altair 8800b

SECTION IV
TROUBLESHOOTING

PREFACE

Section IV is designed to aid the user in pinpointing trouble areas and correcting problems that may be encountered with the Altair 8800b computer. The text that follows contains detailed instructions that should help in locating and correcting most problems. However, if the malfunction(s) cannot be rectified, send the unit to the MITS Repair Department or your local Altair dealer.

Section IV is divided into five major sections :

4-1) Introduction to Troubleshooting which contains general procedures that should always be followed, and IC static level charts showing the proper indications for the most common trouble areas;

4-2) Visual Inspection which contains procedures for locating problems caused by improper assembly;

4-3) Preliminary Check which contains tests for voltages and waveforms;

4-4) Non-PROM Related Switch Problems which concerns the RUN/STOP, SINGLE STEP/SLOW, RESET/EXTERNAL CLEAR and PROTECT/UNPROTECT switches;

4-5) PROM Related Switch Problems which deals with the EXAMINE/ EXAMINE NEXT, DEPOSIT/DEPOSIT NEXT, ACCUMULATOR DISPLAY/ ACCUMULATOR LOAD and IN/OUT switches.

Sections 4-3, 4-4 and 4-5 are presented in chart form, indicating the testing instructions, the correct indication, the incorrect indication and the procedures for remedying the problem.

Before beginning the actual troubleshooting procedures, the Theory of Operation and Section 4-1 should be reviewed. Refer to these portions of the manual when necessary.

An oscilloscope and an inexpensive multimeter will be needed to perform these troubleshooting procedures. The oscilloscope should be used to detect and measure pulses; the multimeter should be used to check voltage levels and continuity.

4-1. INTRODUCTION TO TROUBLESHOOTING

A. Basic Troubleshooting Procedures

Paragraphs 1, 2, 3 and 4 contain general instructions for testing ICs, diodes, transistors and bridge rectifiers, respectively. These procedures should be followed each time the instructions (in the tables that follow) specify that one of the above mentioned components be checked.

1. ICs
   a. With a voltmeter (or oscilloscope), check the IC pin for the proper voltage level or pulse. Make sure that the voltmeter is touching only one pin at a time; if the voltmeter should come in contact with more than one pin, erroneous readings and shorts may occur. (Note: Because the entire system is based upon the 8080 microprocessor chip, IC M on the CPU board, be especially careful when checking this component.) If the correct voltage is not present at the IC:
      1. Use the schematic to trace the signal back to its original source, checking for proper logic operation at each gate.
      2. Visually inspect the area surrounding the IC for solder bridges or opens.
   b. Never assume that when a signal leaves its source it will always reach its destination. Check for continuity with an ohmmeter (set at X1K ohms or higher to protect the ICs from the ohmmeter's current). If opens in the lands are found, solder over them.
   c. Check for power (Vcc) and Ground at the IC. Several of the schematics (in the Theory of Operation section) contain charts indicating the Vcc and Ground pins for each IC. If Vcc and Ground are present, test the IC according to the steps below.
      1) For ICs with sockets:
         a) Turn power off and remove the IC from its socket.
         b) Bend the suspected output pin up and reinstall the IC into its socket.
         c) Turn power on and check for proper logic operation.

NOTE

Removing an IC pin from its socket or from the board may change the IC's input level. When checking for proper logic, refer to the truth tables (pages 3-5 through 3-8) associated with that type of gate.

d) If the IC does not operate properly, replace it. If it does operate properly, bend the pin back and reinsert it into the socket. Look for a solder short or bridge and repair as necessary.

2) For ICs without sockets:

a) Turn power off and cut the suspected IC pin where it meets the component side of the board.

b) Bend the pin up and turn power on.

c) Check for proper logic operation (as shown in the appropriate truth table).

d) If the IC does not operate properly, replace it. If it does operate properly, resolder the pin to the board and look for a solder short or bridge. Repair as necessary.

NOTE

If an IC without a supplied socket needs to be replaced, you may wish to install a good-quality socket with it. Because sockets don't have to be removed from the board in order to test the IC, installation of sockets will aid in future troubleshooting and will prevent wear and tear on the board.

2. Diodes

Diodes can be easily tested with an ohmmeter set at X100 ohms. Turn power off and unsolder one lead from the board. To forward bias the diode, place the ohmmeter's positive lead on the diode's anode lead and the ohmmeter's negative lead on the diode's cathode lead. (The cathode lead is on the side marked with a bar.) The ohmmeter should show a LOW reading (15-300 ohms). To reverse bias the diode, transpose the ohmmeter's leads and check for a HIGH resistance reading (above 1K ohms). If the diode's readings do not correspond with the readings shown here, the diode should be replaced.

3. Transistors

Transistors can be tested with an ohmmeter set at X100 ohms. The following chart shows the correct readings for transistors with at least two leads removed from the board. Refer to the chart on page 5-9 in the Assembly section of the manual for lead identification, and compare the transistor's resistance to the resistance indicated in the chart below. Q1, Q2 and Q3 on the CPU board and Q2 on the Power Supply board are NPN transistors. Q1 on the Power Supply board is a PNP transistor.

Ohmmeter Lead Placement	Transistor Resistance NPN Transistors	PNP Transistors
Positive lead to emitter Negative lead to base	HIGH resistance	LOW resistance
Positive lead to base Negative lead to emitter	LOW resistance	HIGH resistance
Positive lead to base Negative lead to collector	LOW resistance	HIGH resistance
Positive lead to collector Negative lead to base	HIGH resistance	LOW resistance
HIGH = 2K ohms or higher LOW = 1K ohms or lower		

4. Bridge Rectifiers

Unplug the chassis, remove the AC wires to TB1 and refer to the Diode testing instructions on page 4-6 to test the bridge rectifiers.

B. Normal Output Voltage Levels

1. TTL Gates (7400 Series ICs) and MOS ICs:

Condition	Voltage
Valid LOW	.8v or less
Valid HIGH	2v - 4v

An output in the range of .8v - 2v indicates a problem. (Note: Voltages can vary ±10%.)

2. Open Collector Gates

Open collector outputs, such as those of ICs Y, W, U, F, B and K on the Display/Control board, must be connected to +5v or +8v to operate properly. The outputs of ICs Y, W and U are tied to Vcc through resistors R41-R48 when the corresponding address switch is in the "up" position. When the switch is in the down

position, the output will be disconnected from Vcc and will not allow signals to go through.

3. Tri-State Buffers (when enabled)

Condition	Voltage
Valid LOW	.8v or lower
Valid HIGH	2v or higher

An output in the range of .8v - 2v indicates a problem. (Note: Voltages can vary ±10%.)

When disabled, tri-state buffers will have various voltages at their outputs.

C. Static Levels

1. IC Levels

Table 4-1, starting on page 4-9, shows the proper static levels of the most common problem areas, assuming the computer is in a "stopped" state (M1, MEMR and WAIT).

