO  EQU     00100000B       READER-ON CONTROL FLAG
000.020             UCI.ER  EQU     00010000B       ERROR RESET
000.004             UCI.RE  EQU     00000100B       RECEIVE ENABLE
000.002             UCI.IE  EQU     00000010B       ENABLE INTERRUPTS FLAG
000.001             UCI.TE  EQU     00000001B       TRANSMIT ENABLE

                    **      STATUS READ COMMAND BITS.

000.040             USR.FE  EQU     00100000B       FRAMING ERROR
000.020             USR.OE  EQU     00010000B       OVERRUN ERROR
000.010             USR.PE  EQU     00001000B       PARITY ERROR
000.004             USR.TXE EQU     00000100B       TRANSMITTER EMPTY
000.002             USR.RXR EQU     00000010B       RECEIVER READY
000.001             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

                          180  ***    INTERRUPT VECTORS.
                          181  *
                          182

                          184  **     LEVEL 0 - RESET
                          185  *
                          186  *      THIS 'INTERRUPT' MAY NOT BE PROCESSED BY A USER PROGRAM.
                          187
000.000                   188         ORG     00A
                          189
000.000  021 371 003      190  INIT0  LXI     D,PRSROM          (DE) = ROM COPY OF PRS CODE
000.003  041 012 040      191         LXI     H,PRSRAM+PRSL-1   (HL) = RAM DESTINATION FOR CODE
000.006  303 073 000      192         JMP     INIT              INITIALIZE
377.073                   193         ERRPL   INIT-1000A        BYTE IN WORD 10A MUST BE 0

                          195  **     LEVEL 1 - CLOCK
                          196
000.010                   197  INT1   EQU     10Q               INTERRUPT ENTRY POINT
                          198
000.000                   199         ERRNZ   *-11Q             INTO TAKES UP ONE BYTE
000.011  315 132 000      200         CALL    SAVALL            SAVE USER REGISTERS
000.014  026 000          201         MVI     D,0
000.016  303 201 000      202         JMP     CLOCK             PROCESS CLOCK INTERRUPT
377.201                   203         ERRPL   CLOCK-1000A       EXTRA BYTE MUST BE 0

                          205  **     LEVEL 2 - SINGLE STEP
                          206  *
                          207  *      IF THIS INTERRUPT IS RECEIVED WHEN NOT IN MONITOR MODE,
                          208  *      THEN IT IS ASSUMED TO BE GENERATED BY A USER PROGRAM
                          209  *      (SINGLE STEPPING OR BREAKPOINTING). IN SUCH CASE, THE
                          210  *      USER PROGRAM IS ENTERED THROUGH (UIVEC+3
                          211
000.020                   212  INT2   EQU     20A               LEVEL 2 ENTRY
                          213
000.000                   214         ERRNZ   *-21A             INT1 TAKES EXTRA BYTE
000.021  315 132 000      215         CALL    SAVALL            SAVE REGISTERS
000.024  032              216         LDAX    D                 (A) = (CTLFLG)
040.011                   217  .      SET     CTLFLG
000.025  303 244 001      218         JMP     STPRTN            STEP RETURN

                          220  ***    I/O INTERRUPT VECTORS.
                          221  *
                          222  *      INTERRUPTS 3 THROUGH 7 ARE AVAILABLE FOR GENERAL I/O USE.
                          223  *
                          224  *      THESE INTERRUPTS ARE NOT SUPPORTED BY PAM/8, AND SHOULD
                          225  *      NEVER OCCUR UNLESS THE USER HAS SUPPLIED HANDLER ROUTINES
                          226  *      (THROUGH UIVEC)
                          227
```

```
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

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

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

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

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

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

```
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

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


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

004.000                     SINCR   EQU     4000A               SEARCH INCREMENT

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

                        *       DETERMINE MEMORY LIMIT.

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

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

                        *       CONFIGURE LOAD/DUMP UART

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

