Introductory Manual for Technicians

About this manual:

To my knowledge, this preliminary document is the only version ever produced- I don't believe that a finalized version was published. Because it is preliminary, there are lots of mark-ups, sketches, and corrections that were intended for the final version. These notes were done by the engineers and technicians who were creating the document, so they are valid.

The manuals that were included with computers purchased from MITS did not include this in-house document, so you'll want to add it to any other documentation you already have (however, if you purchased an 8800/8800A manual from altairmanuals.com, you already have this information).

Although it is primarily intended for the earlier models (8800 and 8800A), the manual should be very useful in troubleshooting any Altair 8800 version and any Altair memory board.

Steve Shepard
altairmanuals.com
11/2006

altair™

INTRODUCTORY TECHNICIANS MANUAL

For In-House Use Only

Incl. 4K Dyn. + prom. tests

mits

8800 Pass Trans Mod (16 SEP 75)
(Assembled Units)

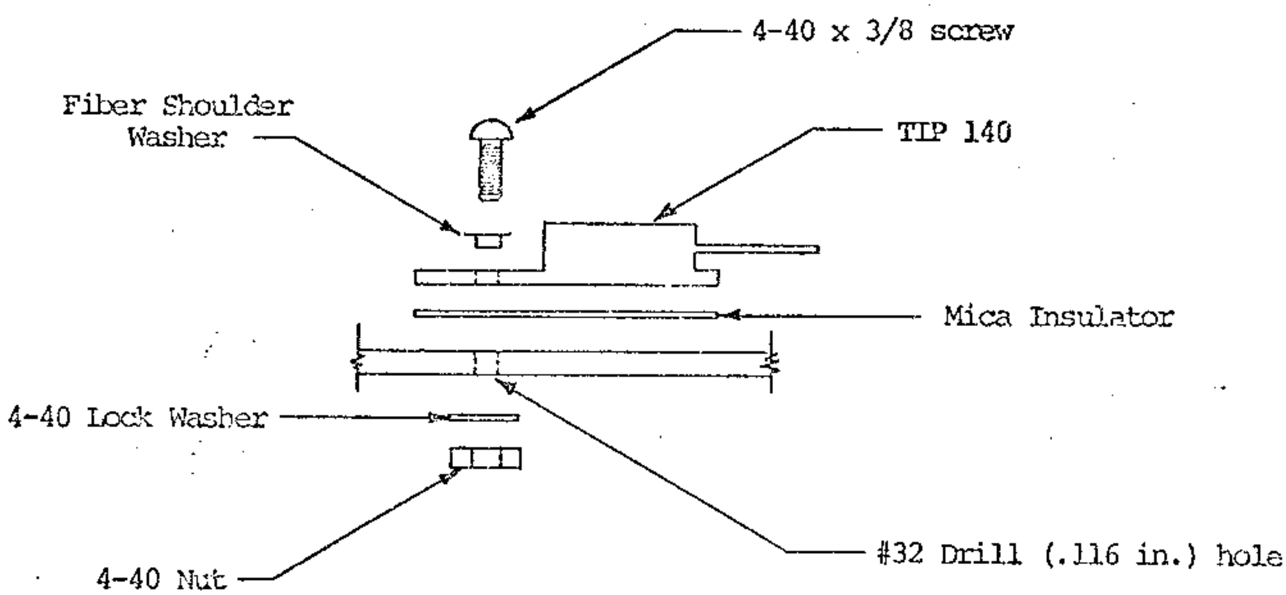
1. This Mod should be made on all assembled units using the 10 volt transformer (#6139) 102613.

2. Components Used.

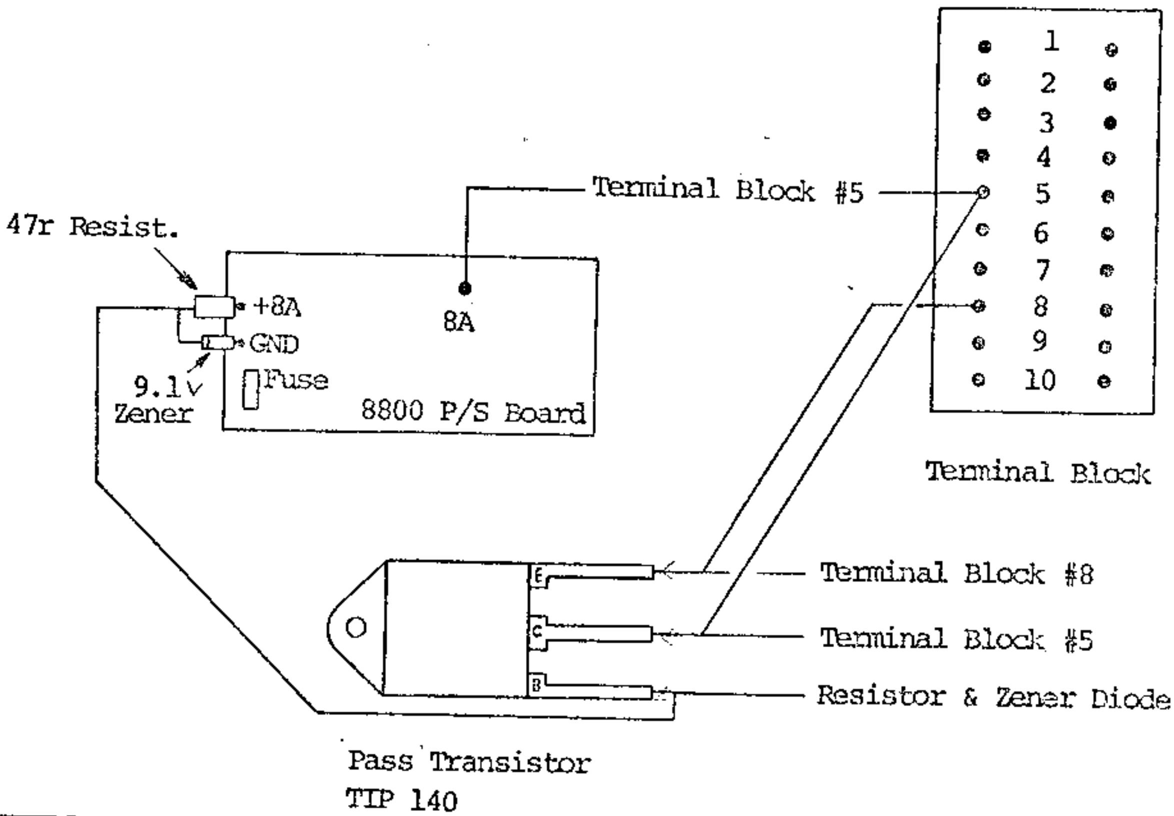
TIP 140 (with mica insulator & fiber washer)	102819
47r 1W	101955
9.1 volt zener (1N4739)	100706
1 4-408 3/8 screw	100908
1 4-40 lock washer	100941
1 4-40 nut	100932

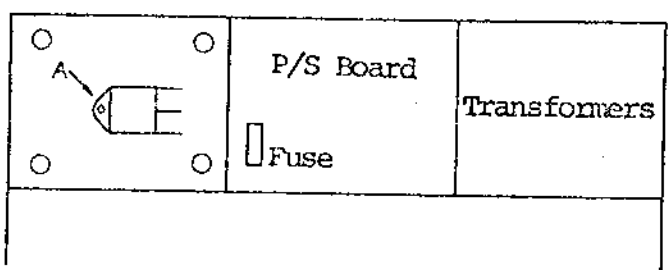
3. CHK:

   a) Make sure acetate (mica) insulator is used with washer.
   b) Clean mounting surface; remove anodize.
   c) Tighten down transistor.
   d) Double insulate transistor leads with heat shrink.
   e) Make sure resistor and zener cannot short to fuse.