Table 4-1. Static Levels of the Most Common Problem Areas

Board	Schematic	IC	Pin #	Static Level
Display/Control	3-16, sheet 1 of 3	G	17, 18, 19, 20	HIGH
		P	2, 8, 9, 11, 14	LOW
		P	12	HIGH
		N	8	LOW
		A	4, 6, 8, 10, 15, 17, 19, 21	LOW
		R	15, 1	HIGH
		S	1	HIGH
		Y	1, 3, 5, 11, 9, 13	LOW
		W	13, 9, 11, 5, 3, 1	LOW
		U	1, 9, 11, 13	LOW
		J	8, 12	HIGH
		Z	5	C8 (see waveform #5, page 4-30)
		V	8	HIGH
		J	4, 2	CS
		E1	6	CS
		A	13	CS
	3-16, sheet 2 of 3	C1, F1, H1, G1, N1, U1, Y1, W1	9	C13 (see waveform #4, page 4-29)
		V1	6, 2, 4, 12, 8, 10	HIGH
		Z1	2, 4, 6, 8, 10, 12	HIGH
		K1	13	LOW
		M1	11	LOW
		M1	8, 13	HIGH
		L1	3, 5	LOW

Table 4-1 (continued)

Board	Schematic	IC	Pin #	Static Level
		L1	1	$\overline{C6}$ (see waveform #6, page 4-30)
		R1	12	HIGH
		M1	2	LOW
		M1	1, 3, 5	HIGH
Interface	3-15, sheet 3 of 3	G	2, 13, 14	HIGH
		G	1, 11	LOW
		K	6	HIGH
		D	10	LOW
		J	11	HIGH
		K	8	HIGH
	3-15, sheet 2 of 3	B	6, 2, 12, 13	HIGH
		E	2, 4, 6, 8, 10, 12	LOW
		M	2, 12	LOW
		A	12, 13, 6, 2	HIGH
		A	1, 8	LOW
		N	6, 10	LOW
		N	4, 2	HIGH
		H	14	LOW
CPU	3-14	C	6, 13	LOW
		C	8, 4	HIGH
		M	23, 12	LOW
		D, E	15	HIGH
		F	7, 2	HIGH

2. Mother Board Static Levels

Table 4-2 shows the proper static levels of the mother board, assuming the computer is in a "stopped" state (M1, MEMR and WAIT). Note that the levels on the pins of the 8080a (IC M on the CPU board) are reflected on the mother board as well as the front panel LEDs. For example:

A HIGH level on pin 24 (WAIT) of IC M on the CPU board causes bus pin 27 to go HIGH, which in turn causes the WAIT light on the front panel to light.

HIGH pulses on pin 27 (address line A2) of IC M on the CPU board produce pulses on bus pin 81, which cause A2 on the front panel to light (dimly).

Table 4-2. Mother Board Static Levels

Bus #	Symbol	Name	Static Level
1	+8v	+8 volts	
2	+18v	+18 volts	
3	XRDY	EXTERNAL READY	HIGH
4	VIO	VECTORED INTERRUPT LINE #0	LOW
5	VI1	VECTORED INTERRUPT LINE #1	LOW
6	VI2	VECTORED INTERRUPT LINE #2	LOW
7	VI3	VECTORED INTERRUPT LINE #3	LOW
8	VI4	VECTORED INTERRUPT LINE #4	LOW
9	VI5	VECTORED INTERRUPT LINE #5	LOW
10	VI6	VECTORED INTERRUPT LINE #6	LOW
11	VI7	VECTORED INTERRUPT LINE #7	LOW
12*	XRDY2	Extra READY Line	HIGH
13-17	Not Used		
18	$\overline{\text{STA DSB}}$	$\overline{\text{STATUS DISABLE}}$	HIGH
19	$\overline{\text{C/C DSB}}$	$\overline{\text{COMMAND/CONTROL DISABLE}}$	HIGH
20**	UNPROT	UNPROTECT	LOW
21**	SS	SINGLE STEP	LOW
22	$\overline{\text{ADD DSB}}$	$\overline{\text{ADDRESS DISABLE}}$	HIGH
23	$\overline{\text{DO DSB}}$	$\overline{\text{DATA OUT DISABLE}}$	HIGH
24	Ø2	PHASE 2 CLOCK	See waveforms 2 and 3, page 4-26
25	Ø1	PHASE 1 CLOCK	See waveforms 2 and 3, page 4-26

Bus #	Symbol	Name	Static Level
26	PHLDA	HOLD ACKNOWLEDGE	LOW
27	PWAIT	WAIT	HIGH
28	PINTE	INTERRUPT ENABLE	LOW
29	A5	ADDRESS LINE #5	
30	A4	ADDRESS LINE #4	
31	A3	ADDRESS LINE #3	
32	A15	ADDRESS LINE #15	
33	A12	ADDRESS LINE #12	
34	A9	ADDRESS LINE #9	
35	DO1	DATA OUT LINE #1	
36	DO0	DATA OUT LINE #0	
37	A10	ADDRESS LINE #10	
38	DO4	DATA OUT LINE #4	
39	DO5	DATA OUT LINE #5	
40	DO6	DATA OUT LINE #6	
41	DI2	DATA IN LINE #2	
42	DI3	DATA IN LINE #3	
43	DI7	DATA IN LINE #7	
44	SM1	M1 (Instruction Fetch Cycle)	HIGH
45	SOUT	OUT (Output Write)	LOW
46	SINP	INP (Input Read)	LOW
47	SMEMR	MEMR (Memory Read)	HIGH
48	SHLTA	HLTA (Halt Acknowledge)	LOW
49	$\overline{\text{CLOCK}}$	$\overline{\text{CLOCK}}$	See Waveforms 2 and 3, page 4-28
50	GND	GROUND	
51	+8v	+8 volts	
52	-18v	-18 volts	
53**	$\overline{\text{SSW DSB}}$	$\overline{\text{SENSE SWITCH DISABLE}}$	HIGH
54	$\overline{\text{EXT CLR}}$	$\overline{\text{EXTERNAL CLEAR}}$	HIGH
55	RTC	REAL TIME CLOCK	
56*	$\overline{\text{STSTB}}$	$\overline{\text{STATUS STROBE}}$	HIGH
57**	DIG1	DIGITAL #1	HIGH
58**	FRDY	Front Panel READY	LOW
59-67	Not Used		
68	MWRT	MEMORY WRITE	LOW
69	$\overline{\text{PS}}$	$\overline{\text{PROTECT STATUS}}$	HIGH

