SOFTWARE REFERENCE MANUAL

H8 COMPUTER

FRONT PANEL MONITOR PAM-8

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INTRODUCTION

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

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

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

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

THEORY OF OPERATION

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

Power Up and Master Clear

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

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

Clock Interrupts

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

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

PAM-8 Modes/Using RST and RTM

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

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

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

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

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

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

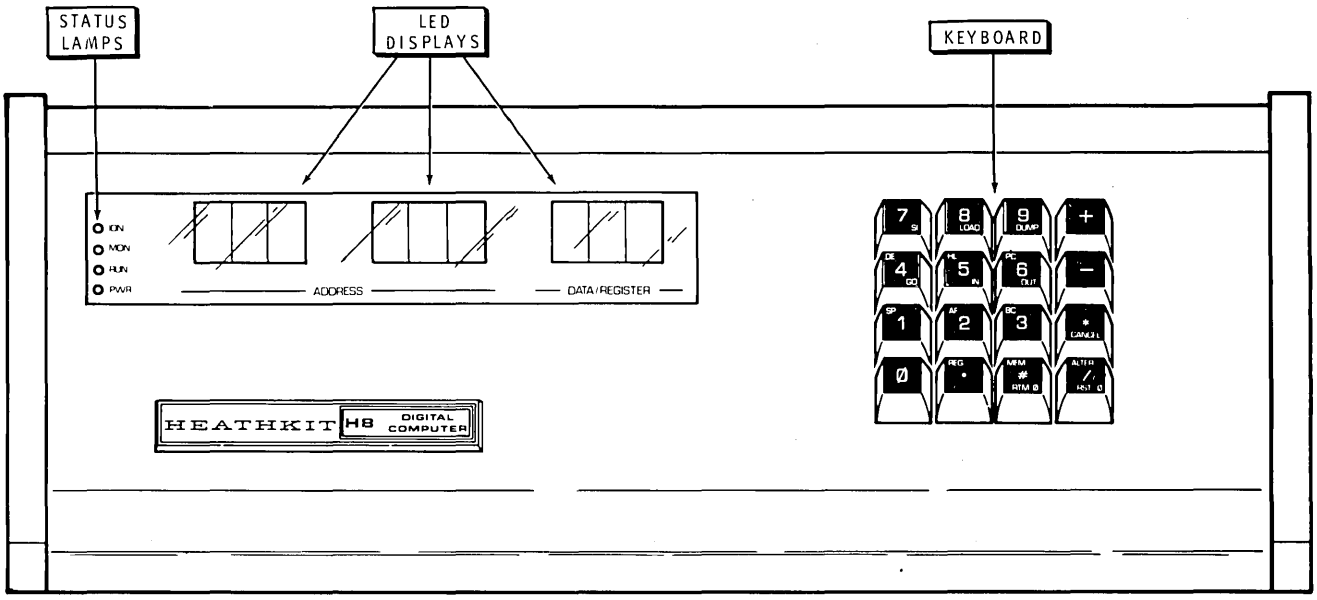


Figure 1-1

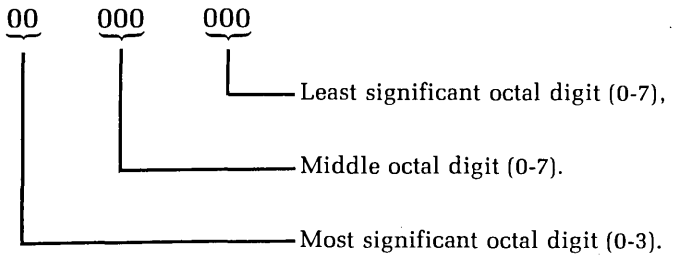
H8 Displays

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

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

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

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



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:

11111111 11111111	A 16-bit binary number
3 7 7 3 7 7	Offset octal representation (377 377)
1111111 111111 111111	A 16-bit binary number
1 7 7 7 7 7	True Octal representation (177777)