8800 P/S Wiring with Pass Transistor (16 SEP 75)

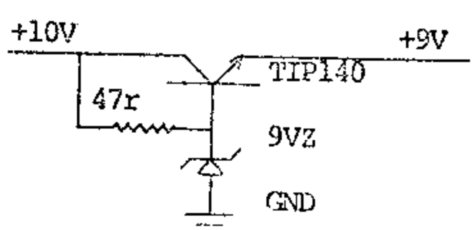


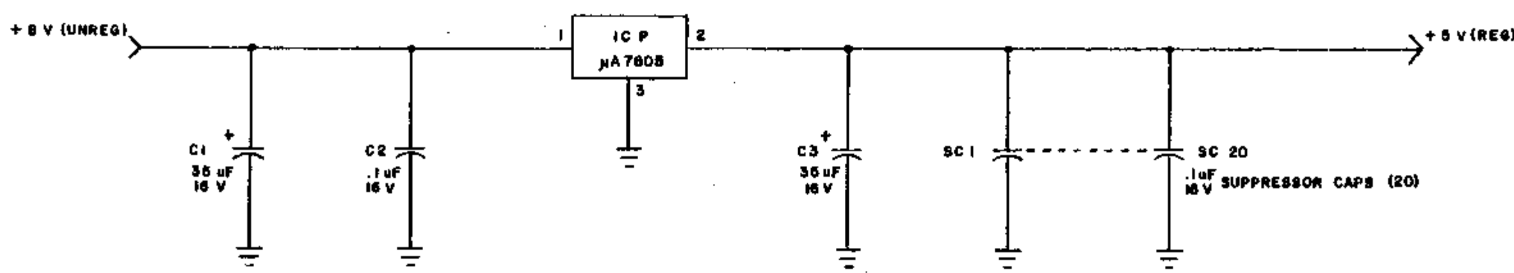


1) Drill hole in back cross member at point A using #32 drill (.116 in.).

2) Install tip 140 transistor as shown above.

3) NOTE: It is best to remove the P/S board from frame to install diode and resistor. (DO NOT UNDO SOLDER CONNECTIONS.) This is so the underside of the P/S board may be accessed for soldering.





880-108
1K STATIC MEMORY ON-BOARD REGULATOR

Introductory Manual for Technicians

8800 BASIC SYSTEM EXPLANATION

A computer is a general purpose tool for processing data. It must have all of the following in order to function: a means of inputting and outputting data, a memory to store the data, a central processing unit (CPU) to manipulate the data, and a program to tell it what to do. (Page 26 ALTAIR 8800 Th. of OP) for test ← next page + page 3 ALT. 8800 Th. of OP

An Altair computer comes with a chassis, a power supply, a CPU, and a front panel with display lights and control switches. To this a person must add at least a memory board and usually an input/output (I/O) terminal. The front panel can be used as a terminal, but has limited usefulness.

In an Altair computer all the circuitry except the 8800a front panel is on PC boards that plug into any hundred pin connector. The connectors are mounted on a "mother board" and all pins are in parallel to each connector so that any board can plug into any connector. However, each board must be plugged in so that when you are facing the front panel the component side of the board is to the right. The connectors are tied to the "Altair Bus". Each line is assigned a particular function and a list of these can be found on page ___ of the 8800a manual (enclosed).

Power Supply

The 8800 systems have three unregulated supply voltages developed by the power supply (+8) (+16) and (-16). These voltages are all regulated on each board and delivered by the bus. The +8 line has the heaviest load, since all TTL chips require a +5 supply. TTL circuitry has leakage and bias current. The LSI chips are generally N-MOS and also require -5v and +12v supplies. Since they are field effect chips, they draw proportionately much less current. A check of the regulated voltages is always the first thing to do. It is easiest to check at the output of the regulator or for most TTL chips, pin 14. If the regulator output is wrong, lift the output pin from the board and retest.

The +5v supply must be above 4.8v and have less than .2v ripple.

Usually there is more tolerance for the other supplies. They can be checked at the regulator or zener diode as the case maybe. Ground should be treated and measured as a supply voltage. When in doubt, measure the voltage on the chip itself. Always do this if the chip is working improperly.

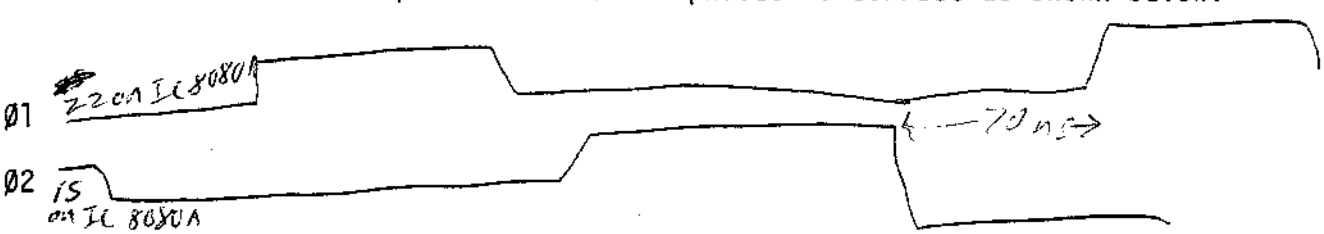
Power Supply see page 9 ALTAIR 8800 Th. of Op.

The CPU

On the CPU board you will see ~~an~~ a 40-pin LSI chip (large scale integration) labelled "8080A". A small wafer of ~~40-pin~~ silicon under the gold cap is the "brains" of the computer. The rest of the computer can be seen as support for this chip. All data is controlled and manipulated by the thousands of logic gates inside of it. These gates are controlled by a "program".

The CPU's operations are controlled by a two phase clock. This clock runs at 2MHz and is controlled by the crystal you see on the board. If the CPU is not running or is working erratically, check Ø1 and Ø2 with a ~~level~~ dual trace scope at any convenient location. Check to see that voltages are right (0-5v or 0-12v depending on where you check); that the frequency is 2MHz and that the relationship between the two phases is correct as shown below.

CPU (3) See page 3 ALTAIR 8800 Th. of Op.



Rise and fall time: 50 nsec. max.

Ø1 pulse width, 60 nsec. min.

