MTRHEX / MTROCT

Replacement Heath H89 monitor ROMs

24025 Fernlake Drive; Harbor City, CA 90710
213/539-4276 9AM-Noon Pacific time

ABSTRACT:

MTRHEX and MTROCT are replacement monitor ROMs for the Heathkit H89 computer that provide increased HDOS processing speed and additional debugging capabilities. The following features are provided:

The monitor clock interrupt processing routine has been rewritten, giving an effective 16% CPU speed increase to HDOS programs running on a 2 MHz system, and a 7% increase to HDOS programs running on a 4 MHz system.

The clock value in memory (TICCNT) has been extended to a four byte counter.

The monitor now supports debugging of programs under HDOS. Additional monitor debugging commands have been provided to display and alter all Z-80 registers, to read and write to I/O ports, to single step and breakpoint programs, and to restart HDOS. With an optional hardware modification, the monitor will allow the RESET key to interrupt a program.

The dynamic RAM test has been updated to provide faster, better testing; the disk drive test now correctly measures the rotation time of any mini-floppy unit.

The monitor supports CPU speeds of 2 or 4 MHz, including booting from an H17 drive, an H47 drive, and Magnolia Microsystems' double density floppy controller board. (Additional software, available from UltiMeth Corp., may be required.)

Full compatibility with HDOS and Heath and Magnolia CP/M has been maintained. Each ROM retains all of the common Heath H89 ROM entry point locations (except for cassette tape processing).

The monitor ROM is available in either a split octal (MTROCT) or hexadecimal (MTRHEX) version, and in either Heath direct plug replacement format (TMS 2716) or in 5 volt 2716 format.

INSTALLATION:

Be sure that power to the H89 is turned off. Remove the top shell of the computer cabinet. If you have a 64K RAM add-on board, you may wish to remove it. On the CPU board, locate and note the orientation of the old monitor ROM (Heath part number

444-40 or 444-62) at U518; note that the notch in the ROM is toward the center of the CPU board. In the following steps, to prevent static electricity damage to the ROMs, move the ROMs directly between the CPU board and the foam provided with the new ROM. Carefully remove the old ROM from the socket at U518 (it is not necessary to remove the CPU board) and immediately insert it in the backside of the foam provided with the new ROM.

If you special-ordered the ROM in the 5 volt 2716 format, move jumpers JJ505, JJ506, JJ507 (next to the ROM socket) from the "0" position to the "1" position.

Carefully remove the new ROM from the foam and immediately install it in the socket at U518; orient the notch in the ROM toward the center of the CPU board. If you removed a 64K RAM board, re-install it now. Replace the top shell of the computer cabinet.

You will need to alter the settings of switch SW501 on the CPU board; the definitions of these switch settings are different than for the Heath ROMs, and are as follows:

Switch number 7 6 5 4 3 2 1 0		Description...
0		The terminal BAUD rate is 9600.
1		The terminal BAUD rate is 19200. To use this option, SW401 (on the terminal board), sections 0-3 must be set to 1011; some Heath terminal boards will not run at 19200 BAUD.
. 0		Normal monitor & boot operation.
. 1		Upon reset (at power-up or when "shift-reset" is depressed), a boot (called an "autoboot") is made from primary boot drive 0.
. . 0		Upon reset (at power-up or when SHIFT - RESET is depressed), the dynamic RAM test is performed.
. . 1		Normal monitor operation. This setting must be used when this switch is wired in parallel with an "external interrupt" switch as described below under "Optional Hardware Modification".
. . . x x x . .		Reserved for future ROMs.
		The following settings define the primary boot device type (the device type letter used in the "Boot" command is shown in "[ ]".)
. . . . . . 0 0	[A]	H17-type 5" floppy.
. . . . . . 0 1	[B]	H47 8" floppy at port 170Q/78H.
. . . . . . 1 0	[C]	H47 8" floppy at port 174Q/7CH.
. . . . . . 1 1	[D]	MMS 5"/8" double density floppy.

Turn on power to the H89; you should immediately hear two "beep"s, and the prompt "MTR:" should shortly appear on the CRT screen. If not, turn off the power and make sure that the new ROM is properly installed at socket U518, and that you did not jar any cables loose.