```
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

                        307 **      SAVALL - SAVE ALL REGISTERS ON STACK.
                        308 *
                        309 *       SAVALL IS CALLED WHEN AN INTERRUPT IS ACCEPTED, IN ORDER TO
                        310 *       SAVE THE CONTENTS OF THE REGISTERS ON THE STACK.
                        311 *
                        312 *       ENTRY   CALLED DIRECTLY FROM INTERRUPT ROUTINE.
                        313 *       EXIT    ALL REGISTERS PUSHED ON STACK.
                        314 *               IF NOT YET IN MONITOR MODE, REGPTR = ADDRESS OF REGISTERS
                        315 *               ON STACK.
                        316 *               (DE) = ADDRESS OF CTLFLG
                        317
                        318
000.132  343            319 SAVALL  XTHL                        SET H,L ON STACK TOP
000.133  325            320         PUSH    D
000.134  305            321         PUSH    B
000.135  365            322         PUSH    PSW
000.136  353            323         XCHG                        (D,E) = RETURN ADDRESS
000.137  041 012 000    324         LXI     H,10
000.142  071            325         DAD     SP                  (H,L) = ADDRESS OF USERS SP
000.143  345            326         PUSH    H                   SET ON STACK AS 'REGISTER'
000.144  325            327         PUSH    D                   SET RETURN ADDRESS
000.145  021 011 040    328         LXI     D,CTLFLG
000.150  032            329         LDAX    D                   (A) = CTLFLG
000.151  057            330         CMA
000.152  346 060        331         ANI     CB.MTL+CB.SSI       SAVE REGISTER ADDR IF USER OR SINGLE STEP
000.154  310            332         RZ                          RETURN IF WAS INTERRUPT OF MONITOR LOOP
000.155  041 002 000    333         LXI     H,2
000.160  071            334         DAD     SP                  (H,L) = ADDRESS OF 'STACKPTR' ON STACK
000.161  042 035 040    335         SHLD    REGPTR
000.164  311            336         RET

                        338 **      CUI - CHECK FOR USER INTERRUPT PROCESSING.
                        339 *
                        340 *       CUI IS CALLED TO SEE IF THE USER HAS SPECIFIED PROCESSING
                        341 *       FOR THE CLOCK INTERRUPT.
                        342
                        343
040.010                 344 .       SET     .MFLAG              REFERENCE TO MFLAG
000.165  012            345 CUI1    LDAX    B                   (A) = .MFLAG
000.000                 346         ERRNZ   UO.CLK-1            CODE ASSUMED = 01
000.166  017            347         RRC
000.167  334 037 040    348         CC      UIVEC               IF SPECIFIED, TRANSFER TO USER
                        349
                        350 *       RETURN TO PROGRAM FROM INTERRUPT.
                        351
000.172  361            352 INTXIT  POP     PSW                 REMOVE FAKE 'STACK REGISTER'
000.173  361            353         POP     PSW
000.174  301            354         POP     B
000.175  321            355         POP     D
000.176  341            356         POP     H
000.177  373            357         EI
000.200  311            358         RET
```

HEATHKIT®

```
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
```

```
PAM/8 - H8 FRONT PANEL MONITOR  #01.00.00.                 HEATH XBASM 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
```

```
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

                         **      SAE - STORE ABUSS AND EXIT.
                         *
                         *       ENTRY   (HL) = ABUSS VALUE
                         *       EXIT    TO (RET)
                         *       USES    NONE

001.063  042 024 040     SAE     SHLD    ABUSS
001.066  311                     RET

                         *       ALTER REGISTER

001.067  365             MTR6    PUSH    PSW             SAVE CODE
001.070  315 047 003             CALL    LRA             LOCATE REGISTER ADDRESS
001.073  247                     ANA     A
001.074  312 322 000             JZ      ERROR           NOT ALLOWED TO ALTER STACKPOINTER
001.077  043                     INX     H
001.100  361                     POP     PSW             RESTORE VALUE AND CARRY FLAG
001.101  303 062 003             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

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

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


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

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


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

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

                               *       IS REGISTER MODE.