Bus #	Symbol	Name	Static Level
70**	PROT	PROTECT	LOW
71**	RUN	RUN	LOW
72	PRDY	READY	HIGH
73	$\overline{\text{PINT}}$	$\overline{\text{INTERRUPT REQUEST}}$	HIGH
74	$\overline{\text{PHOLD}}$	$\overline{\text{HOLD}}$	HIGH
75	$\overline{\text{PRESET}}$	$\overline{\text{RESET}}$	HIGH
76	PSYNC	SYNC	LOW
77	$\overline{\text{PWR}}$	$\overline{\text{WRITE}}$	HIGH
78	PDBIN	DATA BUS IN	HIGH
79	A0	ADDRESS LINE #0	
80	A1	ADDRESS LINE #1	
81	A2	ADDRESS LINE #2	
82	A6	ADDRESS LINE #6	
83	A7	ADDRESS LINE #7	
84	A8	ADDRESS LINE #8	
85	A13	ADDRESS LINE #13	
86	A14	ADDRESS LINE #14	
87	A11	ADDRESS LINE #11	
88	DO2	DATA OUT LINE #2	
89	DO3	DATA OUT LINE #3	
90	DO7	DATA OUT LINE #7	
91	DI4	DATA IN LINE #4	
92	DI5	DATA IN LINE #5	
93	DI6	DATA IN LINE #6	
94	DI1	DATA IN LINE #1	
95	DI0	DATA IN LINE #0	
96	SINTA	INTA (Interrupt Request Acknowledge)	LOW
97	$\overline{\text{SWO}}$	$\overline{\text{WO}}$ (Write Operation)	HIGH
98	SSTACK	STACK	LOW
99	$\overline{\text{POC}}$	POWER ON CLEAR	HIGH
100	GND	GROUND	

* = Not used in 8800a system.

** = Not used in 8800b Turnkey system.

Note: If a static level is not indicated, the signal can be either HIGH or LOW.

4-2. VISUAL INSPECTION

A. Component Inspection

The first step in troubleshooting is to carefully examine each board for solder bridges, open lands, misplaced components, etc. A thorough inspection of this kind will eliminate one possibility for errors and will allow troubleshooting efforts to be concentrated elsewhere. Carefully check each board using the list below:

1. Look for solder bridges.
2. Look for leads that have not been soldered.
3. Look for cold solder connections (cold solder connections do not have a "shiny" appearance).
4. Examine the board's lands for "hairline opens" or bridges."
5. Check the ICs for proper pin placement and good socket connections.
6. Examine the electrolytic and tantalum capacitors for proper polarity.
7. Examine the diodes for proper polarity.
8. Examine the LEDs for proper polarity.
9. Check the color codes on all resistors.

B. Wiring Inspection

> CAUTION
> The computer should be unplugged for this check.

1. Referring to Figure 5-50 on page 5-58 in the Assembly section of the manual, check for incorrect wiring on the mother board.
2. With an ohmmeter, check the power supply wiring on the terminal block (TB1). Check for resistance (about 100 ohms) between pins 2 and 7, 10 and 7, 1 and 7, 2 and 10, 2 and 1 and 1 and 10. If a reading of less than 10 ohms appears, recheck the wiring. Also check continuity from mother board bus pins 1, 2, 52 and 50 to corresponding terminal block pins 2, 10, 1 and 7. If a reading of more than 100 ohms appears, inspect the wiring from the mother board to TB1.

4-3. PRELIMINARY CHECK

The procedures outlined in Section 4-3 are general tests that should be made before going on to the specific problems presented in Sections 4-4 and 4-5. Follow the instructions in the order in which they are given, and always complete each step before going on to the next.

1. Before installing the boards and applying power to the computer, use an ohmmeter to check the resistance of the edge connectors on the mother board. Test the consecutively numbered pins down each row (1, 2, 3 . . . etc.), then cross check the pins (1-51, 2-52 . . . etc.). A LOW resistance reading should appear at pins 1, 50, 51 and 100. If a LOW reading appears at any other location, examine the back of the board for solder bridges or etching errors.
2. Turn the computer on and check for the following voltages on the Power Supply board's terminal block (TB1). See page 5-58 in the Assembly section of the manual for pin locations.

Pin #	Voltage
2, 3, 4	+8v to +10v (unregulated)
10	+16v to +18v (pre-regulated)
1	-16v to -18v (pre-regulated)
7, 8	Ground

> WARNING
>
> When testing components on the Power Supply board, be extremely careful not to touch the AC wiring. Always unplug the chassis when testing continuity or replacing components.

a. If the +8 voltage is absent from pins 2, 3 or 4 of TB1, check for AC at pins 1 and 2 of TB2. If absent, unplug the chassis and check continuity and wiring at connector P4. Also check the fuse and the wiring to the AC cord. Plug in the chassis. If AC is present at pins 1 and 2 of TB2, check the wiring from TB2 to BR1 and from BR1 to TB1. If AC is present at BR1, but no output voltage appears across the "+" and "-" pins of BR1, BR1 is probably defective and should be replaced.

b. If the correct voltage does not appear at pin 10 or pin 1 of TB1, check the voltage at the base of transistor Q2 (for pin 10) and Q1 (for pin 1). If the reading is 27 volts, the transistor or diode may have shorted out. Test these components according to the instructions on pages 4-6 and 4-7.
Check for AC at TB1 pins 6 and 5. If absent, unplug the chassis and check the wiring from connector P4 to the AC cord. If AC is present at TB1, check for AC at BR2. If AC is absent at BR2, check the wiring to BR2. If AC is present at BR2, remove the "+" pin from the board and check for voltage across the "+" and "-" pins. If voltage is not present, replace BR2.

c. If Ground does not appear at pins 7 and 8 of TB1, check the wiring from TB1 to the cross member and from the AC cable to the cross member.

3. If the fuse on the back panel blows:
   a. Check for solder bridges on the Power Supply board or the mother board.
   b. Check for proper orientation of BR2 on the Power Supply board and BR1 on the back panel.
   c. Check wiring on:
      1) voltage wires on the mother board
      2) front panel switch
      3) AC power cord
      4) Ground to +8v line
   d. Check for pinched wires and incorrectly installed components.
4. Turn power off, and install the CPU and Interface boards.

> WARNING
>
> Always turn power off when removing or installing plug-in boards or when connecting or disconnecting the Display/Control board. Failure to turn power off may cause damage to the board and the computer. Note that capacitor C7 (on the cross member) will retain a +8v charge for a few minutes after power has been turned off.

Connect the Interface board cables (P1 and P2) to the front panel and connect P3 from the CPU board to the Interface board. Turn power on. The computer should be automatically reset and in a stopped state.

If there are no memory boards in the computer at address Ø, the front panel LEDs should appear as follows:

LED	Condition
AØ-A15	OFF
M1, MEMR, WAIT	ON
DØ-D7	ON

If a memory board is present at address Ø, the DØ-D7 LEDs will show the random pattern for that board.

Table 4-3. Voltage and Waveform Check

Note: The following checks should be made with the CPU, Interface and Display/Control boards installed and with power turned on (unless otherwise specified) Voltages may vary ±10%.