Ø2 pulse width, 220 nsec. min.

delay Ø1 to Ø2, 0 nsec. min.

delay Ø2 to Ø1, 70 nsec. min.

If the clock does not come on every time the computer is turned on, it may be due to inadequate feedback and a clock mod may be necessary. See accompanying article.

The other LSI chip on this board is the 8212. This serves as a status latch. The operation of this chip is detailed in the Intel 8080 manual and we won't go into it here. Since the 8212 is socketed, it is always easy to exchange it with a known good one if the CPU is working badly.

The 8080A chip is extremely reliable and unlikely to be a cause of error unless it has been mishandled or subjected to incorrect voltages.

Most of the signals going into or out of the CPU board are buffered by 74367 tri-state drivers (also called 8097's or 8T97's.) There are 6 buffers in each chip. They are amplifiers which isolate each side of the circuit and increase the fan-out capability of each line. These buffers are divided into two groups of 4 and 2. Amps 1-4 are enabled by a low (gnd) signal to pin 1 and amps 5-6 by pin 15. Until these inputs are enabled, the amp acts as a high impedance termination of the line. When enabled, it behaves as a unity gain amplifier. These buffers are a frequent cause of problems. Watch out for noisy buffers and replace them if indicated.

Data is communicated between the CPU and front panel by eight wires and a 10-pin plastic "molex" connector. Two of the sockets in the connector are therefore not used and should be plugged into the CPU with empty sockets toward the center of the board.

Front Panel Display/Control Board

A. Addressing

You will notice a line of 16 lights and switches on the front panel labelled A0-A15. The lights display the location in memory that you are at. The switches allow you to examine any location by putting the appropriate switches up or down and pushing the examine switch. They are grouped in three's for convenience. This is called "octal notation" because any group has eight possible values. When a switch is up, it has a value of "1", when down a value of "0". Look at the following table.

A_2	A_1	A_0	Octal Value
2^2	2^1	2^0	
0	0	0	0
0	0	1	1
0	1	0	2
0	1	1	3
1	0	0	4
1	0	1	5
1	1	0	6
1	1	1	7

The address goes from 0-15 instead of 1-16 because each address represents a power of 2. Therefore,

$A_0 = 2^0 = 1$

$A_1 = 2^1 = 2$

$A_2 = 2^2 = 4$

$A_3 = 2^3 = 8$

$A_4 = 2^4 = 16$

$A_5 = 2^5 = 32$

$A_6 = 2^6 = 64$

$A_7 = 2^7 = 128$

$A_8 = 2^8 = 256$

$A_{15} = 2^{15} = 65,536$

The 8800 is an eight bit machine. This means it can only accept eight bits of data at one time. Therefore, it can recognize 2^8 or 256_{10} possible combinations. Since it has 16 address lines, it can directly address 2^{16} or 65, 536 (64K) locations in memory. Eight bits constitute a "byte". Grouping the eight bits in three's (actually 2,3,3) and giving their value in octal vastly simplifies byte description. To wit:

11 000 011 = 303_8

3 0 3

10 101 110 = 256_8

2 5 6

All addresses, instructions and data will be described in this manner from now on.

B. Data

The data lights display the contents of memory at the address shown at the address lights. At every address in memory one byte (eight bits) are stored. Data can be stored by setting the data switches in the desired pattern and then hitting the deposit or deposit next switch. The deposit next switch will deposit the data at the next address after the one you are at, thereby eliminating the drugery of resetting the address switches after each byte.

The run/stop switch does exactly that. (it resets ~~the switches~~ after each byte) The Reset switch puts the program counter inside the CPU at zero address. The single step switch allows you to go through a program one instruction at a time. This is useful for debugging. The Protect switch essentially "locks" up a block of memory so that nothing can be accidently written into it, ~~and thereby destroying a program.~~ Thus, a program cannot be destroyed. If the protect light is on, you cannot deposit data until you toggle the unprotect switch.

The upper eight address switches A8-A15 are also called sense switches. Certain programs utilize data present on these switches for various purposes.

There are twelve status indicator lights on the front panel. We will not go into them in detail here. When the computer is stopped and reset, you should see the following indicators lit.

Wait - the CPU is in a wait condition

MEMR - the CPU is reading data from memory

M1 - the CPU is at machine cycle one of an instruction cycle

WO - the CPU is writing out data

If these lights do not come on or if any others are on, you have a problem.

After turning on a computer, always hit stop and reset.

C. Memory

MITS has several memory boards which differ in capacity and technology, but all are compatible and similar in layout. The actual storage of data is done on a Random Access Memory chip (RAM). All our chips (except on the 1K board) are configured so that they can store one bit at each address. Since there are eight bits to a byte, each board has a multiple of eight RAMs, so it can store a full byte at each address. Let's take a 4K x 1 chip for example. 4K x 1 means it can store 1 bit for 4,096 locations. It requires four power supply connections. Vcc +5v, V_{BB} - 5v, V_{DD} +12v and GND (or VSS). To address 4,096 locations it must have 12 (2^{12} = 4,096) address lines. It requires a data in and data out line. It must have an input to tell it to read or write (R/W) and it has a chip select input. This CS input can be used at the designer's discretion.

Since each board takes up only a fraction of the 64K of memory addressable by the Altair, each board must have an address. The first 4K memory board you put in will be addressed to zero, the second 4K will go to address four thousand, etc. Since 4K is our basic unit of memory, the first board is said to be addressed at zero, the second board is said to be addressed at one, and so on. You will see on each board either a switch or a place to hardwire the address. Here is a handy table. The symbol ($\overline{\quad}$) means low or not.

Board #	Jumpers	Actual Address	Board #	Jumpers	Actual Address
0	$\overline{A15}$ $\overline{A14}$ $\overline{A13}$ $\overline{A12}$	0	8	15 $\overline{14}$ $\overline{13}$ $\overline{12}$	32K
1	$\overline{15}$ $\overline{14}$ $\overline{13}$ 12	4K	9	15 $\overline{14}$ $\overline{13}$ 12	36K
2	$\overline{15}$ $\overline{14}$ 13 $\overline{12}$	8K	10	15 $\overline{14}$ 13 $\overline{12}$	40K
3	$\overline{15}$ $\overline{14}$ 13 12	12K	11	15 $\overline{14}$ 13 12	44K
4	$\overline{15}$ 14 $\overline{13}$ $\overline{12}$	16K	12	15 14 $\overline{13}$ $\overline{12}$	48K
5	$\overline{15}$ 14 $\overline{13}$ 12	20K	13	15 14 $\overline{13}$ 12	52K
6	$\overline{15}$ 14 13 $\overline{12}$	24K	14	15 14 13 $\overline{12}$	56K
7	$\overline{15}$ 14 13 12	28K	15	15 14 13 12	60K

So, if you wanted a board addressed to 12K, then you would jumper I1 to A12 I2 to A13, I3 to $\overline{A14}$ and I4 to $\overline{A15}$.

D. Types of Memory

Semiconductor memory systems can be divided into two types: Dynamic and Static.