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

```
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

                           620  **      LAST - DECREMENT DISPLAY ELEMENT.
                           621  *
                           622  *       ENTRY   (HL) = (ABUSS)
                           623  *               (DE) = ADDRESS OF REGIND
                           624
001.150  053               625  LAST    DCX     H
001.151  312 063 001       626          JZ      SAE                 IF MEMORY, STORE AND EXIT
                           627
                           628  *       IS REGISTER MODE.
                           629
040.005                    630  .       SET     REGI
001.154  032               631  LST2    LDAX    D                   (A) = REGI
001.155  326 002           632          SUI     2
001.157  022               633          STAX    D
001.160  320               634          RNC                         IF OK
001.161  076 012           635          MVI     A,10                UNDERFLOW TO *PC*
001.163  022               636          STAX    D
001.164  311               637          RET
                           638

                           640  **      MEMM - ENTER DISPLAY MEMORY MODE.
                           641  *
                           642  *       ENTRY   (BC) = ADDRESS OF DSPMOD
                           643
001.165  257               644  MEMM    XRA     A                   (A) = 0
040.007                    645  .       SET     DSPMOD
001.166  002               646          STAX    B                   SET DISPLAY MEMORY MODE
000.000                    647          ERRNZ   DSPMOD-DSPROT-1
001.167  013               648          DCX     B                   (BC) = #DSPROT
001.170  002               649          STAX    B                   SET ALL PERIODS ON
001.171  041 025 040       650          LXI     H,ABUSS+1
001.174  303 062 003       651          JMP     IOA                 INPUT OCTAL ADDRESS

                           653  **      IN - INPUT DATA BYTE.
                           654  *
                           655
                           656  **      OUT - OUTPUT DATA BYTE.
                           657  *
                           658  *       ENTRY   (HL) = (ABUSS)
                           659
001.177  006 333           660  IN      MVI     B,MI.IN
001.201  021               661          DB      MI.LXID             SKIP NEXT INSTRUCTION
001.202  006 323           662  OUT     MVI     B,MI.OUT
001.204  174               663          MOV     A,H                 (A) = VALUE
001.205  145               664          MOV     H,L                 (H) = PORT
001.206  150               665          MOV     L,B                 (L) = IN/OUT INSTRUCTION
001.207  042 002 040       666          SHLD    IOWRK
001.212  315 002 040       667          CALL    IOWRK               PERFORM IO
001.215  154               668          MOV     L,H                 (L) = PORT
001.216  147               669          MOV     H,A                 (H) = VALUE
001.217  303 063 001       670          JMP     SAE                 STORE ABUSS AND EXIT
```

```
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

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

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


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

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


                             **      STPRTN - SINGLE STEP RETURN

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


                             **      RMEM - LOAD MEMORY FROM TAPE.
                             *

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

```
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

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

```
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,IPABT
001.377  042 031 040      784          SHLD    IPERRX           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
```

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

                         *      WRITE CHECKSUM

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


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

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


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


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

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

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

```
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

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


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



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


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



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


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

HEATHKIT

```
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 X8ASM 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

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


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


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


003.024  365               WNB     PUSH     PSW
003.025  315 252 002       WNB1    CALL     TPXIT             CHECK FOR *, READ STATUS
003.030  346 001                   ANI      USR.TXR
003.032  312 025 003               JZ       WNB1              IF MORE TO GO
003.035  076 021                   MVI      A,UC1.ER+UCI.TE   ENABLE TRANSMITTER
003.037  323 371                   OUT      OP.TPC            TURN ON TAPE
003.041  361                       POP      PSW
003.042  323 370                   OUT      OP.TPD            OUTPUT DATA
003.044  303 347 002               JMP      CRC               COMPUTE CRC
```

```
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
```

```
PAM/8 - H8 FRONT PANEL MONITOR  #01.00.00.                 HEATH X8ASM V1.0  02/18/77
SUBROUTINES                                                 13:24:01  01-APR-77  PAGE    29

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
```

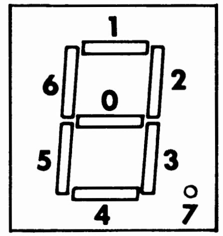
```
PAM/8 - H8 FRONT PANEL MONITOR  #01.00.00.                 HEATH X8ASM V1.0  02/18/77
UFD - UPDATE FRONT PANEL DISPLAYS.                           13:24:02  01-APR-77  PAGE    30