Save the old ROM in the foam provided in case you ever want to go back to the old ROM in the future.

MONITOR COMMANDS:

When typing commands (and, for the MTRHEX ROM, hexadecimal values), letters (except for register names in the "Register" command) may be typed in either upper or lower case. When typing the following commands, only the first letter of the command is typed; the computer displays the entire command. At any point prior to typing the RETURN key, a line may be cancelled by typing the DELETE key. When typing in a split octal or hexadecimal value (depending on the type of ROM that you ordered), errors may be corrected by retyping the entire correct value; the monitor uses only the last digits typed.

In the examples given below, an underscore ("_") is shown where a space would be typed or displayed, and an at-sign ("@") is shown where the RETURN key would be typed. Although the values shown in the examples are hexadecimal, operation is the same for split octal.

Boot:

This command reads the bootstrap code from the boot track into RAM memory beginning at address 42.200 (split octal) or 2280 (hexadecimal), and then transfers control to the bootstrap code at the above address. The default boot device is unit 0 of the primary boot device type designated by the switch settings of SW501. Any other device type may also be booted by typing the device type letter (shown above under "Installation") after the "B". A disk unit other than 0 may be booted by typing the desired disk unit number. If the read of the boot track is not complete after 16 seconds, or if an I/O error occurs, the boot is aborted with the message "I/O error". The read of the boot track may also be aborted by depressing the DELETE key (the DELETE key will also abort an autoboot).

Examples:

Computer prompts:	You type:	Computer displays:
MTR:_	b@	MTR:_Boot
(Unit 0 of the primary boot device is booted.)		
MTR:_	bb1@	MTR:_Boot_B:_1
(Unit 1 of the H47 is booted.)		

Memory:

This command displays and alters the values in memory in dynamic RAM (ROM and static RAM memory values may only be displayed). This command is a replacement for the Heath

"Substitute" command, and is named "Memory" to distinguish it from the new "Register" command. Type a memory address after the "M"; the computer will type the memory address again and the memory value at that address. You may then optionally type a new value, followed by the RETURN key (which terminates the "Memory" command), a space (which increments the memory address and repeats), or a minus sign (which decrements the memory address and repeats).

Example:

Computer prompts:	You type:	Computer displays:
MTR:_	m2293@	MTR:_Memory_2293
2293_78_	_	2293_78
2294_03_	77_	2294_03_77
2295_79_	0-	2295_79_0-
2294_77_	76-	2294_77_76-
2293_78_	@	2293_78
		MTR:_

(This example shows location 2293 examined twice, location 2294 altered twice, and location 2295 altered once.)

Register:

This command displays and alters the register values of a user program. Type the first letter of an 8080 register pair name in upper case (i.e., S(P), A(F), B(C), D(E), H(L), P(C)); type an upper case "X" or "Y" for the Z-80 index registers "IX" and "IY"; type the first letter of a Z-80 alternate register pair name in lower case (i.e., (a(f), b(c), d(e), h(l)). The computer will type the second letter of the name. If you type a value after the register name, that value becomes the new value for that register pair. If you type the RETURN key after the register name, the old value register pair value will be displayed. You may then optionally type a new value for the register pair (except for register SP). Any new values entered become effective when control is next passed to the user program (any new values entered for register SP are ignored). Note that this command includes the function of the Heath "Program Counter" command.

Examples:

Computer prompts:	You type:	Computer displays:
MTR:_	rP@	MTR:_Register_PC
FFFO_	228c@	FFFO_228c
		MTR:_

(This example displays and alters the program counter register.)

MTR:_	rh0@	MTR:_Register_hl_0
		MTR:_

(This example alters Z-80 alternate register hl.)

In:

This command inputs a value from an H89 port (references to an H8 port address produce meaningless values). Type a port address after the "I"; the computer will type the port address again and the input value. You may then type the RETURN key (which terminates the "In" command), or a space or minus sign (which repeats with the same port address).

Example:

Computer prompts:	You type:	Computer displays:
MTR:_	if2@	MTR:_In_f2
00F2_20	_	00F2_20
00F2_20	@	00F2_20
		MTR:_

(This example inputs twice from port F2.)

