

ALTAIR 8800b  
SECTION V  
ASSEMBLY

## SECTION V

### ASSEMBLY

#### 5-1. GENERAL

Section V contains instructions for the circuit and mechanical construction of the Altair 8800b computer. Included in this section are assembly hints, detailed component installation instructions, and printed circuit board and main frame assembly instructions.

#### 5-2. ASSEMBLY HINTS

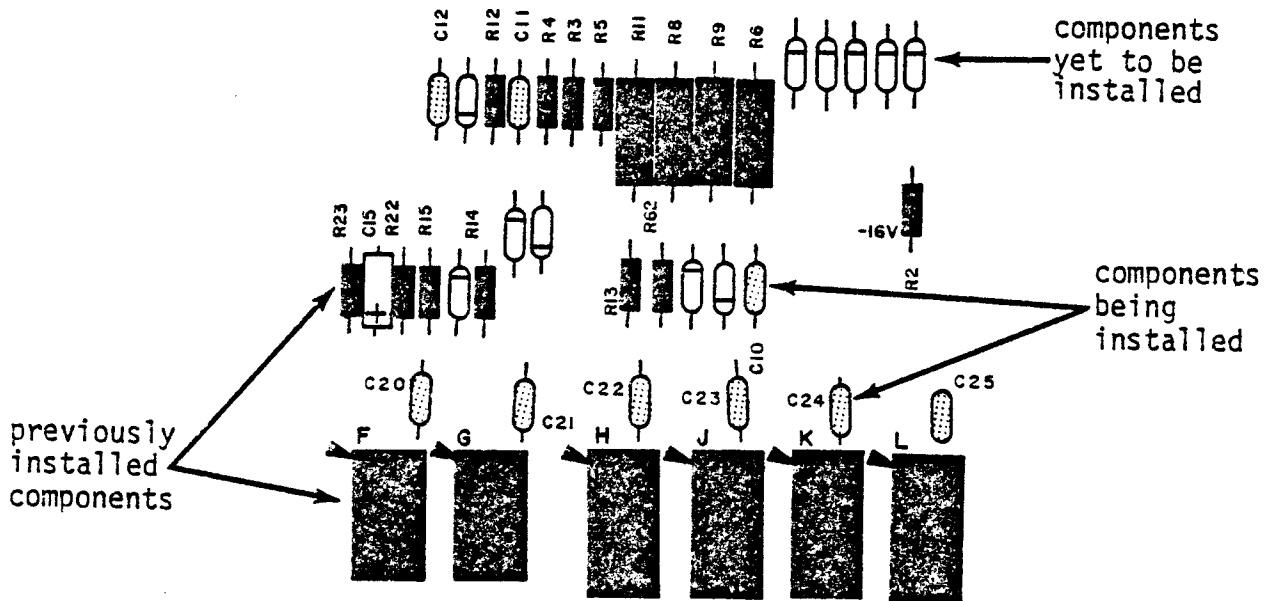
Before beginning the construction of your unit, it is important that you read the "MITS Kits Assembly Hints" booklet included with your kit. Pay particular attention to the section on soldering, because most problems occur as the result of poor soldering. It is essential that you use the correct type of soldering iron. A 25-30 watt iron with a chisel tip (such as an Ungar 776 with a 7155 tip) is recommended in the assembly hints booklet.

#### NOTE

Some important warnings are also included in the hints booklet. Read them carefully before you begin work on your unit -- failure to heed these warnings could cause you to void your warranty.

Check the contents of your kit against Appendix B (Parts List) in this manual to make sure you have all the required components, hardware, and parts. The components are in plastic envelopes; do not open them until you need the components for an assembly step. You will need the tools called for in the "MITS Kits Assembly Hints" booklet.

As you construct your kit, follow the instructions in the order they are presented in the assembly manual. Always complete each section before going on to the next. Two organizational aids are provided throughout the manual to assist you: 1) Boxed off parts identification lists, with spaces provided to check off the components as they are installed; 2) reproductions of the silkscreens showing previously installed components, components being installed, and components yet to be installed (Figure 5-1).