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

                         *       HAVE KEY VALUE

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

```
PAM/8   H8 FRONT PANEL MONITOR  #01.00.00.                    HEATH X8ASM V1.1  06/21/77
SEGMENT PATTERNS AND CONSTANTS.                                15:44:42  01-APR-77  PAGE    34

                           1357  **    DISPLAY SEGMENT CODING:
                           1358  *
                           1359  *     BYTE = 76 543 210
                           1360  *
                           1361  *
                           1362  *
                           1363  *
                           1364  *
                           1365  *
                           1366  *
```




```
                           1370  **    REGISTER INDEX TO 7-SEGMENT PATTERN
                           1371
003.342                    1372  DSPA  DS      0
003.342  244 230           1373        DW      1001100010100100B   SP
003.344  220 234           1374        DW      1001110010010000B   AF
003.346  206 215           1375        DW      1000110110000110B   BC
003.350  302 214           1376        DW      1000110011000010B   DE
003.352  222 217           1377        DW      1000111110010010B   HL
003.354  230 316           1378        DW      1100111010011000B   PC

                           1380  **    OCTAL TO 7-SEGMENT PATTERN
                           1381
003.356                    1382  DODA  DS      0
003.356  001               1383        DB      00000001B     0
003.357  163               1384        DB      01110011B     1
003.360  110               1385        DB      01001000B     2
003.361  140               1386        DB      01100000B     3
003.362  062               1387        DB      00110010B     4
003.363  044               1388        DB      00100100B     5
003.364  004               1389        DB      00000100B     6
003.365  161               1390        DB      01110001B     7
003.366  000               1391        DB      00000000B     8
003.367  040               1392        DB      00100000B     9

                           1394  **    I/O ROUTINES TO BE COPIED INTO AND USED IN RAM.
                           1395  *
                           1396  *     MUST CONTINUE TO 3777A FOR PROPER COPY.
                           1397  *     THE TABLE MUST ALSO BE BACKWARDS TO THE FINAL RAM
                           1398
003.371                    1399        ORG     4000A-7
                           1400
003.371                    1401  PRSROM EQU    *
003.371  001               1402        DB      1             REFIND
003.372  000               1403        DB      0             CTLFLG
003.373  000               1404        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
```

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

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

CROSS REFERENCE TABLE. XREF V1.0 PAGE 37

	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	1147L			
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	656								
CB.SS1	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									
HRNO	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    001275   524       685E
 START    040000   284       750     799     1418L
 STPRIN   001244   218       696E
 TER1     002220   920L      927
 TER3     002215   913L      924
 TFT      002133   765       844L    908
 TICCNT   040033   369       371     406     865     ???     1451L
 TPABT    002244   708       783     935L
 TPERR    002205   737       906L
 TPERRX   040031   709       784     955     1450L
 TPXIT    002252   921       951L    1020    1098
 UC1.ER   000020   165E      1018    1101
 UC1.IE   000002   167E
 UC1.IR   000100   163E
 UC1.RE   000004   166E      1018
 UC1.RO   000040   164E      1018
 UC1.TE   000001   168E      786     1101
 UFD      003161   409       1215E
 UFD1     003227   1230      1251L
 UTVEL    040037   227       234     239     253     260     348     703     1455L
 UM1.16X  000002   158E      303
 UM1.1B   000100   148E      303
 UM1.1X   000001   157E
 UM1.2B   000300   150E
 UM1.64X  000003   159E
 UMI.HB   000200   149E
 UMI.L5   000000   153L
 UMI.L6   000004   154E
 UMI.L7   000010   155E
 UMI.L8   000014   156E      303
 UMI.FA   000020   152E
 UMI.FE   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: PAM8

This program shows the advanced features of PAM8 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 PAM8.

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 PAM8.

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 PAM8 firmware. Although it appears simple enough, you must study both the program and the PAM8 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 EC1108, 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: FAM8
                        *
                        *       SYSTEM DEFINITIONS
                        *
040.100                         ORG     40100A
000.322                 ERROR   EQU     322A     RESET FAM8
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        FAM8    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 FAM-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 FAM-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 #104.01.00.
                                                PAGE  2

                          *
040.144  076 303                  MVI     A,M1.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                      RNZ                         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