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

377.377

Hi Byte Lo Byte

H8 Keypad

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

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

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

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

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

DISPLAYING AND ALTERING MEMORY LOCATIONS

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

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

Specifying a Memory Address

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

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

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

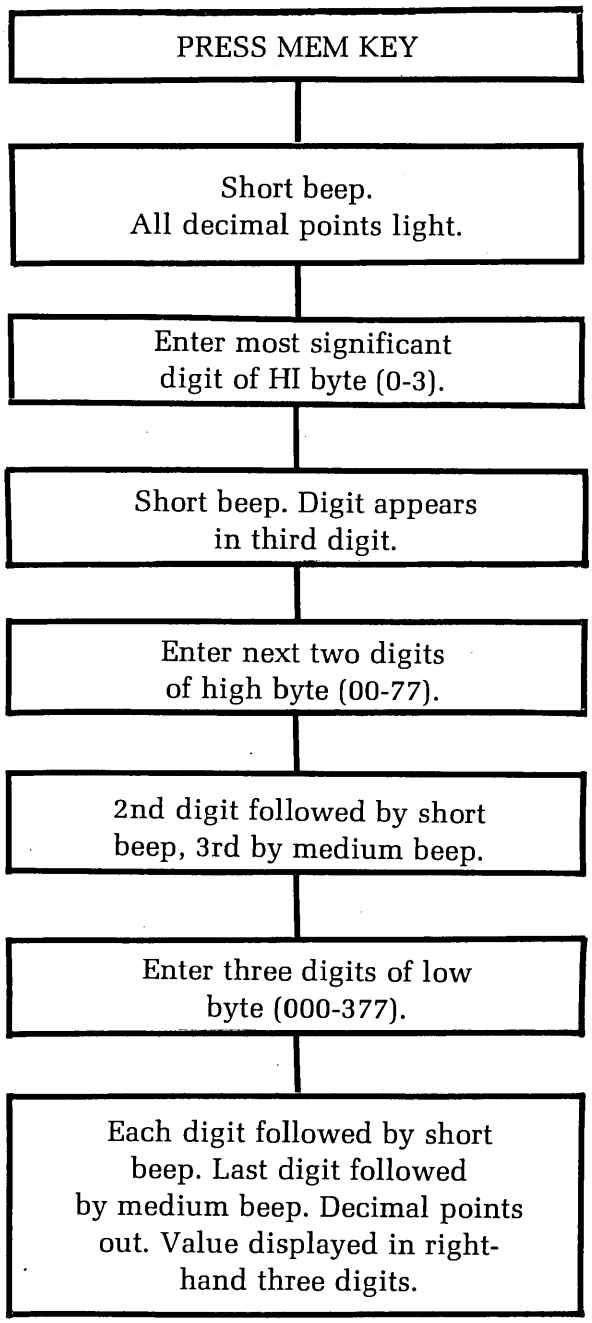


Figure 1-2
Entering a memory address through PAM-8.

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

Altering a Memory Location

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

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

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

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

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

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

Stepping Through Memory

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

DISPLAYING AND ALTERING REGISTERS

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

Specifying a Register for Display

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

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

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

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

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

Register A contains 256 and F contains 312.

Altering the Contents of a Selected Register

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

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

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

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

Stepping Through the Registers

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

PROGRAM EXECUTION CONTROL

PAM-8 supports three basic program execution control facilities:

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

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

Initiating Program Execution

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

Breakpointing

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

When the H8 executes a program and encounters a halt instruction, it re-enters PAM-8 and sounds the alarm. All of the registers are preserved and the program counter points to the address **following** the address of the halt instruction. Thus, you can breakpoint a program from the front panel by inserting halt instructions (HLT = 166) at the desired points throughout the program. When a particular

section of the program is tested and the breakpoint feature is no longer required, you can change the halt to a NOP (NOP = 000). Once the halts are changed to NOPs, execution of the NOP simply passes control to the next successive instruction. Program execution for breakpointing uses the GO key as described above.

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

Single Instruction Operation

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

Interrupting a Program During Execution

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

LOAD/DUMP ROUTINES

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

Loading From Tape

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

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

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

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

Dumping to Tape

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

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

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

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

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

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

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

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

Figure 1-3A
The H8 memory image dump.

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

Figure 1-3B
The H8 memory image load.

Copying a Tape

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

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

Tape Errors

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

RECORD ERRORS

The following are typical causes of record errors.