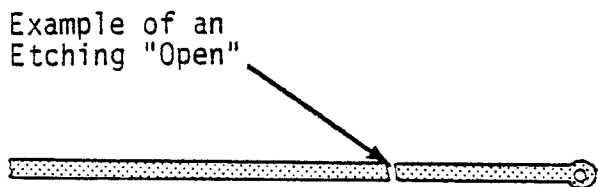
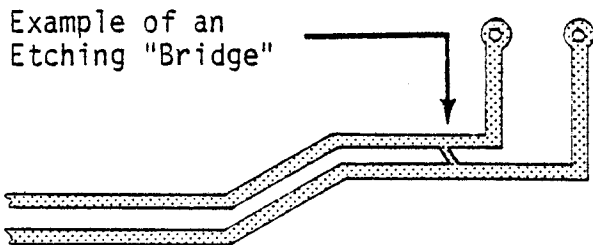


5-1. Typical Silkscreen

## PRINTED CIRCUIT BOARD VISUAL INSPECTION

It is recommended that a visual inspection of the PC Board(s) in your kit be made before beginning the assembly procedures.

Look for etching "bridges" or etching "opens" in the printed circuit lands, as shown in the drawings below:



This could also appear as a "hairline" cut.

A thorough visual inspection will eliminate one possibility for errors, should the board not operate properly after it is assembled. Troubleshooting efforts may then be concentrated elsewhere.

## 5-3. COMPONENT INSTALLATION INSTRUCTIONS

Pages 5-6 through 5-12 describe the proper procedures for installing various types of components in your kit.

Read these instructions over very carefully and refer back to them whenever necessary. Failure to properly install components may cause permanent damage to the component or the rest of the unit; it will definitely void your warranty.

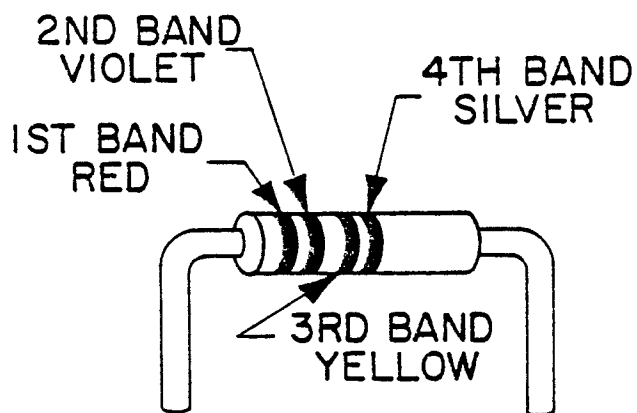
More specific instructions, or procedures of a less general nature, will be included within the assembly text itself.

Under no circumstances should you proceed with an assembly step without fully understanding the procedures involved. A little patience at this stage will save a great deal of time and potential "headaches" later.

#### 5-4. Resistor Installation Instructions

Resistors have four (or possibly five) color-coded bands as represented in the chart below. The fourth band is gold or silver and indicates the tolerance. NOTE: In assembling a MITS kit, you need only be concerned with the three bands of color to the one side of the gold or silver (tolerance) band. These three bands denote the resistor's value in ohms. The first two bands correspond to the first two digits of the resistor's value and the third band represents a multiplier.

For example: a resistor with red, violet, yellow and silver bands has a value of 270,000 ohms and a tolerance of 10%. By looking at the chart below, you see that red is 2 and violet 7. By multiplying 27 by the yellow multiplier band (10,000), you find you have a 270,000 ohm (270K) resistor. The silver band denotes the 10% tolerance. Use this process to choose the correct resistor called for in the manual.



Use the following procedure to install the resistors onto the boards. Make sure the colored bands on each resistor match the colors called for in the list of Resistor Values and Color Codes given in the assembly instructions.