Out:

This command outputs a value to an H89 port (references to an H8 port address are ignored). Type a port address after the "O"; the computer will type the port address again. You may then optionally type an output value, followed by the RETURN key (which terminates the "Out" command), or a space or minus sign (which repeats with the same port address).

Example:

Computer prompts:	You type:	Computer displays:
MTR:_	oe0	MTR:_Out_e0
00E0_	48_	00E0_48
00E0_	49@	00E0_49
		MTR:_

(This command outputs two values to port E0.)

Go:

This command transfers control to a program. If you type an address after the "G", control passes to the program at that address. If you type the RETURN key after the "G", control passes to the current address value in the user PC register.

Examples:

Computer prompts:	You type:	Computer displays:
MTR:_	g2280@	MTR:_Go_2280

(Control is transferred to the program at 2280.)

Computer prompts:	You type:	Computer displays:
MTR:_	g@	MTR:_Go

(Control is transferred to the program at the address specified by the current value of the program counter register.)

Step:

This command transfers control to a program, executes one instruction, displays the new register PC value, and returns control to the monitor. If you type an address after the "S", control passes to the program at that address. If you type the RETURN key after the "S", control passes to the current address value in the user PC register. Note that if the single instruction executed is a "DI" (disable interrupts), execution of the program will continue until an "EI" (enable interrupts) instruction is executed. You should not step through any time-dependent code in HDOS, such as device drivers (if you step through a disk device driver, you might destory information on a diskette).

Example:

Computer prompts:	You type:	Computer displays:
MTR:_	s2280@	MTR:_Step_2280 PC_@_2281
MTR:_	s@	MTR:_Step PC_@_2282 MTR:_

(This example single steps twice the program beginning at 2280.)

Pause:

This command inserts a breakpoint in a user program. Type a memory address after the "P"; the computer will type the memory address again and the memory value at that address. It will then replace that value with a "Pause" instruction (an "RST 0"). When the "Pause" is subsequently encountered during program execution, the monitor regains control. Note that any transfer of control to memory address zero (except for a hardware reset) is considered a "Pause"; the value in the top of the stack is assumed to be the current PC register value. If you intend to resume program execution after a "Pause", you should replace the byte at the "Pause" address (the current PC register value minus one) with the original value (displayed by the "Pause" command) at that address, and then transfer control to that address (via the "Go" command).

Example:

Computer prompts:	You type:	Computer displays:
MTR:_	p2280@	MTR:_Pause_2280 2280_00
MTR:_	g2280@	MTR:_Go_2280 [Pause] PC_@_2281 MTR:_

(This example inserts a "Pause" in memory and then transfers control to the "Pause" instruction.)

HDOS restart:

This command is equivalent to a "Go 40100" (split octal) or "Go 2040" (hexadecimal). If HDOS is still in memory, HDOS will regain control and display the HDOS prompt.

Example:

Computer You Computer

prompts:	type:	displays:
MTR:_	h@	MTR:_HDØS_restart

(Control is transferred to the program at 2040.)

Test disk drive:

This command replaces the function of the JMP instruction at 7372 (split octal) or 7FA (hexadecimal). Insert any diskette in a mini-floppy disk drive and type the unit number after the "T". The diskette is not altered; any initialized or uninitialized hard-sectored (10 sectors per track) diskette may be used. The display will show the word "Rotation" flashing, and, if the disk drive is within tolerance (1%), the display will show a number between 173 and 205 (octal) or 1FB and 205 (hexadecimal). The drive may be adjusted to show a number as close to 200 as feasible. This command is terminated by depressing the DELETE key.

Example:

Computer prompts:	You type:	Computer displays:
MTR:_	t0@	MTR:_Test_disk_drive_0 ____Rotation_time:_0200

(This example tests the rotation speed of mini-floppy disk drive 0.)