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

CHECKSUM ERRORS

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

I/O FACILITIES

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

Inputting From a Port

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

Outputting to a Port

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

Addressing Port Pairs

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

ADVANCED CONTROL

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

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

16-Bit Tick Counter (TICCNT)

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

Using the Keypad

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

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

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

Display Usage

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

MANUAL UPDATING

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

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

MANUAL DISPLAY REFRESHING

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

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

Using Interrupts

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

I/O INTERRUPTS

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

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

CLOCK INTERRUPTS

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

SINGLE INSTRUCTION AND BREAKPOINT INTERRUPTS

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

APPENDIX A

Panel Monitor Listing

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

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

```
PAM/8 - H8 FRONT PANEL MONITOR  #01.00.00.                    HEATH X8ASM V1.1  06/21/77
  INTRODUCTION.                                                15:43:50  01-APR-77  PAGE     1


                    4  ***     PAM/8 - H8 FRONT PANEL MONITOR.
                    5  *
                    6  *       JGL, 05/01/76.
                    7  *
                    8  *       FOR *WINTEK* INC.
                    9  *
                   10  *       COPYRIGHT  05/1976, WINTEK CORPORATION,
                   11  *                          902 N. 9TH ST.
                   12  *                          LAFAYETTE, IND.


                   14  ***     PAM/8 - H8 FRONT PANEL MONITOR.
                   15  *
                   16  *       THIS PROGRAM RESIDES (IN ROM) IN THE LOW 1024 BYTES OF THE HEATH
                   17  *       H8 COMPUTER.  IT ACTUALLY CONSISTS OF TWO VIRTUALLY INDEPENDENT
                   18  *       ROUTINES: A TASK-TIME PROGRAM WHICH PROVIDES SOPHISTICATED
                   19  *       FRONT PANEL MONITOR SERVICE, AND AN INTERRUPT-TIME PROGRAM WHICH
                   20  *       PROVIDES BOTH A REAL-TIME CLOCK AND EMULATES AN EFFECTIVE
                   21  *       HARDWARE FRONT PANEL.


                   23  ***     INTERRUPTS.
                   24  *
                   25  *       PAM/8 IS THE PRIMARY PROCESSOR FOR ALL INTERRUPTS.
                   26  *       THEY ARE PROCESSED AS FOLLOWS:
                   27  *
                   28  *       RST     USE
                   29  *
                   30  *       0       MASTER CLEAR.  (NEVER USED FOR I/O OR RST)
                   31  *
                   32  *       1       CLOCK INTERRUPT.  NORMALLY TAKEN BY PAM/8,
                   33  *               SETTING BIT *UO.CLK* IN BYTE *.MFLAG* ALLOWS
                   34  *               USER PROCESSING (VIA A JUMP THROUGH *UIVEC*).
                   35  *               UPON ENTRY OF THE USER ROUTINE, THE STACK
                   36  *               CONTAINS:
                   37  *               (STACK+0)  = RETURN ADDRESS (TO PAM/8)
                   38  *               (STACK+2)  = (STACKPTR+14)
                   39  *               (STACK+4)  = (AF)
                   40  *               (STACK+6)  = (BC)
                   41  *               (STACK+8)  = (DE)
                   42  *               (STACK+10) = (HL)
                   43  *               (STACK+12) = (PC)
                   44  *               THE USER'S ROUTINE SHOULD RETURN TO PAM/8 VIA
                   45  *               A *RET* WITHOUT ENABLING INTERRUPTS.
                   46  *
                   47  *       2       SINGLE STEP.  SINGLE STEP INTERRUPTS GENERATED
                   48  *               BY PAM/8 ARE PROCESSED BY PAM/8.
                   49  *               ANY SINGLE STEP INTERRUPT RECEIVED WHEN IN
                   50  *               USER MODE CAUSES A JUMP THROUGH *UIVEC*+3.
                   51  *               STACK UPON USER ROUTINE ENTRY:
                   52  *               (STACK+0)  = (STACKPTR+12)
                   53  *               (STACK+2)  = (AF)
                   54  *               (STACK+4)  = (BC)
```