Dynamic memory is so called because it must be "refreshed" or it will forget. The actual memory cells are MOS devices, some of which are acting as capacitors. These will tend to discharge unless they are strobed every 2 milliseconds or so. By pulsing each row of cells in sequence, they are able to recharge themselves. This type of memory is fast, less expensive, and requires less power than Static memory. Static memory behaves as if each cell is a switch which can be set high or low. It draws more power and is slower, but tends to be more stable than dynamic. Static memory requires less support circuitry.

Specific Memory Boards

A. 4K Dynamic--The 4K dynamic board was our first large memory board. Because of some problems associated with it, you will see a great deal of these boards in repair. There is a good article in a past issue of Computer Notes (our company monthly) on troubleshooting this board.

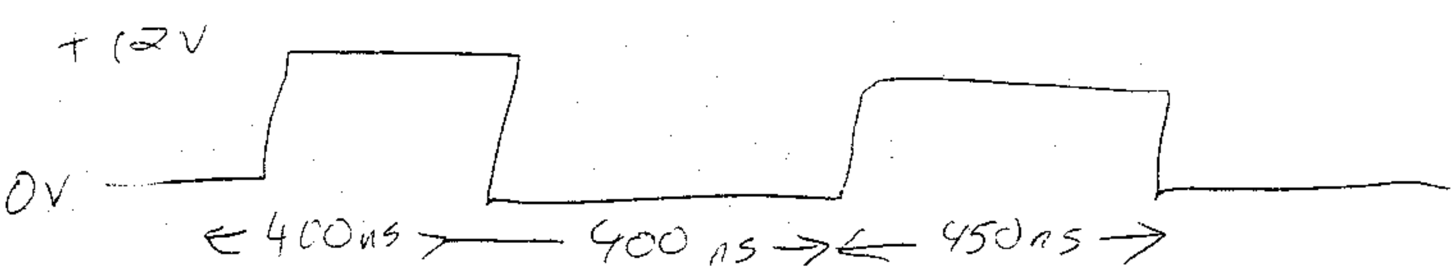
Theory of Operation--Here is a brief explanation of how it works.

Refresh--The refreshing is done on inputs A0-A5 of each RAM. ICs T, D and G divide the Ø2 clock by 64. $\frac{2MHz}{64}$ results in a 32 microsecond period. IC E then counts up to 64 on lines A0-5. There are 64 rows of cells in each RAM so first row 0 is refreshed then 1, 2, etc., up to 64. If the computer is running, it will go into a wait state ($\overline{ready}$) while refresh is occurring. This tells the CPU to wait because the memory board is temporarily unavailable.

5 → CS See 4K RAM Schem...

Read--In order to be read, the chip must be selected (pin 5 chip select must be low). This occurs when the board is properly stopped for the address you want to examine. IC J pin 8 is the key point to check.

Chip Enable is a pulse train that allows reading, writing and refresh to occur. This is a key signal and should be carefully checked! Set the scope for a 200 ns. sweep, 5 volts/on and positive triggering. Look at the collector of the transistor, pin 17 of any RAM or IC Z, pin 2. The Computer is stopped and the board is addressed.



If the pulses are too wide, decrease R6. If the time between pulses is too wide, decrease R5. Then play around with C4 and C5 as well as ICs H and I. Times given are ± 10%.

Data becomes valid after a period of time and appears at the latch (IC N). A strobe to pin 11 latches the data to the output of N which is then available to the CPU.

<u>Writing</u>--For data to be deposited, $\overline{CS}$ and CE are still required and in addition the $\overline{\text{Write Enable}}$ input (12) must pulse low. This pulse <u>cannot be seen on a normal</u> scope. Data is buffered and inverted by ICs R and Z and appears at data in (pin 6). You can see this with a slow sweep if you try to deposit Ø's. This is another <u>key test point</u>.

12 - WE

Here is a check out procedure for 4K dynamic:

1. Read complaint, if any.
2. Visually inspect board for proper components, orientation, shorts, and solder bridges.
3. Check to see if board is a Rev. 2. If not, send to production for mods.
4. Strap board to zero ($\overline{A15}$, $\overline{A14}$, $\overline{A13}$, $\overline{A12}$).
5. If the bypass resistor for the +5v regulator is not a 10 ohm, 2 watt, then put one in.
6. If any timing capacitor (C2, C4, C5, C3, C1, C18, C22) has this mark on it "◆", replace it.
7. If H and I are 26L123 chips, R5 should be 15K ohms, R6 30K ohms. If H and I are 74123s, then R5 should be 20K ohms and R6 should be 43K ohms.
8. On ~~ICT~~ IC-T pin 10 should be cut from the board, bent over to pin 11 and soldered to it. Insert a .01 uf capacitor between pin 5 and ground. (Protect mod.)
9. Insert into test chassis and check the following voltages on any RAM pin 1- 5v, Pin 11-+5v, pin 18-+12 volts.

10. Deposit a zero at address 0, deposit D1 high at 0001, D2 high at 0002, D3 high at 0003, etc., and back again. Examine what you deposited and see if it's right. Need this dimension

11. Try to load up BASIC from PROM (explained later).

12. Try to load BASIC from disk with board strapped to zero (explained later).

13. Rowpat test overnight (explained later).

Some Troubleshooting Hints--1. If all the signals appear to be correct and the board still does not work reliably, start changing some of the tri-state buffers (Q, P, P, S). where?

2. If problems do not occur when board is first plugged in, suspect a thermal problem. Try to isolate with a freeze spray and/or heat gun.

3. If board almost loads BASIC, and then dies, try replacing E and F. If they are 74193's replace with 93L66's.

4. Note that the original schematic is not valid where it involves chips H, L and A due to revisions. There is a supplemental sheet. ?

5. Make sure you check the relationship of Ø2 at S3 and $\overline{\text{READY}}$ at S11 as outlined in the Computer Notes article. This is another critical test point. Get Computer Notes

6. Borrow and copy an annotated schematic from another technician. Do not be intimidated by the complexity of the schematic. Normally you will be dealing only with small sections of it.

7. Check to see if you are getting a data strobe on pin 11 of IC N (should pulse every 32 microseconds).

8. Check the RAMs for shorts and continuity. All the same numbered pins of each RAM should be common except pins 6 (data in), 7 (data out), 16 (no connection). Put an ohmmeter on high range (X100) and make sure they

are shorted together. Then make sure that no two pins with different numbers are shorted together. This has only to be done on one RAM. Shorts can occur underneath an IC socket. Most of them can be carefully pulled up with a hook-nosed scribe.

9. Bring the card edge up to your eye and look for bent pins. Look to see that the legs of capacitors are not shorting any PC traces.
10. Check to see that the jumpers are correctly installed by comparison with a known good board. Note that they do not all go to their labelled positions (esp. J6, J2 and J10). See card
11. If you find a bad RAM, move it to a different location to see that the socket is not the cause.
12. Do not hesitate to ask more experienced technicians for advice.
13. When in doubt about what you should be seeing at a given point, compare it to a known good board.