RESISTOR COLOR CODES		
COLOR	BANDS 1&2	3rd BAND (Multiplier)
Black	0	1
Brown	1	10 <sup>2</sup>
Red	2	10 <sup>3</sup>
Orange	3	10 <sup>4</sup>
Yellow	4	10 <sup>5</sup>
Green	5	10 <sup>6</sup>
Blue	6	10 <sup>7</sup>
Violet	7	10 <sup>8</sup>
Gray	8	10 <sup>9</sup>
White	9	10 <sup>9</sup>

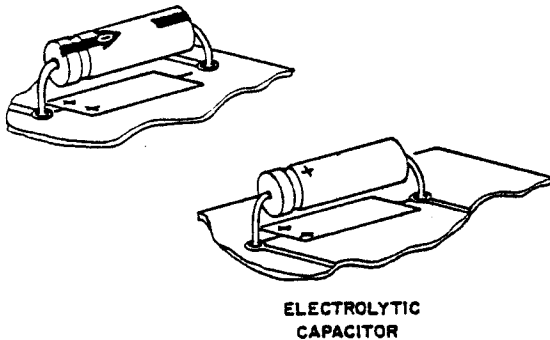
1. Using needle-nose pliers, bend the leads of the resistor at right angles to match their respective holes on the PC board.
2. Install the resistor into the correct holes on the silk-screened side of the PC board.
3. Holding the resistor in place with one hand, turn the board over and bend the two leads slightly outward.
4. Solder the leads to the foil patte on the back side of the board; then clip off any excess lead lengths.

## 5-5. Capacitor Installation Instructions

### A. Electrolytic Capacitors

Polarity must be noted on electrolytic capacitors before they are installed.

The electrolytic capacitors contained in your kit may have one or possibly two of three types of polarity markings. To determine the correct orientation, look for the following.



One type will have plus (+) signs on the positive end; another will have a band or a groove around the positive side in addition to the plus signs. The third type will have an arrow on it; in the tip of the arrow there will be a negative (-) sign. The capacitor must be oriented so the arrow points to the negative side.

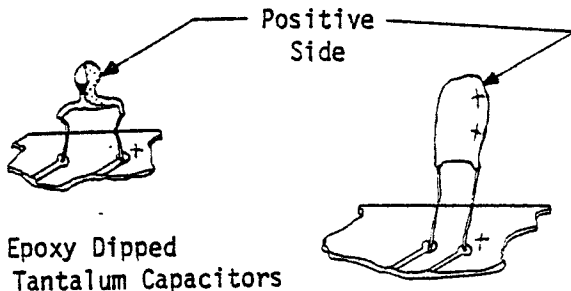
Install the electrolytic capacitors using the following procedure. Make sure you have the correct capacitor value before installing each one.

1. Bend the two leads of the capacitor at right angles to conform to their respective holes on the board. Insert the capacitor into the holes on the silk-screened side of the board, aligning the positive side with the "+" signs printed on the board.
2. Holding the capacitor in place, turn the board over and bend the two leads slightly outward. Solder the leads to the foil (bottom) side of the board and, clip off any excess lead lengths.

### B. Epoxy Dipped Tantalum, Epoxy Dipped Ceramic, and Ceramic Disk Capacitors

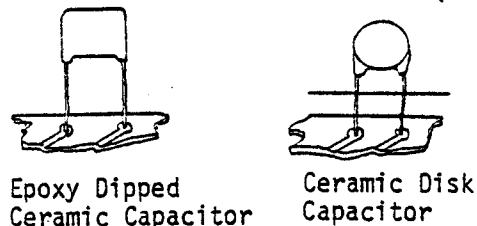
Polarity must be noted on epoxy dipped tantalum capacitors before they are installed.

There are two types of epoxy dipped tantalum capacitors contained in your kit. The first type is blue on the positive side. The second type is marked with "+" signs on the positive side. Both types of epoxy dipped tantalum capacitors are shown in the drawings below.



The epoxy dipped ceramic capacitors and the ceramic disk capacitors are non-polarized.

These two types of capacitors are shown in the drawings below.

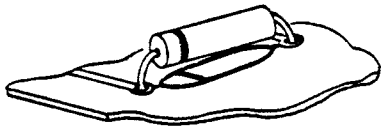


Install these 4 types of capacitors using the following procedure. Make sure you have the correct capacitor value before installing each one.