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

```
                        77  **      ASSEMBLY CONSTANTS

                        79  **      I/O PORTS
                        80
000.360                 81  IP.PAD  EQU     360Q            PAD INPUT PORT
000.360                 82  OP.CTL  EQU     360Q            CONTROL OUTPUT PORT
000.360                 83  OP.DIG  EQU     360Q            DIGIT SELECT OUTPUT PORT
000.361                 84  OP.SEG  EQU     361Q            SEGMENT SELECT OUTPUT PORT
000.371                 85  IP.TPC  EQU     371Q            TAPE CONTROL IN
000.371                 86  OP.TPC  EQU     371Q            TAPE CONTROL OUT
000.370                 87  IP.TPD  EQU     370Q            TAPE DATA IN
000.370                 88  OP.TPD  EQU     370Q            TAPE DATA OUT

                        90  **      ASCII CHARACTERS.
                        91
000.026                 92  A.SYN   EQU     026Q            SYNC CHARACTER
000.002                 93  A.STX   EQU     002Q            STX CHARACTER

                        95  **      FRONT PANEL HARDWARE CONTROL BITS.
                        96
000.020                 97  CB.SSI  EQU     00010000B       SINGLE STEP INTERRUPT
000.040                 98  CB.MTL  EQU     00100000B       MONITOR LIGHT
000.100                 99  CB.CLI  EQU     01000000B       CLOCK INTERRUPT ENABLE
000.200                100  CB.SPK  EQU     10000000B       SPEAKER ENABLE

                       102  **      DISPLAY MODE FLAGS (IN *DSPMOD*)
                       103
000.000                104  DM.MR   EQU     0               MEMORY READ
000.001                105  DM.MW   EQU     1               MEMORY WRITE
000.002                106  DM.RR   EQU     2               REGISTER READ
000.003                107  DM.RW   EQU     3               REGISTER WRITE
000.000                108          XTEXT   TAPE            TAPE DEFINITIONS

                       110X **      TAPE EQUIVALENCES.
                       111X
000.001                112X RT.MI   EQU     1               RECORD TYPE - MEMORY DUMP IMAGE
000.002                113X RT.BP   EQU     2               RECORD TYPE - BASIC PROGRAM
000.003                114X RT.CT   EQU     3               RECORD TYPE - COMPRESSED TEXT
                       115X
                       116X **      BLOCK SIZE FOR INTER-PRODUCT COMMUNICATION.
                       117X
002.000                118X BLKSIZ  EQU     512
                       119X
```

```
                        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


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

```
                                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           INT0 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     7

                                228             ORG     30A
000.030                         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
```

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

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


                                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   UD.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
```

```
                                    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
```

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

000,266  013              417          DCX     B
000,000                   418          ERRNZ   CTLFLG-.MFLAG-1
000,267  012              419          LDAX    B               (A) = .MFLAG
000,000                   420          ERRNZ   U0.HLT-200Q     ASSUME HIGH-ORDER
000,270  027              421          RAL
000,271  332 313 000      422          JC      CLK4            SKIP IT
                          423
                          424  *       NOT IN MONITOR MODE, CHECK FOR HALT
                          425
000,274  076 012          426          MVI     A,10            (A) = INDEX OF *P* REG
000,276  315 052 003      427          CALL    LRA,            LOCATE REGISTER ADDRESS
000,301  136              428          MOV     E,M
000,302  043              429          INX     H
000,303  126              430          MOV     D,M             (D,E) = PC CONTENTS
000,304  033              431          DCX     D
000,305  032              432          LDAX    D
000,306  376 166          433          CPI     MI.HLT          CHECK FOR HALT
000,310  312 322 000      434          JE      ERROR           IF HALT, BE IN MONITOR MODE
                          435
                          436  *       CHECK FOR 'RETURN TO MONITOR' KEY ENTRY.
                          437
000,313                   438  CLK4    EQU     *
000,313  333 360          439          IN      IP.PAD
000,315  376 056          440          CPI     56Q             SEE IF '0' AND '#'
000,317  302 165 000      441          JNE     CUI1            IF NOT, ALLOW USER PROCESSING OF CLOCK
```

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


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

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

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

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

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

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


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


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


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

```
                                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
```

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

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


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


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


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