Step	Instructions	If Correct	If Incorrect
1	Check the 7805 voltage regulators on the CPU and Interface boards.	Both regulators should read +5v at pin 2. The figure below shows the correct pin locations for all voltage regulators. 	If voltage is incorrect, refer to schematics 3-18 and 3-19. Check pin 3 for Ground. If absent, trace continuity back to bus pin 100 or 50. Pin 1 is the unregulated output--at least 8v. If absent, trace continuity back to bus pins 1 and 51. If Ground and sufficient unregulated voltage are present at these pins, check pin 2 of the voltage regulator for +5v. If voltage is absent, turn power off and remove voltage regulator pin 2 from the board. Turn power on and recheck for +5v. If the voltage is still below +5v, the voltage regulator is defective and should be replaced. If voltage is correct, look for a short on the board. With power off, resolder pin 2 to the board.
2	Check the 7812 voltage regulator on the CPU board.	It should read +12v at pin 2. Proceed to Step 3.	If voltage is incorrect, refer to schematic 3-18 and check pin 3 for Ground. If absent, trace continuity to bus pin 100 or 50. Pin 1 is the unregulated output--at least 16v. If voltage is absent, trace continuity back to bus pin 2. If Ground and sufficient unregulated voltage are present, check pin 2 of the voltage regulator for a +12v signal. If absent, turn power off and disconnect voltage regulator pin 2 from the board.

Step	Instructions	If Correct	If Incorrect
			Turn power on and check again for the +12v signal. If the voltage is below 11v, the voltage regulator should be replaced. If the voltage is correct, look for a short on the board. Resolder pin 2 to the board.
3	Check the anode lead of diode D2 on the CPU board.	It should read -5v. Proceed to Step 4.	If the voltage is incorrect, check D2 for proper polarity. Check for -18v on capacitor C13 (negative side) on the CPU board. If absent, trace continuity to bus pin 52. Turn power off and check diode D2 according to the instructions on page 4-6. Replace, if necessary. With an ohmmeter set at X10K or higher, check the resistance from the negative side of C11 to Ground. A reading of zero ohms indicates a short on the board. Resolder the anode lead of D2 to the board.
4	Check pin 2 of VR2 on the Display/Control board.	It should read -9v. Proceed to Step 5.	If the voltage is incorrect, check for -18v on pin 3 of the voltage regulator. If absent, trace continuity back to bus pin 2. Check for the correct part number on VR2, D1, D2 and R20. Turn power off and remove the anode lead of diodes D1 and D2 from the board. Check both diodes according to the instructions on page 4-6. If the readings are incorrect, replace D1 and/or D2. Remove pin 2 of VR2 from the board. Turn power on and check for a -9v reading at VR2. If incorrect, replace VR2. If correct, look for a short on the board. Resolder the output pin to the board.

Step	Instructions	If Correct	If Incorrect
5	On the CPU board, check the voltage on IC M pins 20, 11 and 28. Be careful not to touch more than one pin at a time.	Pin 20 should read +5v. Pin 11 should read -5v. Pin 28 should read +12v. Proceed to Step 6.	If incorrect, use an ohmmeter set at X10K or higher to trace continuity back to the CPU board's voltage regulators. If opens are found, solder over them.
6	On bus pins 24 and 25, check for proper Ø2 and Ø1 waveforms (see waveforms 2 and 3, page 4-28). On the CPU board, check for Ø2 and Ø1 on corresponding pins, 22 and 15 of IC M. (See waveform #1, page 4-27.)	If present, proceed to Step 7.	If Ø2 and Ø1 waveforms are absent on the bus pins, trace logic through ICs J and A on the CPU board. If Ø2 or Ø1 is present at the inputs of IC J or IC A, but absent at the outputs, check the IC according to the instructions on page 4-5. If there is no Ø1 or Ø2 signal at IC A (pin 14 or 7), trace continuity to pins 10 and 11 of IC F. (Note: Ø1 and Ø2 are 12v in amplitude at pins 10 and 11.) If signals are absent at pins 10 and 11, check for +12v at pin 9 of IC F. If absent, trace continuity to VR2 pin 2 on the CPU board. Check for an 18 MHz signal at pins 14 and 15 of IC F. If absent, check IC F according to the instructions on page 4-5, and replace if necessary.
7	On bus pin 99, check for a HIGH $\overline{POC}$ level. This signal is usually a 4 VDC level with a small amount of AC ripple voltage.	If present, proceed to Step 8.	Visually inspect transistors Q1, Q2 and Q3 and diode D1 on the CPU board for proper installment. Check the base of Q1 for a 1v level. If absent, check D1 according to the instructions on page 4-6. Replace if necessary. Q1 should be active, causing a 0v level to appear at the base of Q2. If this 0v level is absent, check Q1 according to the instructions on page 4-6. Q2 should cause a 5v signal to appear at

Step	Instructions	If Correct	If Incorrect
			the base of Q3. If the 5v signal is absent, check Q2 according to the instructions on page 4-6. Then turn power off, and wait a moment for C4 to discharge. Remove one of the leads of C4 from the board, and measure C4's resistance with an ohmmeter. (Note: The ohmmeter needle may fluctuate slightly.) If the reading is lower than 10 ohms, replace C4. If C4 is working properly, reinstall C4 and check continuity from the base of Q3 to Vcc. Repair as necessary. The Q3 emitter should be above 2v. If not, check Q3 according to the instructions on page 4-7. Trace this HIGH level through ICs S and J on the CPU board to bus pin 99. If ICs S and J do not invert the signal, test the ICs according to the instructions on page 4-5.
8	Pin 13 (HOLD) of IC M on the CPU board should be LOW.	Proceed to Step 9.	If a LOW is not present at IC M pin 13, check IC G on the CPU board according to the instructions on page 4-5. Check for Vcc at resistors R23 and R40. If absent, check continuity and repair as necessary. Bus pin 74 should be HIGH. If not, look for a short on the mother board.
9	On the Display/Control board check for Ø2 at pin 10 of IC L. If Ø2 is absent, the entire front panel will not operate.	If present, proceed to Step 10.	If Ø2 is absent at IC L pin 10, trace continuity and logic from IC S1 on the Display/Control board through IC T on the Interface board to bus pin 24. Any inverter having a Ø2 input, but no Ø2 output,