4K Static Board and 16K Static Boards

I will not go into detail on these boards. Both have good troubleshooting sections in their respective manuals. There is also an article on troubleshooting 16K boards in the Computer Notes. Most of this information is applicable to both boards.

The 88-S4K Dynamic Memory Board is a new replacement for the 88-4MCD Dynamic Board. It incorporates some new circuits to alleviate the timing problems associated with the 88-4MCD Board; and therefore, takes some explanation of operation.

The 88-4MCD Memory Board uses an asynchronous system for generation of refresh, chip enable, and $\overline{PRDY}$ pulses. The 88-S4K board uses the same signals, but derives them from existing signals in a manner which synchronizes them and ensures their timing specifications.

Basically the board consists of 8 4K x 1 bit Dynamic RAM memory chips with associated address and data buffers. (ICs EE, DD, CC, JJ, HH, BB, and AA). ICs EE and AA being address buffers; IC BB being an address inverter, and ICs DD, CC, JJ and HH being data buffers. ICs GG and FF are latches which latch data read from the RAMs on the falling edge of the STB pulse.

Board Decoding for Board Enable is done from address lines A12 through A15 which selects boards in increments of 4K blocks. IC W inverts these lines for the $\overline{A}$ select position and switch S1 selects $\overline{A}$ or A. If the board is selected, all inputs at IC V will be low, causing a low on $\overline{RCS}$, thus selecting the RAMs. This low is also routed to IC D for use in protect circuitry. The output of V is also inverted and fed to IC G for use in Refresh, Chip Enable, and STB. This output is also used to enable the Protect Status and the $\overline{PRDY}$ buffers.

The actual refresh generation is complicated and is explained in the Theory of Operation Manual. It basically consists of a counter to determine the refresh address and two generators depending on the mode of operation.

The only problems found with the board at this time are not too complicated. The first problems to be aware of are of a physical nature. Check all despiking capacitors to insure that they have been installed in the proper holes. Check for solder bridges, ICs partially out of the socket (or board), and proper orientation of all components. One silkscreen error is on the board on Transistor Q1. The marking for the emitter is wrong, but just make sure the flat side of the transistor is facing the bottom of the board.

We have experienced some problems with the protect circuitry. If the board is selected and you cannot protect or unprotect the board, check ICs U, and D and Diode D2. IC D is configured into an RS flip-flop and a state change is caused by driving either pin 2 or pin 12 high depending upon condition. IC D is the most suspect. If the board comes on protected from power on; check to see if it will come on protected at a position other than the 0 position. If it does, check ICs U, T and D, or diode D2. If not, do a protect mod which consists of a diode from IC T, pin 2, to IC D, pin 12, with the cathode end at D12. This mod may be made in either power on instance.

The only other problem is that the board may not work with certain other boards in the chassis, including a PROM board with Monitor or a 1K static. To cure this problem, a modification can be made to generate a refresh pulse during a wait state in order to refresh during operations involving slow memories. This modification is included.

How to use the 8800 computer.

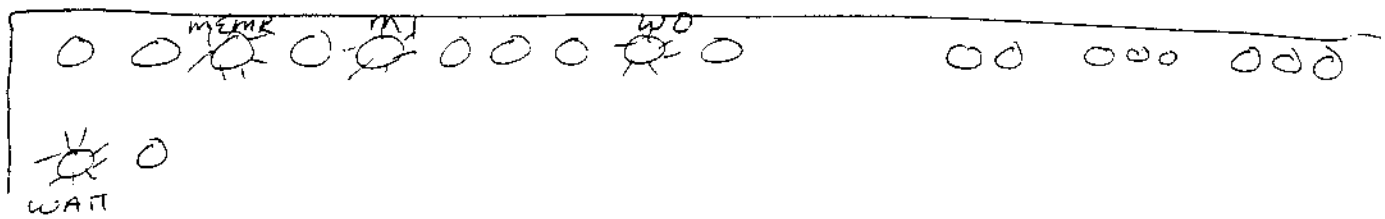
1. Check to see that you have the necessary boards in the chassis.
   a. CPU board correctly plugged in.
   b. Adequate memory for what you want to do. The boards must be strapped consecutively starting at zero. You cannot have two boards at the same address. You need this amount of memory for the following:
      i. front panel tests-minimal
      ii. 4K BASIC PROM-4K
      iii. 8K BASIC tapes-8K
      iv. Extended BASIC tapes-12K
      v. Disk-20K
      vi. Rowpat-one 4K strapped to zero and the boards to be tested anywhere else (except 15 when using PROM)
   c. The correct I/O board for the terminal you are using:
      i. CRT or Compter-SIOA or 2SIO strapped for RS-232
      ii. Teletype-SIOC or 2SIO strapped for TTY. Check your baud rates and I/O addresses. Always connect cable so that black wire (ground) is at pin 4 (from left). Use the right cable!
   d. Do you need a PROM card for a bootstrap?

e. Do you need the disk controller cards?

2. Are all cards plugged into the mother board correctly?

3. Turn on computer.

4. Lift stop and reset switches. Is status correct?



5. You are now ready to roll. The computer is waiting to be told what to do.

<u>Using the PROM cards</u>

A PROM is a Programmable Read Only Memory. When you turn off the computer, the memory does not die. The data in them is for reading only and can be altered only by special devices. PROMs are normally addressed to the top end of memory. On the PROM is a program to write data into a RAM and/or to tell a computer how to start going about its business. Such information as how the computer is going to input and output data. This is called a bootstrap. When you have your computer ready to go, merely send ~~the~~ computer to the starting address in the PROM by the address switches and hit RUN and the computer is ready for a program. The most frequently used PROMs are used as follows:

1. A15-A8 up except A9
2. Examine this address
3. You should see 041 (00100001) on data lights
4. Put down switches A15-A12 (if using a 2SIO board, leave A15 up)
5. Hit RUN
6. Terminal device should print out "4K memory test . . . which board to test, 1 = 4K, 2 = 8K, 3 = 12K . . ."

7. At this point you can either push the "C" key and the computer will cycle through each board continuously or you can type the number of the board you wish to test (1-14) and it will test that board one time.

8. After testing a board, the computer will say "And that's it"

9. To stop the computer, hit STOP

10 . Turn off power before removing any board!

If an error occurs, it will print something like "error address 031247 bad bits 5". This address is in octal in the same way the front panel switches are arranged.