```
                                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  LOAO    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    RNF             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    RNF             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
```

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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     LOA0            READ ANOTHER RECORD
```

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

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

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


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


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

```
                                    880  **      CTC - VERIFY CHECKSUM.
                                    881  *
                                    882  *       ENTRY   TAPE JUST BEFORE CRC
                                    883  *       EXIT    TO CALLER IF OK
                                    884  *               TO *TPERR* IF BAD
                                    885  *       USES    A,F,H,L
                                    886
                                    887
002.172  315 325 002               888  CTC     CALL    RNP             READ NEXT PAIR
002.175  052 027 040               889          LHLD    CRCSUM
002.200  174                       890          MOV     A,H
002.201  265                       891          ORA     L
002.202  310                       892          RZ                      RETURN OF OK
002.203  076 001                   893          MVI     A,1             CHECKSUM ERROR
                                    894  *       JMP     TPERR           (B) = CODE


                                    896  **      TPERR - PROCESS TAPE ERROR.
                                    897  *
                                    898  *       DISPLAY ERR NUMBER IN LOW BYTE OF ABUSS
                                    899  *
                                    900  *       IF ERROR NUMBER EVEN, DONT ALLOW #
                                    901  *       IF ERROR NUMBER ODD, ALLOW #
                                    902  *
                                    903  *       ENTRY   (A) = NUMBER
                                    904
                                    905
002.205  062 024 040               906  TPERR   STA     ABUSS
002.210  107                       907          MOV     B,A             (B) = CODE
002.211  315 133 002               908          CALL    TFT             TURN OFF TAPE
                                    909
                                    910  *       IS #, RETURN (IF PARITY ERROR)
                                    911
002.214  346                       912          DB      MI.ANI          FALL THROUGH WITH CARRY CLEAR
002.215  170                       913  TER3    MOV     A,B
                                    914
002.216  017                       915          RRC
002.217  330                       916          RC                      RETURN IF OK
                                    917
                                    918  *       BEEP AND FLASH ERROR NUMBER
                                    919
002.220  334 136 002               920  TER1    CC      ALARM           ALARM IF PROPER TIME
002.223  315 252 002               921          CALL    TPXIT           SEE IF *
002.226  333 360                   922          IN      IP.PAD
002.230  376 057                   923          CPI     00101111B       CHECK FOR #
002.232  312 215 002               924          JE      TER3            IF #
002.235  072 034 040               925          LDA     TICCNT+1
002.240  037                       926          RAR                     'C' SET IF 1/2 SECOND
002.241  303 220 002               927          JMP     TER1
```

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


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









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









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

```
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
```

```
                                1026  **      CRC - COMPUTE CRC-16
                                1027  *
                                1028  *       CRC COMPUTES A CRC-16 CHECKSUM FROM THE POLYNOMIAL
                                1029  *
                                1030  *       (X + 1) * (X^15 + X + 1)
                                1031  *
                                1032  *       SINCE THE CHECKSUM GENERATED IS A DIVISION REMAINDER,
                                1033  *       A CHECKSUMED DATA SEQUENCE CAN BE VERIFIED BY RUNNING
                                1034  *       THE DATA THROUGH CRC, AND THEN RUNNING THE PREVIOUSLY OBTAINED
                                1035  *       CHECKSUM THROUGH CRC. THE RESULTANT CHECKSUM SHOULD BE 0.
                                1036  *
                                1037  *       ENTRY   (CRCSUM) = CURRENT CHECKSUM
                                1038  *               (A) = BYTE
                                1039  *       EXIT    (CRCSUM) UPDATED
                                1040  *               (A) UNCHANGED.
                                1041  *       USES    F
                                1042
                                1043
002.347  305                   1044  CRC     PUSH    B               SAVE (BC)
002.350  006 010               1045          MVI     B,8             (B) = BIT COUNT
002.352  345                   1046          PUSH    H
002.353  052 027 040           1047          LHLD    CRCSUM
002.356  007                   1048  CRC1    RLC
002.357  117                   1049          MOV     C,A             (C) = BIT
002.360  175                   1050          MOV     A,L
002.361  207                   1051          ADD     A
002.362  157                   1052          MOV     L,A
002.363  174                   1053          MOV     A,H
002.364  027                   1054          RAL
002.365  147                   1055          MOV     H,A
002.366  027                   1056          RAL
002.367  251                   1057          XRA     C
002.370  017                   1058          RRC
002.371  322 004 003           1059          JNC     CRC2            IF NOT TO XOR
002.374  174                   1060          MOV     A,H
002.375  356 200               1061          XRI     200Q
002.377  147                   1062          MOV     H,A
003.000  175                   1063          MOV     A,L
003.001  356 005               1064          XRI     5Q
003.003  157                   1065          MOV     L,A
003.004  171                   1066  CRC2    MOV     A,C
003.005  005                   1067          DCR     B
003.006  302 356 002           1068          JNZ     CRC1            IF MORE TO GO
003.011  042 027 040           1069          SHLD    CRCSUM
003.014  341                   1070          POP     H               RESTORE (HL)
003.015  301                   1071          POP     B               RESTORE (BC)
003.016  311                   1072          RET                     EXIT
```