Step	Instructions	If Correct	If Incorrect
	(Note: If you received your 8800b computer before January, 1977, an extra capacitor, C7, for the Display/Control board was included in the installation instructions. This capacitor is not needed and should be removed.)		should be checked according to the instructions on page 4-5. If the IC(s) are functioning properly, look for a short and repair as necessary.
10	On the Display/Control board, check for a $\overline{C13}$ signal (see waveform #4, page 4-29) at pin 9 of ICs C1, N1, F1, U1, H1, Y1, G1 and W1. (Note: If no switches are pressed, R54-R65 should produce a signal of approximately 4v at the input pins of these ICs.)	If present, proceed to Step 11.	If absent, trace the $\overline{C13}$ signal through ICs K1, J1, E1 and S1 to IC X pin 9 on the Display/Control board. If any of these ICs have a C13 input, but no C13 output, they should be checked according to the instructions on page 4-5. If IC X pin 9 has no C13 signal, check for a square wave (approximately .1 ms. wide) at pin 10 of IC X. If present, check IC X according to the instructions on page 4-5. If a square wave is not present at pin 10 of IC X, check IC L. If a square wave is not present at pin 1 of IC L when it is removed from the board, replace IC L.
11	Check for a HIGH $\overline{POC}$ level at ICs M1 pin 4, P1 pin 2, T1 pin 5 and Z pin 13 on the Display/Control board.	If present, proceed to Step 12.	If a LOW appears at any of the pins, trace $\overline{POC}$ from the suspected pin to pin 6 of IC J1 on the Display/Control board. If $\overline{POC}$ is absent at pin 6, check IC J1 according to the instructions on page 4-5. Check the Vcc connection at R42. If Vcc is absent, check continuity to VR1 pin 2 on the Display/Control board. Check the logic operation of the

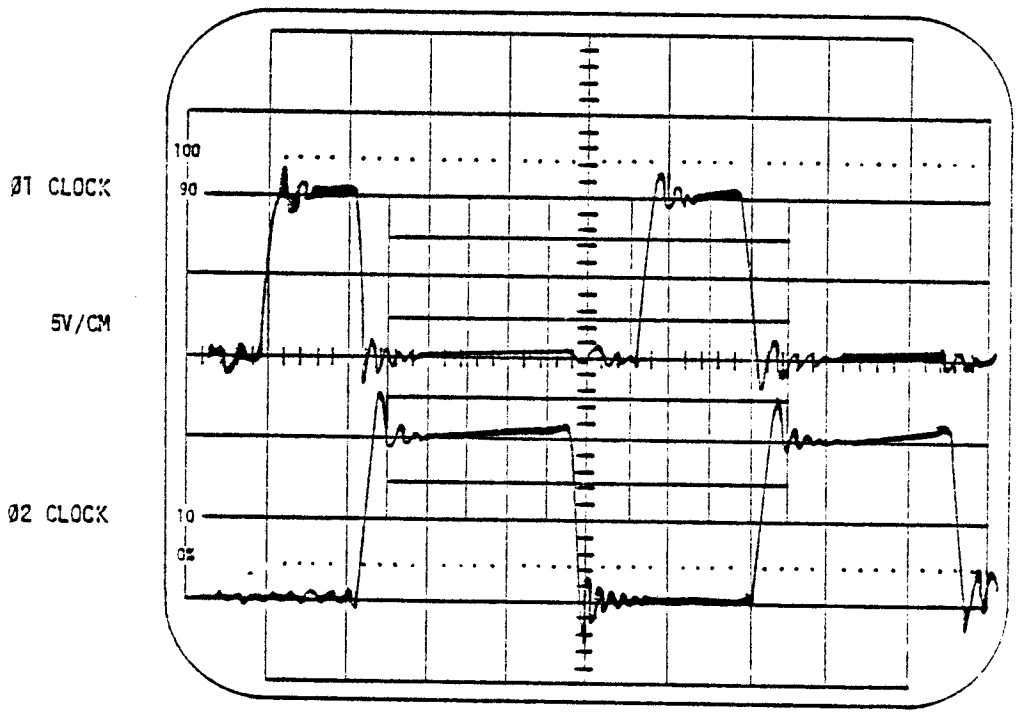
Step	Instructions	If Correct	If Incorrect
			ICs from J1 through U on the Interface board to bus pin 99. Check and replace the ICs if necessary.
12	On the Display/Control board, check for a LOW at pin 13 of IC K1. (Note: If the computer is running, pin 13 will be HIGH and only the RUN/STOP or RESET/EXT CLR switches will work.)	If present, proceed to Step 13.	If the computer is not in a run state and a LOW is not present at pin 13, trace logic from IC K1 to a LOW at IC M1 pin 6. Check any suspected ICs according to the instructions on page 4-5. If lifting the STOP switch does not stop the computer, continue with the remaining steps in this chart and onto Section 4-4.
13	On the Display/Control board, check for a CS signal (see waveform #5, page 4-30) at pin 13 of IC A.	If the proper CS signal is present, proceed to Step 14.	If the CS signal does not match waveform #5, examine IC V pins 1, 2 and 13 on the Display/Control board. Pin 1 should be a 64 μsec. pulse width square wave; pin 2 a 32 μsec. pulse width square wave; and pin 13 a 16 μsec. pulse width square wave. If all of these signals are present, check ICs V and E1 according to the instructions on page 4-5. If any of the signals are absent from pins 1, 2 and 13 of IC V, trace the signal back through ICs E1 and S1 to IC L. Any ICs that have input signals but no output signals should be checked according to the instructions on page 4-5. If all of the ICs are operating properly, check for the corresponding square waves at pins 2, 4 and 13 of IC L. If absent, check IC L according to the instructions on page 4-5.

Step	Instructions	If Correct	If Incorrect
14	On the Display/Control board, check pin 1 of IC L1 for a $\overline{C6}$ signal (see waveform #6, page 4-30).	If present, proceed to Step 15.	If absent or incorrect, check the logic operation from IC S1 to pin 2 of IC L. Check for a 16 μsec. square wave pulse at pin 2 of IC L. If absent, check the IC according to the instructions on page 4-5.
15	On the Display/Control board, check pin 5 of IC Z for a C8 signal (see waveform #5, page 4-30).	If present, proceed to Step 16.	If absent, trace logic through ICs E1 and S1 to pin 13 of IC L on the Display/Control board. If E1 or S1 has an input signal but no output signal, check that IC according to the instructions on page 4-5. If an output is not present at IC L pin 13, check IC L.
16	On the Display/Control board, examine the PROM, IC G. It should be labelled B D/C. If it is <u>not</u> labelled B D/C, contact the MITS Marketing Dept. or your local Altair dealer. Check for Ground at pin 14; for +5v at pins 12, 13, 15, 22 and 23; and for -9v at pins 24 and 16 (of IC G).	If IC G is labelled B D/C and if the voltage levels are correct, proceed to Step 17.	If the +5v signal is absent, use an ohmmeter set at X1K or higher to trace continuity to VR1 pin 2. (Note: If another computer with a PROM board is available, the data in the suspected PROM can be checked by installing it in the other computer's PROM board and examining its output with Table 3-2 in the Theory of Operation section.) If the -9v signal is absent, use the ohmmeter to trace continuity to VR2 pin 2.
17	When the RESET switch is held, all address lights and data lights should be lit. All status lights except WO should be lit if PRESET on the CPU board is connected to pin 14 of	If the correct LEDs are lit, proceed to Section 4-4 (if problems exist with the RUN/STOP, SINGLE STEP/SLOW or PROTECT/UNPROTECT switches). Then proceed to Section 4-5	If pin 2 of IC F on the CPU board does not go LOW with RESET, a problem exists in the RESET circuitry; proceed to Section 4-4. When the RESET switch is pressed and pin 2 goes LOW, pin 1 of IC F should go HIGH. If not, check IC F according to the instructions on page 4-5. A HIGH at pin 1