1. Bend the two capacitor leads to conform to their respective holes on the board.
2. Insert the capacitor into the correct holes from the silk-screened side of the board. Holding the capacitor in place, turn the board over and bend the two leads slightly outward.
3. Solder the two leads to the foil (bottom) side of the board and, clip off any excess lead lengths.

## 5-6. Diode Installation Instructions

NOTE: Diodes are marked with a band on one end indicating the cathode end. Each diode must be installed so that the end with the band is oriented towards the band printed on the PC board. Failure to orient the diodes correctly may result in permanent damage to your unit.



DIODE

Use the following procedure to install diodes onto the board. Refer to the list of Diode Part Numbers included for each board to make sure you install the correct diode each time.

1. Bend the leads of the diode at right angles to match their respective holes on the board.
2. Insert the diode into the correct holes on the silk screen, making sure the cathode end is properly oriented. Turn the board over and bend the leads slightly outward.
3. Solder the two leads to the foil pattern on the back side of the board; then clip off any excess lead lengths.

## 5-7. Transistor Installation Instructions

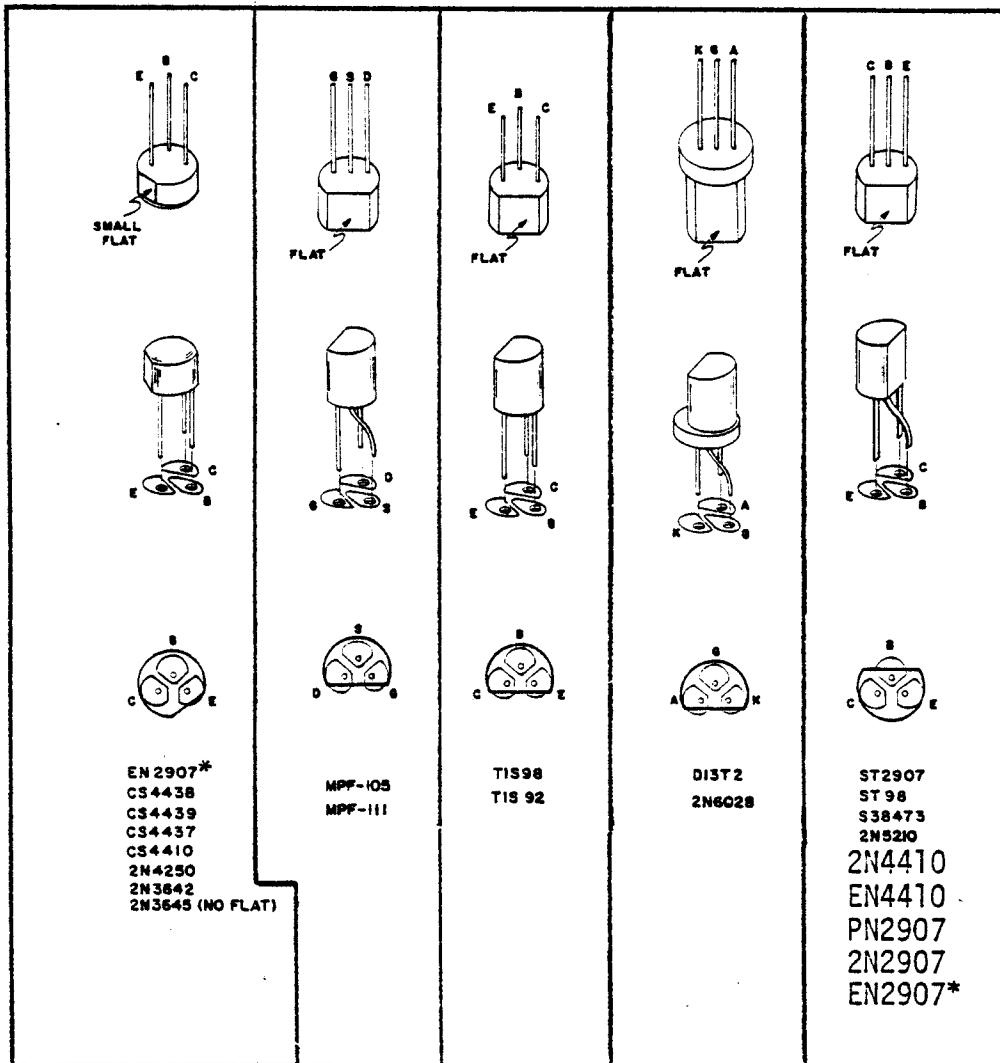
To install transistors, use the following instructions.