Validate RAM:

This command replaces the function of the JMP instruction at 7375 (split octal) or 7FD (hexadecimal). The display will show the upper limit RAM address, and will show a varying "Mask:" value. The mask value is used along with the address bits to generate a test value of either 252 or 125 (octal) or either AA or 55 (hexadecimal) for each byte in memory. This test is very effective because it tests for one data bit interfering with another data bit (crosstalk) both within a byte (circuit board capacitance crosstalk) and between bytes at different memory addresses (memory chip matrix crosstalk). The test uses 16 mask values, beginning with 253 (octal) or AB (hexadecimal), and then repeats. An error is indicated by the upper limit RAM address being incorrect, or by an error message. The error message will show a memory location and a byte value; the error bit is a missing or extra bit in a value of 252 or 125 (octal) or AA or 55 (hexadecimal). This command is terminated by resetting the computer (keying SHIFT - RESET).

Example:

Computer prompts:	You type:	Computer displays:
MTR:_	v@	MTR:_Validate_RAM 2_MHz_reset Dynamic_RAM_test ____High_address:_DFFF ____Mask:_AB

(This example initiates the dynamic RAM test.)

OPTIONAL HARDWARE MODIFICATION:

This modification allows the monitor ROM to detect when an external switch is depressed. On each clock interrupt, section 5 of SW501 on the CPU board is sampled; if the switch is ON (closed, or set to "0"), the monitor regains control. Typing a "G(o)" command (with no address) returns control to the original program at the point of interrupt. Another switch can be wired in parallel with section 5 of SW501, giving an external interrupt capability.

NOTE THAT UltiMeth Corporation CANNOT ACCEPT ANY RESPONSIBILITY FOR THE PROPER FUNCTIONING OF YOUR UNIT IF YOU MAKE THE FOLLOWING MODIFICATION. You must use good engineering practices and perform the modification carefully. Before making any hardware modification to your unit, read the remainder of this section carefully to understand both the modification and its effect on your unit.

Any modification that provides a switch in parallel with section 5 of SW501 will work. Be sure and use the x-ray charts provided with the unit to locate parts and to check your work; the circuit diagrams (schematics) are useful to double-check your work and to understand the modification. We recommend the following modification, which allows you to use the RESET key on the keyboard as the additional "external interrupt" switch:

> Remove the terminal board and install a jumper wire on the component side of the circuit board from pin 12 of P404 to the far end (near the bottom of the board) of R419 (above P403) - - alternatively, if you are using small diameter wire (which you should), you may use the feed-through hole just below C471.
>
> Modify the cable that runs from P4C4 on the terminal board to P513 on the CPU board to include a wire from pin 12 to pin 12. If you do not have any remaining "small spring connectors" from your assembly of the unit, you will have to find two. They are available from Heath as part number 432-866.
>
> Remove the CPU board and install a jumper wire on the foil side of the circuit board from pin 12 of P513 to the far end of section 5 of SW501.

Section 5 of SW501 (and any switch installed in parallel with it) is used for two purposes: When the computer is reset, if the switch is ON, the monitor performs a dynamic RAM test. At any other time, whenever the monitor updates the clock (TICCNT), which occurs every 2 milliseconds when the CPU is enabled for clock interrupts, the monitor examines the switch. If the switch is ON, the monitor suspends execution of whatever program is running and displays the following:

```
[Interrupt]
PC @`xxxx
```

Note that "xxxx" is the current PC register value.

This means that if you wire the RESET key on the keyboard in parallel with section 5 of SW501, and you depress the RESET and (right-) SHIFT keys to reset the computer, you may hear two "beeps" - - one when the monitor detected the RESET key being depressed, and another when the RESET key is released and the computer resets. Also, if you reset the computer and you release the SHIFT key before you release the RESET key, the monitor will perform the dynamic RAM test, destroying the contents of memory.

You should realize that some computer programs should not be interrupted. For example, some device drivers will lose data if they are interrupted in the middle of a critical task. A properly written device driver will protect itself by disabling interrupts during the execution of critical timing situations. Interrupts are generally only disabled for short periods of time. HDOS was written with this in mind; however, you should be aware of the following: The mini-floppy device driver uses the clock for timing, and thus is enabled during part of its execution to allow the clock to be updated. If you interrupt HDOS while one of the mini-floppy disk drives is selected (the LED is on), the LED will stay on until you exit from the monitor, and you may get a soft disk error. Therefore, we recommend not interrupting HDOS while disk operations are in progress. AGAIN, UltiMeth Corporation CANNOT ACCEPT ANY RESPONSIBILITY FOR LOST DATA AS A RESULT OF USING THIS FEATURE. You should always have adequate backups of both programs and data on separate diskettes.