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



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

```
PAM/8 - H8 FRONT PANEL MONITOR  #01.00.00.                    HEATH X8ASM V1.0  02/18/77
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                                1109  **      LRA - LOCATE REGISTER ADDRESS.
                                1110  *
                                1111  *       ENTRY   NONE.
                                1112  *       EXIT    (A) = REGISTER INDEX
                                1113  *               (H,L) = STORAGE ADDRESS
                                1114  *               (D,E) = (0,A)
                                1115  *       USES    A,D,E,H,L,F
                                1116
                                1117
                                1118
003.047  072 005 040            1119  LRA     LDA     REGI
003.052  137                    1120  LRA.    MOV     E,A
003.053  026 000                1121          MVI     D,0
003.055  052 035 040            1122          LHLD    REGPTR
003.060  031                    1123          DAD     D               (DE) = (REGPTR)+(REGI)
003.061  311                    1124          RET


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


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

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



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

```
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


                                1203  **      UFD - UPDATE FRONT PANEL DISPLAYS.
                                1204  *
                                1205  *
                                1206  *       UFD IS CALLED BY THE CLOCK INTERRUPT PROCESSOR WHEN IT IS
                                1207  *       TIME TO UPDATE THE DISPLAY CONTENTS, CURRENTLY, THIS IS DONE
                                1208  *       EVERY 32 INTERRUPTS, OR ABOUT 32 TIMES A SECOND.
                                1209  *
                                1210  *       ENTRY   (H,L) = ADDRESS OF REFCNT
                                1211  *       EXIT    NONE
                                1212  *       USES    ALL
                                1213
                                1214
003.161                         1215  UFD     EQU     *
003.161  076 002                1216          MVI     A,UO.DDU
003.163  240                    1217          ANA     B
003.164  300                    1218          RNZ                     IF NOT TO HANDLE UPDATE
                                1219
003.165  056 006                1220          MVI     L,#DSPROT
003.167  176                    1221          MOV     A,M
003.170  007                    1222          RLC
003.171  167                    1223          MOV     M,A             ROTATE PATTERN
003.172  107                    1224          MOV     B,A
003.173  043                    1225          INX     H
000.000                         1226          ERRNZ   DSPMOD-DSPROT-1
003.174  176                    1227          MOV     A,M             (A) = DSPMOD
003.175  346 002                1228          ANI     2
003.177  052 024 040            1229          LHLD    ABUSS
003.202  312 227 003            1230          JZ      UFDI            IF MEMORY
                                1231
                                1232  *       AM DISPLAYING REGISTERS.
                                1233
003.205  315 047 003            1234          CALL    LRA             LOCATE REGISTER ADDRESS
003.210  345                    1235          PUSH    H
003.211  041 342 003            1236          LXI     H,DSPA
003.214  031                    1237          DAD     D               (H,L) = ADDRESS OF REG NAME PATTERNS
003.215  176                    1238          MOV     A,M
003.216  043                    1239          INX     H
003.217  146                    1240          MOV     H,M
003.220  157                    1241          MOV     L,A             (H,L) = REG NAME PATTERN
003.221  343                    1242          XTHL
003.222  264                    1243          ORA     H               CLEAR 'Z'
003.223  176                    1244          MOV     A,M
003.224  043                    1245          INX     H
003.225  146                    1246          MOV     H,M
003.226  157                    1247          MOV     L,A             (HL) = ADDRESS OF REGISTER PAIR CONTENTS
                                1248
                                1249  *       SETUP DISPLAY
                                1250
003.227  365                    1251  UFD1    PUSH    PSW
003.230  353                    1252          XCHG
003.231  041 013 040            1253          LXI     H,ALEDS
003.234  172                    1254          MOV     A,D
003.235  315 122 003            1255          CALL    DOD             FORMAT ABANK HIGH HALF
003.240  173                    1256          MOV     A,E
003.241  315 122 003.           1257          CALL    DOD             FORMAT ABANK LOW HALF
003.244  361                    1258          POP     PSW
```

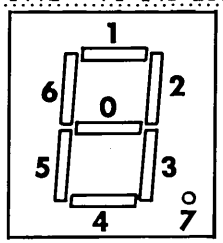
```
003.245  032           1259          LDAX    D
003.246  312 122 003   1260          JZ      DOD             IF MEMORY, DECODE BYTE VALUE
                       1261
                       1262  *       IS REGISTER. SET REGISTER NAME.
                       1263
003.251  066 377       1264          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