NOTE: Always check the part number of each transistor before you install it. (See listing of Transistor Part Numbers for each board.) Some transistors look identical but differ in electrical characteristics, according to part number. If you have received substitute part numbers for the transistors in your kit, check the Transistor Identification Chart which follows these instructions to be sure you make the correct substitutions.

NOTE: Always make sure the transistor is oriented so that the emitter lead is installed in the hole on the PC board labeled with an "E". To determine which lead is the emitter lead, refer to the Transistor Identification Chart.

1. After the correct transistor has been selected and the leads have been properly oriented, insert the transistor into the holes on the silk-screened side of the board.
2. Holding the transistor in place, turn the board over and bend the three leads slightly outward.
3. Solder the leads to the foil pattern on the back side of the board; then clip off any excess lead lengths.

## TRANSISTOR IDENTIFICATION CHART



IN THE ILLUSTRATION ABOVE THE OUTLINE OF EACH TYPE OF TRANSISTOR IS SHOWN ABOVE THE PADS ON THE CIRCUIT BOARD WITH THE CORRECT DESIGNATION FOR EACH OF THE THREE LEADS. USE THIS INFORMATION TOGETHER WITH THE INFORMATION IN THE ASSEMBLY MANUAL FOR THE CORRECT ORIENTATION OF THE TRANSISTORS AS YOU INSTALL THEM.

THE FOLLOWING IS A LIST OF POSSIBLE SUBSTITUTIONS: IF ANY OTHERS ARE USED YOU WILL RISK DAMAGING YOUR UNIT:

2N4410 = EN4410 = CS4410 = CS4437, CS4438, TIS98, ST98, S38473 (NPN)  
EN2907 = 2N2907 = PN2907 = ST2907, CS4439 (PNP)

WHEN MAKING SUBSTITUTIONS, REFER TO THE ILLUSTRATION TO DETERMINE THE CORRECT ORIENTATION FOR THE THREE LEADS.

\*Configuration of the leads on EN2907 may vary.



## 5-8. IC Installation Instructions

All ICs must be oriented so that the notched end is toward the end with the arrowhead printed on the PC board. Pin 1 of the IC should correspond with the pad marked with the arrowhead. If the IC does not have a notch on one end, refer to the IC Identification Chart to identify Pin 1.

### To prepare ICs for installation:

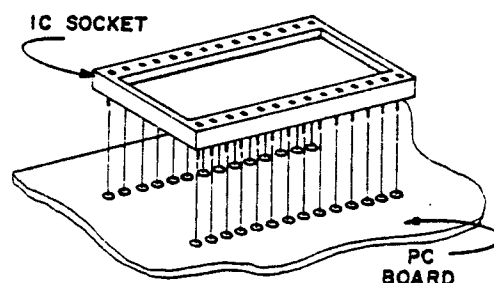
All ICs are damaged easily and should be handled carefully -- especially static-sensitive MOS ICs. Always try to hold the IC by the ends, touching the pins as little as possible. When you remove the IC from its holder, **CAREFULLY** straighten any bent pins using needle-nose pliers. All pins should be evenly spaced and should be aligned in a straight line, perpendicular to the body of the IC itself.