Step	Instructions	If Correct	If Incorrect
	IC K. (Note: If the pins of IC M on the CPU board are HIGH, the corresponding LEDs on the front panel should be lit.)	if problems exist with the EXAMINE/EXAMINE NEXT, DEPOSIT/DEPOSIT NEXT, ACCUMULATOR DISPLAY/ ACCUMULATOR LOAD, or IN/ OUT switches.	of IC F should cause a HIGH at pin 12 of IC M. If not, check continuity and repair as necessary. If any of the address lights or data lights are not lit when the RESET switch is held, the problem may be due to shorts or defective LEDs. RESET should cause all data lines (DØ-D7) and address lines (AØ-A15) from IC M on the CPU board to go HIGH. If any of these lines fail to go HIGH when pin 12 of IC M is HIGH, check for shorts and repair as necessary. If any of the address or data lights are unlit when RESET is lifted, start at the corresponding pin of IC M on the CPU board and trace the levels through the Interface board to the Display/Control board. The address lights correspond to AØ-A15 (IC M pins 25, 26, 27, 1, 29-40) and the data lights correspond to DØ-D7 (IC M pins 3-10). To trace the data lines (DØ-D7), pins 1 and 15 of both ICs D and E on the CPU board should be LOW. If pin 1 is not LOW, trace continuity to pin 3 of VR1. If pin 15 is not LOW, trace logic to a LOW at pin 17 of IC M on the CPU board. If pin 17 is not LOW, check IC M according to the instructions on page 4-20, step 6. If the inputs of ICs D and E do not match the outputs, D and E should be checked according to the instructions on page 4-5.

Step	Instructions	If Correct	If Incorrect
			Trace the logic levels of ICs Y and P to IC G on the Interface board. Pins 2, 13 and 14 of IC G should be HIGH to allow data to pass through. Check any suspected ICs according to the instructions on page 4-5. Refer to schematic 3-16 (sheet 3 of 3), and check the anode lead of the suspected LED for +8v. If the voltage is absent, trace continuity to bus pin 1. Repair as necessary. A LOW (less than .8v) output from open collector ICs H, K, M, D, B or F on the Display/Control board should produce a voltage of approximately 5v at the cathode lead of the corresponding LED. If this voltage is absent, check for shorts. Check for Vcc and Ground to the open collector IC. If absent, check continuity. If Vcc and Ground are present, check the LED before replacing the IC. A lower voltage (5v) should cause the LED to light; if the LED remains unlit, turn power off and unsolder the LED. Refer to Figure 5-23 on page 5-34 for orientation and install the LED in place of a working (lit) LED. If the LED does not light when power is returned and the RESET switch is lifted, the LED is defective and should be replaced.

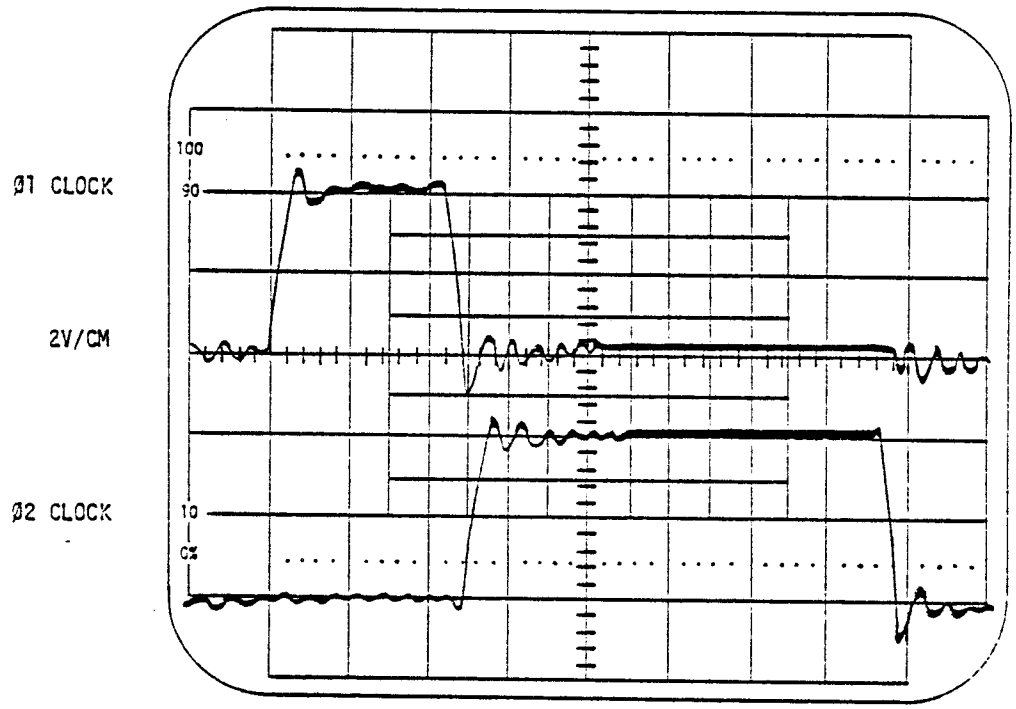
Waveform #1 shows the clock inputs to the 8080A microprocessor chip itself.



100 NS/CM

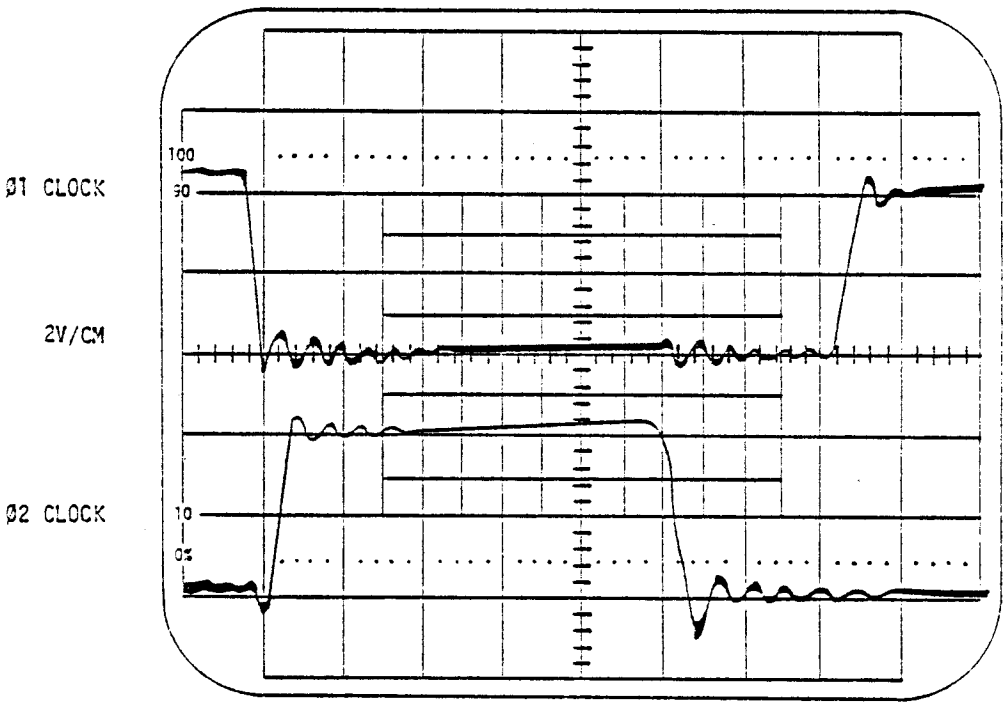
Waveform #1

Waveforms 2 and 3 show Ø1 and Ø2 signals on the bus.