                                1271  **      RCK - READ CONSOLE KEYPAD.
                                1272  *
                                1273  *       RCK IS CALLED TO READ A KEYSTROKE FROM THE CONSOLE KEYPAD.
                                1274  *       WHENEVER A KEY IS ACCEPTED,
                                1275  *       RCK PERFORMS DEBOUNCING, AND AUTO-REPEAT. A *BIP* IS SOUNDED
                                1276  *       WHEN A VALUE IS ACCEPTED.
                                1277  *
                                1278  *       KEY PAD VALUES:
                                1279  *
                                1280  *       1111 1110  -  0
                                1281  *       1111 1100  -  1
                                1282  *       1111 1010  -  2
                                1283  *       1111 1000  -  3
                                1284  *       1111 0110  -  4
                                1285  *       1111 0100  -  5
                                1286  *       1111 0010  -  6
                                1287  *       1111 0000  -  7
                                1288  *       1110 1111  -  8
                                1289  *       1100 1111  -  9
                                1290  *       1010 1111  -  +
                                1291  *       1000 1111  -  -
                                1292  *       0110 1111  -  *
                                1293  *       0100 1111  -  /
                                1294  *       0010 1111  -  #
                                1295  *       0000 1111  -  .
                                1296  *
                                1297  *
                                1298  *       ENTRY   NONE
                                1299  *       EXIT    TO CALLER WHEN A KEY IS HIT
                                1300  *               (A) =  0 - '0'
                                1301  *                      1 - '1'
                                1302  *                      2 - '2'
                                1303  *                      3 - '3'
                                1304  *                      4 - '4'
                                1305  *                      5 - '5'
                                1306  *                      6 - '6'
                                1307  *                      7 - '7'
                                1308  *                      8 - '8'
                                1309  *                      9 - '9'
                                1310  *                     10 - '+'
                                1311  *                     11 - '-'
                                1312  *                     12 - '*'
                                1313  *                     13 - '/'
                                1314  *                     14 - '#'
                                1315  *                     15 - '.'
                                1316  *       USES    A,F
                                1317
                                1318
003.260                         1319  RCK     EQU     *
003.260  345                    1320          PUSH    H
003.261  305                    1321          PUSH    B
003.262  016 024                1322          MVI     C,400/20        WAIT 400 MS
003.264  041 026 040            1323          LXI     H,RCKA
                                1324
003.267  333 360                1325  RCK1    IN      IP.PAD          INPUT PAD VALUE
003.271  107                    1326          MOV     B,A             (B) = VALUE
```

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

```
                        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
```

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

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


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

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

```
CROSS REFERENCE TABLE.                                XREF V1.0  PAGE   38

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

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

25434 BYTES FREE

APPENDIX B

Demo: PAM-8

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

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

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

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

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

The Sample Program

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

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

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

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

```
                                                        HEATH ASM #104.01.00.
                                                        PAGE  1

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

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

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

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

INDEX