### A. Installing ICs without sockets:

1. Orient the IC so that Pin 1 coincides with the arrowhead on the PC board.
2. Align the pins on one side of the IC so that just the tips are inserted into the proper holes on the board.
3. Lower the other side of the IC into place. If the pins don't go into their holes right away, rock the IC back, exerting a little inward pressure, and try again. Be patient. The tip of a small screwdriver may be used to help guide the pins into place. When the tips of all the pins have been started into their holes, push the IC into the board the rest of the way. Tape the IC to the board with a piece of masking tape.
4. Turn the board over and solder each pin to the foil pattern on the back side of the board. Be sure to solder each pin and be careful not to leave any solder bridges. Remove the masking tape.

### B. Installing ICs with sockets:

1. Referring to the drawing below, set the IC socket into the designated holes on the board and secure it with a piece of masking tape.



2. Turn the board over and solder each pin to the foil pattern on the back side of the board. Be sure to solder each pin and be careful not to leave any solder bridges. Remove the masking tape.
3. Orient the IC over the socket so that Pin 1 coincides with the arrowhead on the PC board.
4. Align the pins on one side of the socket so that just the tips are inserted into the holes.
5. Lower the other side of the IC into place. If the pins don't go into their holes right away, rock the IC back, exerting a little inward pressure, and try again. Be patient. When the tips of all the pins have been started into their holes, push the IC into the socket the rest of the way.