Also, interrupting out of a program which is in the process of altering the terminal characteristics without protecting itself by disabling interrupts (such as the HDOS boot track code) may cause the terminal to "hang up".

TECHNICAL INFORMATION:

On power-up or reset, the monitor measures and displays the processing speed of the CPU. It then determines the limit of RAM memory, and the user program counter (PC) and stack pointer (SP) are set to fifteen less than the address of the last byte of RAM. You may use the first 10 bytes of this area for a "JMP" instruction and/or other data. For example, if you have Org-0 CP/M, you could modify your BIOS cold start routine to place there a JMP to the warm start routine (make sure that the warm start routine remaps memory to all RAM, and reinitializes any serial ports used). Then, a reset followed by the monitor "G(o)" command (with no address) performs a CP/M warm start.

The following routine entry points in the Heath MTR-88 and -89 ROMs have been preserved at their original locations. Note that only the function of the routine has been preserved; the code may have changed. The routines have been preserved only to allow compatibility with existing programs; it is strongly recommended that you do not write code that references these routines, as Heath or UltiMeth may not provide them in future ROMs. In the MTRHEX ROM, routines that used to perform octal conversion functions now perform the corresponding hexadecimal conversion functions. The TYPMSG routine now stops on either a null character or a character with the high-order bit on.

Heath routine name   Location

DLY	002B	000.053
INTXIT	007A	000.172
PIN	0137	001.067
ALARM	025E	002.136
HORN	0260	002.140
IOA	0332	003.062
IOB	0336	003.066
RCC	03B2	003.262
WCC	03C2	003.302
IROC	0568	005.150
IOA1	057E	005.176
IOC	05C1	005.301
TOA	05CB	005.313
TOA.	05D5	005.325
TOB	05E3	005.343
WCR	0603	006.003
DAT	0613	006.023
COM	0617	006.027
OUT.	0633	006.063
OUT.1	0638	006.070
TYPMSG	0640	006.100
RDBLCK	0651	006.121
OUT1.	0666	006.146
IN1.	066E	006.156
IN.	0678	006.170
IN.1	067C	006.174

The following RAM locations are used or reserved by the monitor ROM:

Heath location name	Location(s)	
(reserved)	2000-2007	040.000-040.007
.MFLAG	2008	040.010
CTLFLG	2009	040.011
(reserved)	200A-201A	040.012-040.032
TICCNT	201B-201E	040.033-040.036
UIVEC	201F-2033	040.037-040.063
(reserved)	2034-203F	040.064-040.077

.MFLAG:

The default value for this byte is zero.

If bit 0 is set, the monitor will CALL the instruction at UIVEC on each clock interrupt with all interrupts disabled; return should be made to the monitor via the "RET" instruction without enabling interrupts. After the CALL, the stack contains, in ascending order, the following items (note that this list is different than Heath's list):

(SP+0) = Return location in the monitor.
(SP+2 ...) The contents of this part of the stack should not be relied upon.

Note that HDOS supplies a JMP to its own clock interrupt processing routine (bit 0 is set during HDOS operation); this routine is critical to the proper operation of the mini-floppy disks.

If bit 7 is set, the monitor will not attempt to detect a halt condition (bit 7 is set during HDOS operation). If bit 7 is not set, the clock interrupt routine checks the last byte of the last instruction executed prior to each clock interrupt. If the operation code value for a "HLT" instruction is found, the monitor regains control and displays the following:

```
[Halt]
PC @ xxxx
```

Note that "xxxx" is the current PC register value, which is the location of the "HLT" operation code value plus one. Note that many multiple-byte instructions could have the last byte of the instruction look like a "HLT" operation code, so the monitor may falsely detect a halt condition when none exists (which is why Heath provided bit 7 of .MFLAG to disable this feature under HDOS).