For our example:

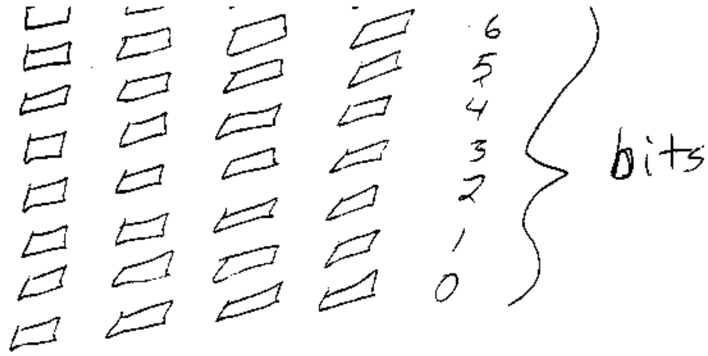
Value	32K	16K	8K	4K	2K	1K	512	256	128	64	32	16	8	4	2	1
Address line	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Sample Address (octal)	0		3			1			2			4			7	
Sample Address (binary)	0		011			001			010			100			111	
Decimal Value	8K+4K	+	512	+		128		+	32	+		4+2+1				

= 8192
4096
512
128
32
4
2
1
12,967 decimal address

From this we can tell that the failure is at board 3 (0-4K = 0, 4K-8K = 1, 8K-12K = 2, 12K=16K = 3) and that it is at decimal address 967 of this board. If the board was a 4K static, which has 4 rows of 1,000 bytes each, we would know that the failure was in row A at bit 5 (the computer told us that earlier).

4K Static

RAM Configuration



A B C D

0-1K 1K-2K 2K-3K 3K-4K

At this point you would examine this chip and see if all pins were in the socket well. If a bent pin is found, you would straighten it and retest. If not, interchange bits 5 and 6 and retest. If it fails again at the same address with bit 6 bad, then the chip should be replaced and the board retested. If something else happens, it was probably a socket problem.

<u>DISK Boot Loader</u>-This PROM loads the program that loads the Altair Floppy Disk. This is mass memory storage device. To load up a disk, do the following:

1. Check to see that the Disk controller boards are in the Altair and that their cable is properly plugged into the disk drive cabinet.
2. Check to see that a disk is properly installed into the drive unit (label goes to top, right corner nearest you).
3. You need 20K of memory starting at 0.
4. Turn on disk drive.
5. Reset computer and set address switches A15-A8 high.
6. Examine this address, 041 should appear on data lights.
7. Put all address switches down (unless you are using a 2SIO as the I/O board. In that case, leave All high).
8. Hit run, disk drive should click and all lights should come on.
9. After a few seconds, the terminal should say:

Terminal	Your Response
Memory size?	Hit return button on keyboard
Terminal width?	Same
How many files?	Same
How many random files?	Same

It will then print out some information about the Disk Extended BASIC and finally print "OK". At this point you can start writing a program in BASIC. If you wish to read or write on the disk, you must "mount" it.

1. Type mount and hit return.

   After about 10 seconds, it will print out OK.

2. If you want to know what is written on the disk, type "files" and hit return.

3. If you want to load a file into memory so that you can run it, type LOAD "ANYFILE YOU WANT" and hit return.

4. After it prints OK, type RUN and hit return.

WARNING

When the head is loaded, you cannot turn off the Altair. In order to unload it, type OUT 8, 128 and hit return. If that doesn't work, load this program:

Reset

Examine 0

Deposit 076 at zero

Deposit next 200

Deposit next 323

Deposit next 010

Examine 0

Reset

Run stop

The disk enable and head load lamp should go out.

4K BASIC PROM--This PROM board loads a short version of a high level language directly into memory.

1. Switches A14, 11, 10, 9, 8 up (upper level address 057).
2. Examine-should be 041 on data lights.
3. Switches down-hit run.
4. Terminal should print out "SN ERROR".
5. Type "RUN" and hit return and it will come back with "100 elements 1, 2, 3, 4" and keep counting. You can stop it by pushing the "C" key and the control key at the same time.
6. After step 4 or 5, you can write a simple BASIC program to test the board. For example:

   10 x = 1 | set on initial value for x

   20 Print x, SQR (X) | Print out X, then compute the square root of X and print that

   30 X = X+1 | Make X = equal to the previous value + 1

   40 ~~Go to~~ GOTO 20 | Go to statement 20 and print the new X and its square root

   When you type RUN and hit return, you will see:

```
RUN
1       1
2       1.414
3       1.732
4       2
```

etc., This program is a loop and will run forever if not stopped by the operator.

88-S4K Memory Board

Addenda Page

November, 1976

In order to make the 88-S4K Memory Board compatible with memory boards that use wait states (the 88-PMC or the 88-1MCS), the following modifications must be implemented. If neither of these boards are used, the modifications are not necessary. If your 88-S4K board was factory assembled, it can be returned to the factory for installation of these modifications. The only customer charge will be shipping costs.

1. There are four lands on the silkscreened side of the S4K board that must be cut. One land comes off IC N, pin 3. The other three come off IC V at pins 10, 8 and 13. The small arrows in Figure 1 point to each of the lands and small "x's" designate the exact points at which the lands should be cut.

2. There are six jumper connections that must be made on the back of the S4K board. They are:

   a) V10 and V13 to +5v (V14)
   b) K3 to G11
   c) N8 to G12
   d) V8 to N10
   e) G8 to M1
   f) G13 to F8

   The locations for these connections are shown by the screened lines in Figure 2.

Refer to Figure 3 for a simplified diagram of where the land cuts and jumper connections should be made.

Figure 4 shows how the board should look when all of the modifications have been completed.