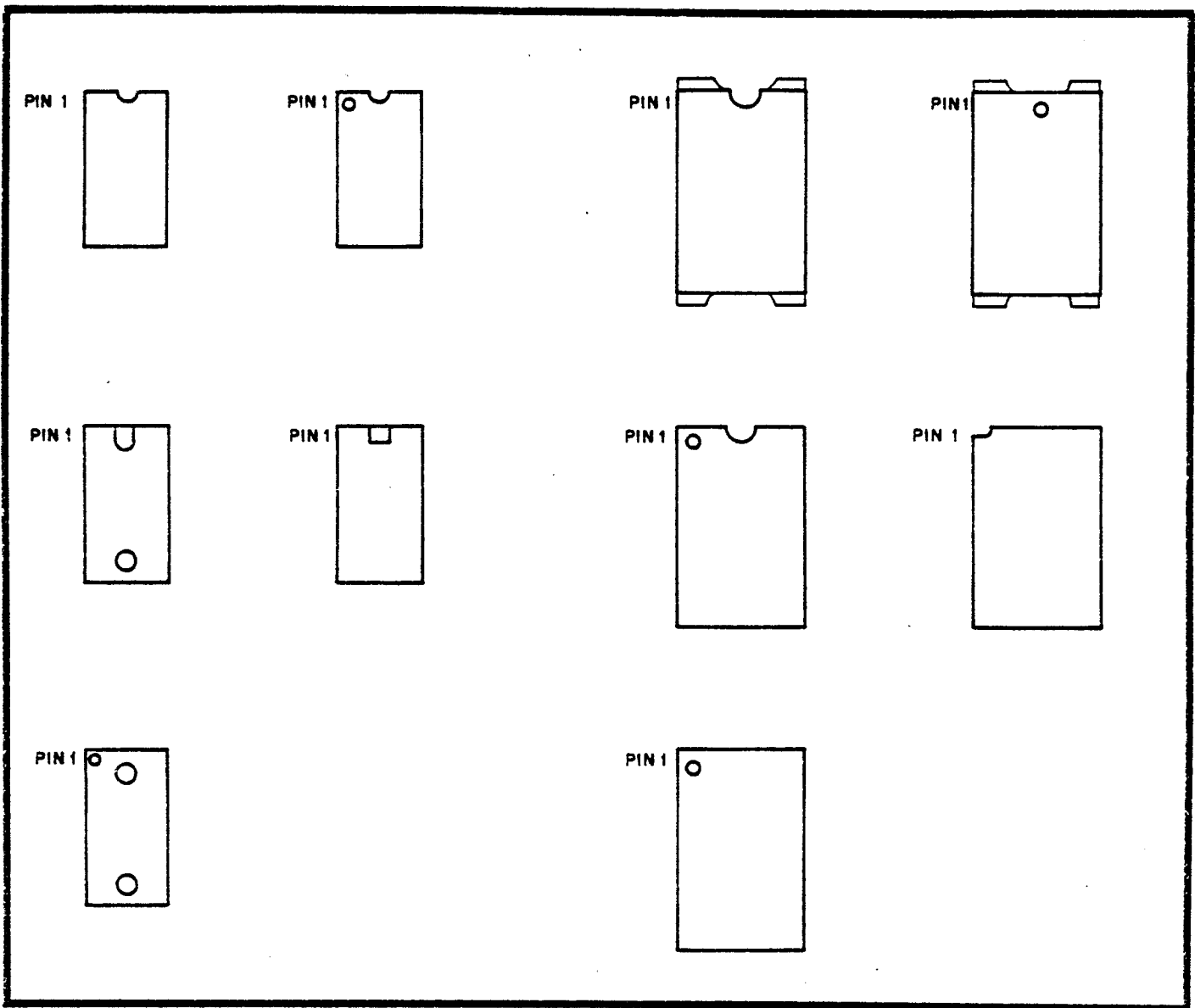
#### **WARNING:**

Make sure none of the pins have been pushed underneath the IC during insertion.

## MOS IC SPECIAL HANDLING PRECAUTIONS

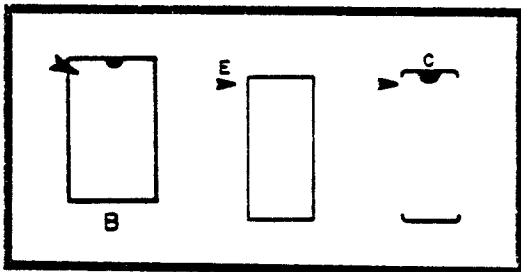
There are several MOS integrated circuits contained in this kit. These IC's are very sensitive to static electricity and transient voltages. In order to prevent damaging these components, read over the following precautions and adhere to them as closely as possible. FAILURE TO DO SO MAY RESULT IN PERMANENT DAMAGE TO THE IC.

- 1) All equipment (soldering iron, tools, solder, etc.) should be at the same potential as the PC board, the assembler, the work surface and the IC itself along with its container. This can be accomplished by continuous physical contact with the work surface, the components, and everything else involved in the operation.
- 2) When handling the IC, develop the habit of first touching the conductive container in which it is stored before touching the IC itself.
- 3) If the IC has to be moved from one container to another, touch both containers before doing so.
- 4) Do not wear clothing which will build up static charges. Preferably wear clothing made of cotton rather than wool or synthetic fibers.
- 5) Always touch the PC board before touching the IC to the board. Try to maintain this contact as much as possible while installing the IC.
- 6) Handle the IC by the edges. Avoid touching the pins themselves as much as possible.
- 7) Dry air moving over plastic can result in the development of a significant static charge. Avoid placing the IC near any such area or object.
- 8) In general, never touch anything to the IC that you have not touched first while touching both it and the IC itself.



INTEGRATED CIRCUITS (ICs) CAN COME WITH ANY ONE OF, OR A COMBINATION OF, SEVERAL DIFFERENT MARKINGS. THESE MARKINGS ARE VERY IMPORTANT IN DETERMINING THE CORRECT ORIENTATION FOR THE ICs WHEN THEY ARE PLACED ON THE PRINTED CIRCUIT BOARDS. REFER TO THE ABOVE DRAWING TO LOCATE PIN 1 OF THE ICs, THEN USE THIS INFORMATION IN CONJUNCTION WITH THE INFORMATION BELOW TO PROPERLY ORIENT EACH IC FOR INSTALLATION.

**WARNING: INCORRECTLY ORIENTED IC'S MAY CAUSE PERMANENT DAMAGE!**



THE DRAWING ON THE LEFT INDICATES VARIOUS METHODS USED TO SHOW THE POSITION OF ICs ON THE PRINTED CIRCUIT BOARDS. THESE ARE SILK-SCREENED DIRECTLY ON THE BOARD. THE ARROWHEAD INDICATES THE POSITION FOR PIN 1 WHEN THE IC IS INSTALLED.