50 MS/CM

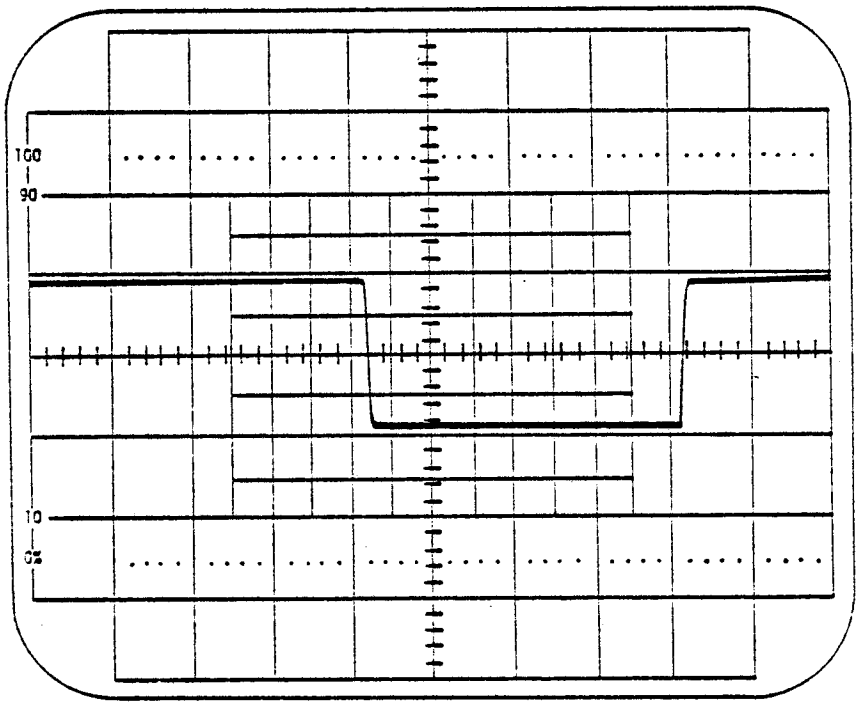
Waveform #2



50 MS/CM

Waveform #3

Waveform #4 shows the $\overline{C13}$ waveform on the D/C board for all conditions.



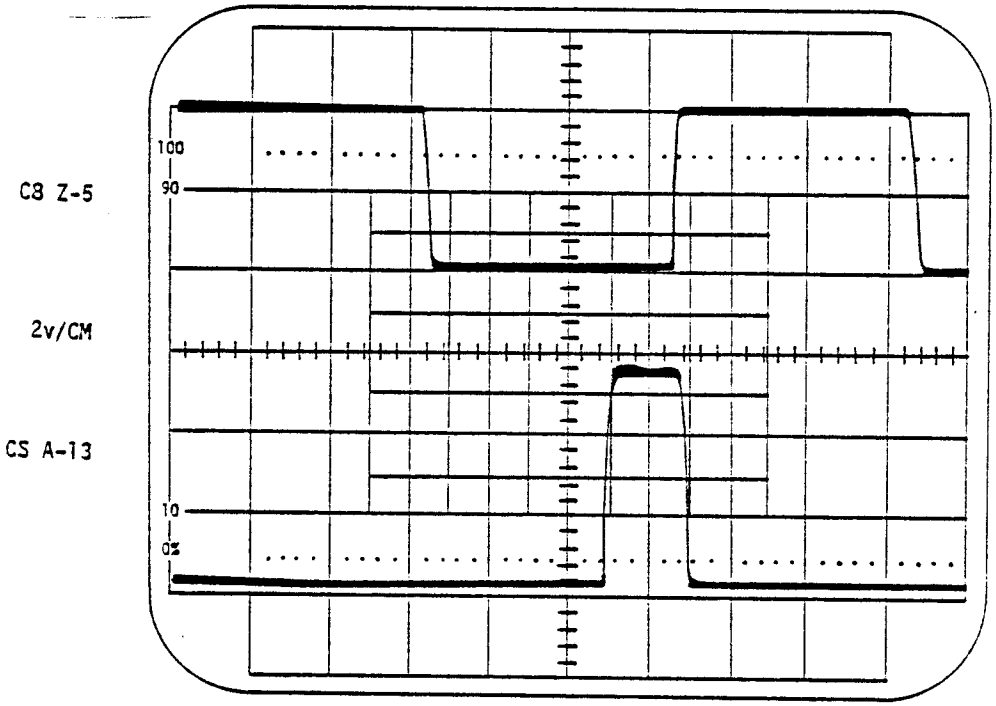
$\overline{C13}$ W 1-9

2v/CM

500 ns/CM

Wave form #4

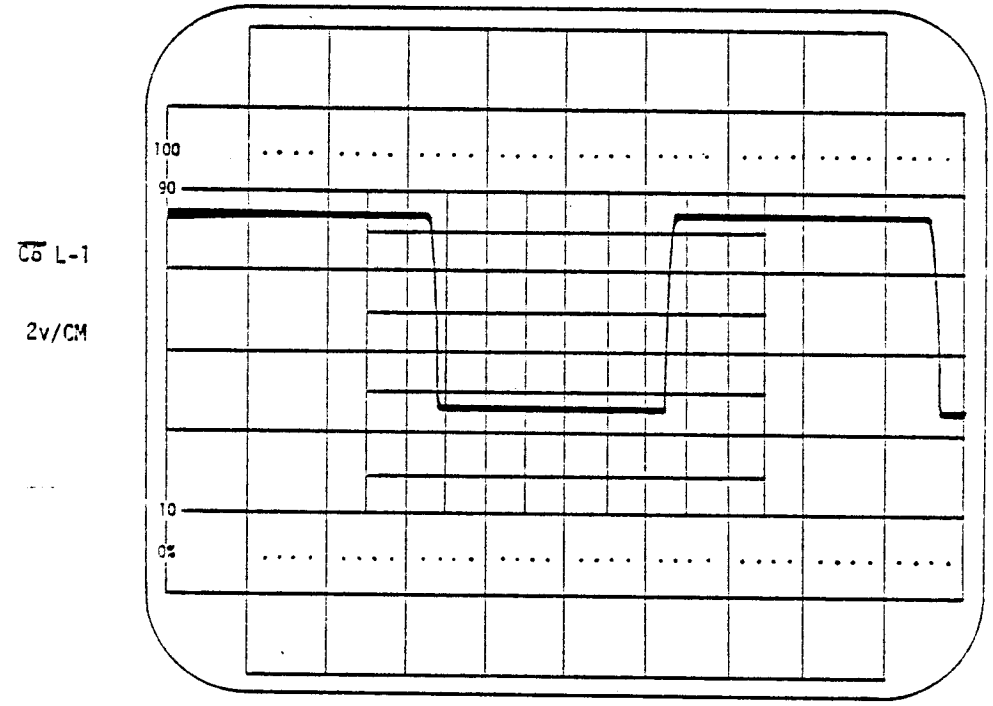
Waveform #5 shows the C8 and CS waveforms on the D/C board for all conditions.