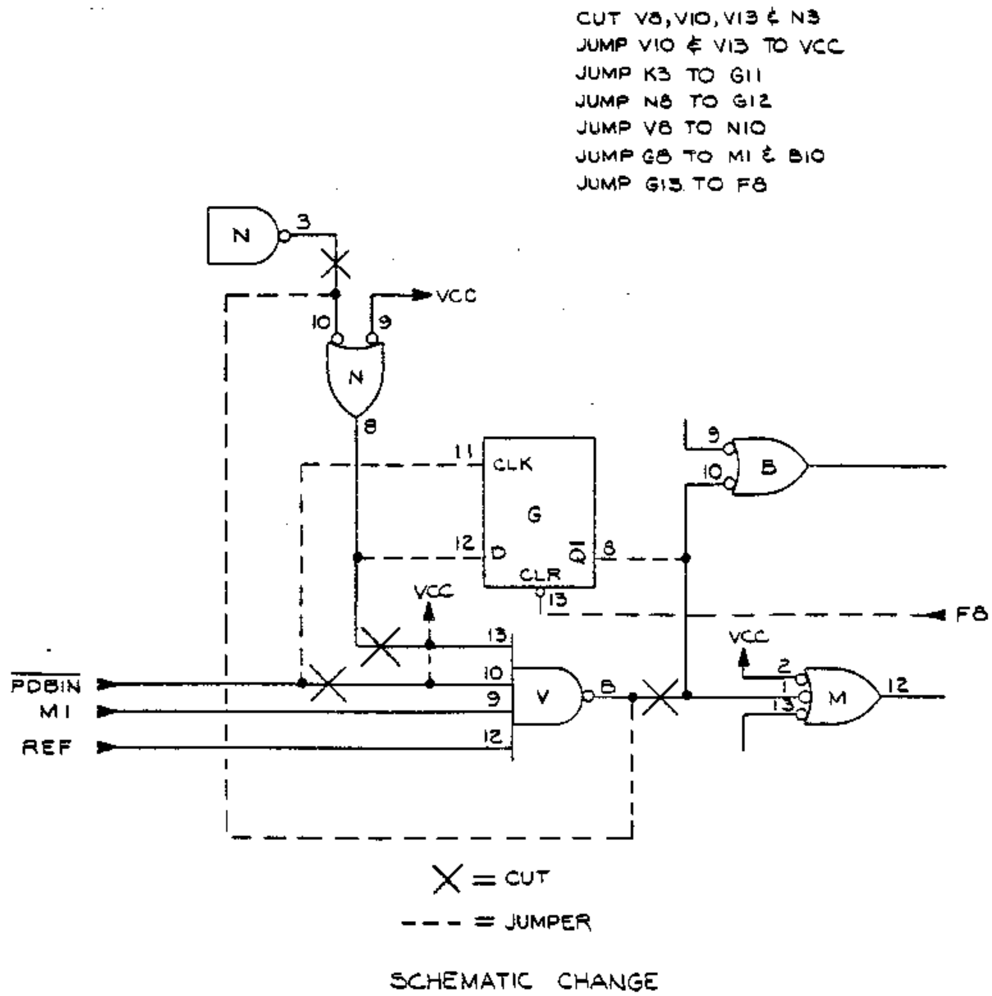


Figure 3. Simplified Schematic

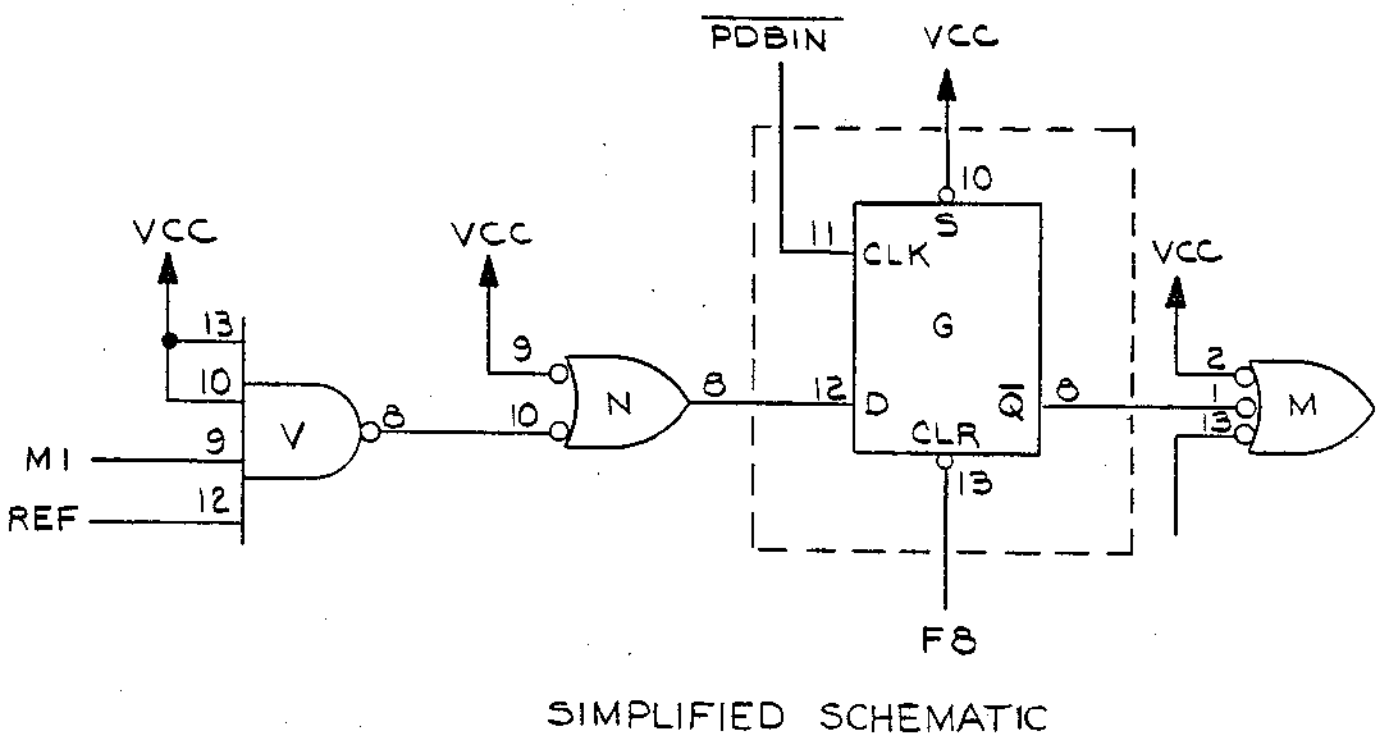


Figure 4. Simplified Schematic with Completed Modifications

REPAIR INFORMATION RECORD

NOTE: *This is for the purpose of collecting data to be incorporated into a troubleshooting manual for MITS equipment. Please be precise and as detailed as possible. Turn this sheet into Tech. Writing when filled.*

UNIT	PROBLEM/SYMPTOMS	SOLUTION/COMMENTS
FRONT PANEL	WON'T STOP AFTER RUN → A∅ LIT ALL THE TIME →	→ ONE END OF J1 CONNECTED IN WRONG HOLE → LINE 79 CONNECTED TO WRONG PAD ON MOTHER BOARD
CPU	WRITES 071 + 000 ALTERNATELY THROUGHOUT MEMORY AFTER RUN REGARDLESS OF PROGRAM	IC "O" BAD
CPU	CLOCK DOESN'T WORK → BAD STATUS →	→ C3 CONNECTED TO WRONG PAD → IC "Q" BAD
FRONT PANEL	BAD STATUS →	→ IC "X" PINS 15+16 SHORTED
1 K MEMORY	PROT. UNPROT SWITCH OPERATES IN REVERSE	IC "N" BAD
FRONT PANEL	EXAM NXT, DEP NXT "FLAKY"	NOISY SWITCHES
CPU	A4 + A6 ONLY LIGHT WHEN BOTH SWITCHES ARE UP	SHORT ON CPU EDGE CONNECTOR
FRONT PANEL	RANDOM RUN - PSYNC WON'T STOP CAUSING PRDY TO PULSE HI, R/S WORKS BUT HAS NO EFFECT	PINS 12 + 13 ON IC "M" SHORTED
FRONT PANEL	NO EXAM., FLAKY RUN EXAM NXT. WORKS	IC'S "U" + "J" BAD
FRONT PANEL	FLAKY RUN, STOPS WHEN CPU PLUG IS REMOVED + STP/RST IS HIT.	C7 SHORTED TO IC "G" PIN 9
1 K MEMORY	WASN'T DISABLING OUTPUT DRIVERS WHEN YOU EXAMINED OUT OF MEMORY	IC "B" WAS A 7404 INSTEAD OF A 74L30
FRONT PANEL	AFTER RUN (FLAKY TYPE RUN) IT WROTE 071 + 000 THROUGHOUT MEMORY WOULDN'T WORK PROGRAMS	RUN PULSE WASN'T GETTING THRU IC "X"

REPAIR INFORMATION RECORD

NOTE: This is for the purpose of collecting data to be incorporated into a troubleshooting manual for MITS equipment. Please be precise and as detailed as possible. Turn this sheet into Tech. Writing when filled.