CTLFLG:

This byte should reflect the current value output to port F0 (hexadecimal) or 360 (octal). Since this port exists only on an H8, and not on an H89, the H89 hardware causes a Z-80 non-maskable interrupt to be generated whenever a reference is made to an H8 port address. The monitor ROM intercepts the non-maskable interrupt and, if an 8080 "OUT" instruction reference to port F0 (hexadecimal) or 360 (octal) caused the non-maskable interrupt, the monitor changes the format of the output value to the corresponding H89 value, and outputs the value to port F2 (hexadecimal) or 362 (octal). (Note that the monitor "I(n)" and "O(ut)" commands use Z-80 input and output instructions, and thus produce meaningless results when used to reference H8 port addresses.)

User programs wishing to output to port 360 (octal) or F0 (hexadecimal) should disable interrupts, get the current value of CTLFLG, alter bits 4 and\or 6 as desired, store the new value in CTLFLG, then output to the port, and then enable interrupts.

If bit 4 is set, the single step interrupt feature is disabled (the default). If bit 4 is reset, the single step feature is enabled. When the single step interrupt occurs, the monitor will JMP to the instruction at UIVEC+3 with interrupts disabled; the return to the point of interrupt is the responsibility of the user program. After the JMP, the stack contains, in ascending order, the following items (note that this list is the same as Heath's list):

```
(SP+0)  = Stack pointer value at time of interrupt.
(SP+2)  = Program status word (register AF).
(SP+4)  = Register BC.
(SP+6)  = Register DE.
(SP+8)  = Register HL.
(SP+10) = Interrupt return location (register PC).
```

Bit 6 is set to enable clock interrupts (the default). Note that HDOS requires that clock interrupts be enabled (see above under .MFLAG).

TICCNT:

This 4-byte area contains a 32-bit binary value which is incremented on every clock interrupt (every 2 milli-seconds). TICCNT contains the lowest-order byte, and

TICCNT+3 contains the highest-order byte. The two high-order bytes have been added to Heath's TICCNT to allow the value in TICCNT to represent more than 24 hours. Note that HDOS disk I/O operations disable interrupts for periods of time exceeding 2 milliseconds, causing clock interrupts to be delayed; thus, TICCNT cannot be used as a highly accurate 24-hour clock.

UIVEC:
This 21-byte area reserves a 3-byte instruction area for each possible user interrupt (1 to 7); user interrupts "1" and "2" are the clock and single step interrupts, respectively, and are discussed above under ".MFLAG" and "CTLFLG". User interrupts "3" through "7" cause the monitor to JMP directly to the following entry in UIVEC with interrupts disabled:

Interrupt number:	JMP location:
3	UIVEC+6
4	UIVEC+9
5	UIVEC+12
6	UIVEC+15
7	UIVEC+18

After the JMP, the stack contains only the interrupt return location. The user interrupt routine must save and restore any registers it uses, and must enable interrupts before returning to the point of interrupt. Note that HDOS uses interrupt "3" (for console I/O) and "7" (for SCALLs).

MTRHEX
Appendix A

The following patches to HDOS 2.0 programs change the number radix (base) for output from split octal to hexadecimal (for SET, the patches allow hexadecimal input). THESE PATCHES ARE SUPPLIED AS IS, AS A SERVICE TO UltiMeth CUSTOMERS. NO WARRANTY IS MADE AS TO THE CORRECTNESS OF THESE PATCHES. CUSTOMERS SHOULD HAVE ADEQUATE BACKUPS OF THE PROGRAMS PATCHED, AS WELL AS CUSTOMER DATA, BEFORE MAKING THESE PATCHES. You should have some program for making the patches. An appropriately modified version of Heath's PATCH program will work; however, we recommend the use of the Heath User's Group program "DUMP". THESE PATCHES ONLY APPLY TO HDOS 2.0.