20μs/CM

Waveform #5

Waveform #6 shows the $\overline{C6}$ waveform on the D/C board for all conditions.



5μs/CM

Waveform #6

4-4. NON-PROM RELATED SWITCH PROBLEMS

Section 4-4 contains tests for the RESET, STOP, RUN, SINGLE STEP/SLOW, PROTECT/UNPROTECT, SENSE and STATUS circuitry. If problems involving the PROM related switches also exist, solve the non-PROM related switch problems first.

Table 4-4. Reset Check

Problem Description: During proper operation, lifting the RESET switch should cause all data and address lights to go HIGH whether the computer is running or not. If this does not occur, follow the steps below.

Step	Instructions	If Correct	If Incorrect
1	Press the RESET switch and check IC G1 pin 4 and IC W1 pins 5 and 7 on the Display/Control board.	Pin 4 of IC G1 should go LOW. Pins 5 and 7 of IC W1 should go HIGH. Proceed to Step 2.	If pin 4 fails to go LOW, check the RESET switch with an ohmmeter and replace if necessary. If pins 5 and 7 fail to go HIGH, check ICs W1 and G1 according to the instructions on page 4-5. Trace continuity from pin 1 of ICs W1 and G1 to VR1 pin 2. If absent, repair as necessary.
2	Trace the HIGH level of IC W1 pin 7 through ICs R and N on the Interface board to bus pin 75 (which should be LOW when the RESET switch is lifted).	If proper logic operation is present, proceed to Step 3.	If ICs R and N do not follow their respective truth tables, check them according to the instructions on page 4-5. With an ohmmeter, check continuity from the Display/Control board to the Interface board. If opens are found, repair as necessary.
3	A LOW $\overline{\text{PRESET}}$ signal should produce a LOW at IC F pin 2 on the CPU board.	If present, proceed to Step 4.	If a LOW is not present at IC F pin 2, check for proper logic operation through ICs G and B on the CPU board. Check any IC that does not follow its truth table according to the instructions on page 4-5.
4	A LOW input at IC F pin 2 should produce a HIGH at IC M pin 12 on the CPU board.	If present, proceed to Step 5.	Check IC F for +5v at pin 16, +12v at pin 9 and Ground at pin 8. If absent or incorrect, trace continuity to VR1 pin 2, VR2 pin 2 and bus pin 1, respectively. If continuity is present, check IC F according to the instructions on page 4-5, and replace if necessary.

Step	Instructions	If Correct	If Incorrect
5	A HIGH signal at pin 12 of IC M on the CPU board should cause all address and data lines to go HIGH. (The LEDs corresponding to the address and data lines should light.)	Proceed to Table 4-5.	If any of the address (AØ-A15) or data (DØ-D7) lines fail to go HIGH, check for shorts. If the address and data lights do not light when the corresponding pin of IC M (on the CPU board) is HIGH, refer to Section 4-3, Step17 on page 4-24.

Table 4-5. Stop Check

Problem

Description: Normal Operation--When the computer is running, the Wait light should be off or dim and several address lights should be dim. The Ready line will be HIGH on pin 23 of IC M on the CPU board. When the computer is stopped, only status lights M1, MEMR and WAIT should be on. Pin 23 of IC M will be LOW. There should be no change in the address lights. If the computer cannot be stopped, proceed with the steps below.

Step	Instructions	If Correct	If Incorrect
1	Check the logic operation from IC R1 on the Display/Control board to IC M on the CPU board. A LOW signal at IC R1 pin 12 should cause a HIGH at pin 23 of IC M on the CPU board. Check for proper logic operation at IC P1 on the Display/Control board.	If logic to the Display/Control board is correct, the problem lies in either one of two areas: the RUN/STOP circuitry or the SS Control circuitry. Check pins 12 and 13 of IC P1 on the Display/Control board. A constant LOW on pin 12 indicates a problem in the RUN/STOP circuitry. Irregular LOW going pulses at pin 13 of IC P1 indicate a problem in the SS Control circuitry. To test for RUN/STOP problems, proceed to Step 2 on page 4-35. To test for SS Control problems, proceed to Step 3 on page 4-39.	Trace the logic levels from IC R1 on the Display/Control board through ICs R and H on the Interface board. Pin 12 of IC R1 should be LOW and bus pin 58 should be HIGH. If not, check ICs R and H according to the instructions on page 4-5. A LOW at bus pin 58 should produce a HIGH at IC F pin 3 on the CPU board. If this HIGH signal is absent at pin 3, check ICs C and B on the CPU board according to the instructions on page 4-5. The HIGH at IC F pin 3 should produce a HIGH at IC M pin 23. If not, check IC F pins 16, 9 and 8. Pin 16 should read +5v; pin 9, +12v; and pin 8, Ground. If the procedures on this page have solved the problem, proceed to Table 4-5 on page 4-43. If the problem still exists, proceed to Step 2 on page 4-35.

Step	Instructions	If Correct	If Incorrect
2	RUN/STOP Circuitry.		
	A. If a board was pulled out with power on, proceed with the steps below:	Proceed to Step B.	
	1) Turn the computer off and remove all boards. Test the mother board pins with an ohmmeter as described in Step 1 on page 4-15.		Repair according to the instructions on page 4-15.
	2) Inspect the mother board for opens along the lands corresponding to bus pins 1, 2 and 52.		Repair as necessary.
	3) Turn power on and check for proper voltages on the bus as described on page 4-15, step 2.		If voltages are incorrect, repair according to the instructions on page 4-15.
	4) Pulling a board out while power is on usually damages the ICs connected to bus pins 3 and 53 which are shorted to bus pins 2 and 52. Check these ICs according to the instructions on page 4-15.		Replace IC C on the CPU board and IC N on the Interface board if necessary.