UNIT	PROBLEM/SYMPTOMS	SOLUTION/COMMENTS
FRONT PANEL	EXAM INCREMENTS IN 3 STEPS INTO FLAKY RUN + BACK. EXAM NXT + DEP NXT DON'T COUNT (DISPLAY)	IC "Z" BAD NOT LETTING PSYNC GET THRU.
CPU	BAD STATUS	BREAK IN FOIL FROM PIN 10 OF "O" TO 1 OF "H" + "G" ALSO BREAK IN FOIL FROM PIN 15 OF "S" TO P[illegible] OF CIRCUIT [illegible]
CPU	PROGRAMS INVOLVING SENSE SWITCHES WOULDN'T WORK	BREAK IN FOIL FROM PIN 8 OF IC "B" TO GRND
FRONT PANEL	WOULDN'T EXAM EX NXT DEP OR DEP NXT. NO PULSE COMING FROM ANY OF THE SWITCHES	C11 + R20 NOT PROPERLY SOLDERED IN.
CPU	RANDOM EXAM ETC.	PIN 11 OF IC "P" SHORTED TO PIN 7 OF IC "Q"
CPU	BAD STATUS	BAD XTAL
FRONT PANEL	NO EXAMINE EVERYTHING ELSE WORKS	BAD SWITCH.
FRONT PANEL	EVERYTHING WORKS EXCEPT EXM. WHEN EXECUTED A15 – A8 LIGHT + STAY LIT WHILE A7 – A0 FUNCTION NORMALLY	IC "B" ON FRONT PANEL HOLDING OUTPUT PULSE FROM ~~[illegible]~~ "U" 8 LOW.
FRONT PANEL	DEP NXT CIRCUIT WAS ACTING LIKE IT WAS EXAM. ONLY IT DID DEPOSIT. PULSES OUT OF "F" WEREN'T NORMAL	TIME CONSTANT COMPONENTS ~~WERE~~ WAS BAD. ~~[illegible]~~ C9. 1μ AD CAP
FRONT PANEL	DEP NXT CAUSED ALL DATA LIGHTS TO COME ON, MESSED UP STATUS, AND A0 NEVER CAME ON WHILE COUNTING.	ETCHING BRIDGE FROM PAD 4 OF "F" TO LAND GOING TO PAD 12 OF "F"

REPAIR INFORMATION RECORD

NOTE: This is for the purpose of collecting data to be incorporated into a troubleshooting manual for MITS equipment. Please be precise and as detailed as possible. Turn this sheet into Tech. Writing when filled.

UNIT	PROBLEM/SYMPTOMS	SOLUTION/COMMENTS
MEMORY 1K	WOULD NOT DEPOSIT	RAMS LOCATED ~~ON~~ IN WRONG PLACE
MOTHER BOARD	WOULD NOT DEPOSIT IN OR EXAM. 1st MEM. LOCATION. D1-D7 ALL LIGHT WHEN AØ IS EXAMINED)	GAP IN FOIL BETWEEN PIN 37 + WIRE TO FRONT PANEL
MEMORY 1K	DØ + D2 DEP. ONLY WHEN BOTH SWITCHES ARE UP.	DØ + D2 SHORTED TOGETHER ON MEMORY BOARD
FRONT PANEL	EXAM. ONLY EXAMS ADRESS 70. EXAM NXT DEP NXT NOT FUNCTIONING UNSTABLE STATUS	SOLDER BRIDGE BETWEEN PIN 7 + PIN 5 ON IC "S"
CPU	RANDOM EXAMINE	IC "R" BAD
FRONT PANEL	WON'T EXAMINE AT ALL	IC "L" BAD
FRONT PANEL	A7 + A15 STAY LIT ALL THE TIME	LINE TO D7 ON FRONT PANEL BROKEN
FRONT PANEL	A1 WOULD NOT LIGHT	LINE TO 79 ON FRONT PANEL BROKEN (A1 LINE)
FRONT PANEL	WHEN EXAMINING, A8-A15 WOULD LIGHT + STAY THAT WAY. WHILE A0-A7 FUNCTIONED NORMALLY	IC "U" BAD
FRONT PANEL	EVERYTHING WORKS EXCEPT PROGRAMS INVOLVING SENSE SWITCHES	IC "T" BAD
CPU	NO EXAMINE	IC "O" + "R"
CPU	D5 WOULD NOT DEPOSIT	D5 LINE OPEN

– deposit ... [illegible]
All states running no [illegible]
Ø 2 ✓ Ø [illegible]

REPAIR INFORMATION RECORD

NOTE: *This is for the purpose of collecting data to be incorporated into a troubleshooting manual for MITS equipment. Please be precise and as detailed as possible. Turn this sheet into Tech. Writing when filled.*

UNIT	PROBLEM/SYMPTOMS	SOLUTION/COMMENTS
CPU	RANDOM RUN WON'T STOP PSYNC ACTING LIKE ITS SHORTED TO +5	SC 10 ON CPU WAS CONNECTED TO PSYNC LINE INSTEAD OF THE +5 V LINE. BYPASSING PSYNC TO GRD.
FRONT PANEL	WOULD NOT DEPOSIT 1st FEW SECONDS AFTER MACHINE WAS TURNED ON IT WOULD AFTER THAT NO DICE!	IC "F" WAS LATCHING OUTPUT OF IC "N" HIGH, HOLDING IC "G" IN ONE STATE
FRONT PANEL	WOULDN'T EXAMINE DEPOSITED ZEROS	SSW 2 SD GROUNDED GROUNDING OUTPUT OF "T8" + MAKING U8 high
CPU	WOULDN'T EXAMINE A3, A4, OR A5,	IC "B" BAD
MOTHER BOARD	D7 WOULD NOT LIGHT ON DEPOSIT.	BAD CONNECTION BETWEEN CPU + MEMORY BOARDS
FRONT PANEL	NO RUN/STOP FUNCTION	IC "S" BAD
FRONT PANEL	DEPOSITS ALL 1's	C8 .001 INSTEAD OF .1
FRONT PANEL	RANDOM RUN	IC "N" WAS A 7414 INSTEAD OF A 7400
FRONT PANEL	RANDOM EXAM, EXAM NXT DEP. NEXT	IC "N" IN IC "Z" PLACE + VICE VERSA
POWER SUPPLY	+8A + +8B NOT WORKING	POOR SOLDER JOINTS ON POWER SUPPLY.
FRONT PANEL	EXAM INCREMENTS IN 4 STEPS INTO RUN + OTHER FLAKY MODES REPETITIOUSLY	IC "J" ACTING LIKE A FLIP FLOP COUNTER.
FRONT PANEL	RANDOM EXAMINE OR NO EXAMINE	IC "L"'s OUT PUT (PIN 5) OSCILLATING

CPU   [illegible] by 3   IC "R"
CPU   [illegible] gives (17)   IC "A"