The following patches make Heath's ASM print hexadecimal output:

FILE DISP	PROG ADDR	OLD DATA	NEW DATA	EXPLANATION		
0E89	3101	3E68	3E67	MVI	A,67	GET LOW-ORDER BYTE OF PRINT LINE LOC OF LAST HEX DATA BYTE
0F67	31DF	215C3A	215B3A	LXI	HL,3A5B	GET PRINT LINE LOC OF FIRST HEX DATA BYTE
0FEF	3267	21533A	21553A	LXI	HL,3A55	GET PRINT LINE LOC OF FIRST ADDRESS BYTE
0FF6	326E	362E	0000	NOP,NOP		DELETE PERIOD INSERTION
...	...	23	00	NOP		
1237	34AF	C5	F5	PUSH	PSH	CONVERT TO HEX ROUTINE
...	...	06	OF	RRC		(SEE ISSUE 14 OF REMARK)
		03	OF	RRC		
		A7	OF	RRC		
		17	OF	RRC		
		1717F5	CDB834	CALL	*+4	
		E6	F1	POP	PSW	
		07C6	E60F	ANI	OFH	
		3077	C690	ADI	90H	
		23	27	DAA		
		F105	CE40	ACI	40H	
		C2	27	DAA		
		B3	77	MOV	M,A	
		34	23	INX	HL	
		C1	C9	RET		

In addition, the following patches must be made to XREF to make it print hexadecimal output:

FILE DISP	PROG ADDR	OLD DATA	NEW DATA	EXPLANATION		
0514	278C	21B927	21BB27	LXI	HL,27BB	GET PRINT LINE LOC OF FIRST ADDRESS BYTE
0541	27B9	3030	2020	DB	' '	BLANK OUT UNUSED PRINT LINE
0A3E	2CB6	C5	F5	PUSH	PSH	CONVERT TO HEX ROUTINE
...	...	06	OF	RRC		(SEE ISSUE 14 OF REMARK)

```
03      0F      RRC
A7      0F      RRC
17      0F      RRC
1717F5  CDBF2C  CALL    *+4
E6      F1      POP     PSW
07C6    E60F    ANI     0FH
3077    C690    ADI     90H
23      27      DAA
F105    CE40    ACI     40H
C2      27      DAA
BA      77      MOV     M,A
2C      23      INX     HL
C1      C9      RET
```

The following patches to SYSCMD.SYS cause the STAT command to print its output in hexadecimal:

```
04CB 2743 218D27 218F27 LXI     HL,278F GET PRINT LINE DATA LOC

04D5 274D 21A927 21AB27 LXI     HL,27AB GET PRINT LINE DATA LOC

04DF 2757 21C927 21CB27 LXI     HL,27CB GET PRINT LINE DATA LOC

0514 278C 093030 202020 DB      '   '   BLANK OUT UNUSED PRINT LINE

0530 27A8 093030 202020 DB      '   '   BLANK OUT UNUSED PRINT LINE

0550 27C8 093030 202020 DB      '   '   BLANK OUT UNUSED PRINT LINE

0ACA 2D42 C5      F5      PUSH    PSH     CONVERT TO HEX ROUTINE
...  ...  06      0F      RRC             (SEE ISSUE 14 OF REMARK)
          03      0F      RRC
          A7      0F      RRC
          17      0F      RRC
          1717F5  CD4B2D  CALL    *+4
          E6      F1      POP     PSW
          07C6    E60F    ANI     0FH
          3077    C690    ADI     90H
          23      27      DAA
          F105    CE40    ACI     40H
          C2      27      DAA
          46      77      MOV     M,A
          2D      23      INX     HL
          C1      C9      RET
```

The following patches to SET.ABS allows hexadecimal values (e.g., port addresses) to be SET as well as binary, octal, and decimal values. The SET value should be followed by a radix indicator of "B", "O", "Q", "D", or "H" (e.g., "340Q" or "E0H"). The Heath device drivers have various default radices (bases) for each numeric parameter that can be entered, but they don't document what the default radix is for each parameter. Line widths, page depths, etc., are usually decimal; port addresses and character values are usually octal. When in doubt, specify the radix. Note that a hexadecimal value ending in "B" or "D" MUST have an explicit radix, or the "B" or "D" will be interpreted as a radix indicator!

```
09FA 2C72 D8FE0A C3E92C JMP     2CE9    CONVERT HEX INPUT TO BINARY
```