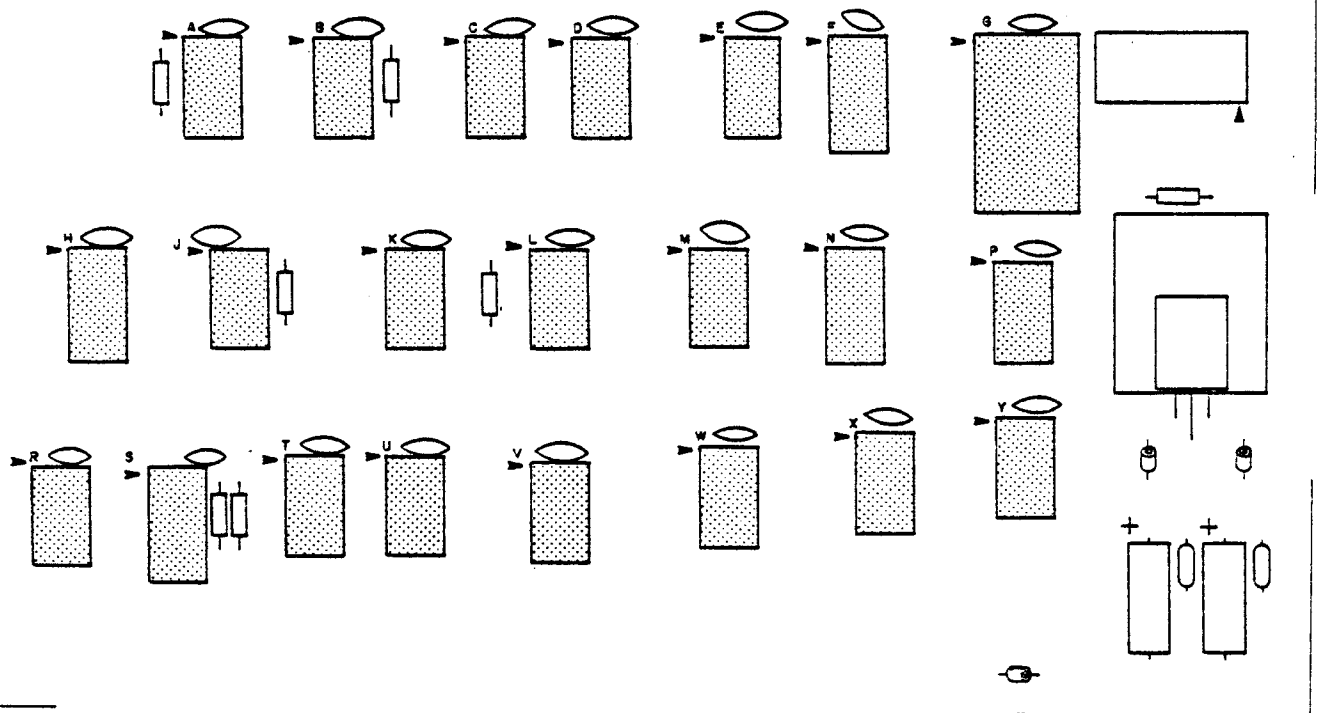
## 5-9. INTERFACE CARD ASSEMBLY

### 5-10. IC INSTALLATION (Figure 5-2)

Install the following 22 integrated circuits (Bag 1) on the Interface Card according to the IC Installation Instructions, Section A, given on page 5-10. IC G will be installed with a 24-pin socket according to the IC Installation Instructions, Section B, page 5-10.

The chart below lists the 22 ICs, their corresponding part numbers, and acceptable part substitutions.

IC Part Numbers	
( ) C, E, M, P, R, T U, V, W, X, Y	74LS04 or 74LS14
( ) A, B, L	74LS20 or 74LS13
( ) F, H, N, S	74367 or 8097 or 8T97
( ) J	7400 or 74LS00
( ) D	7402 or 74LS02
( ) K	7410 or 74LS10
( ) G (with socket)	8212



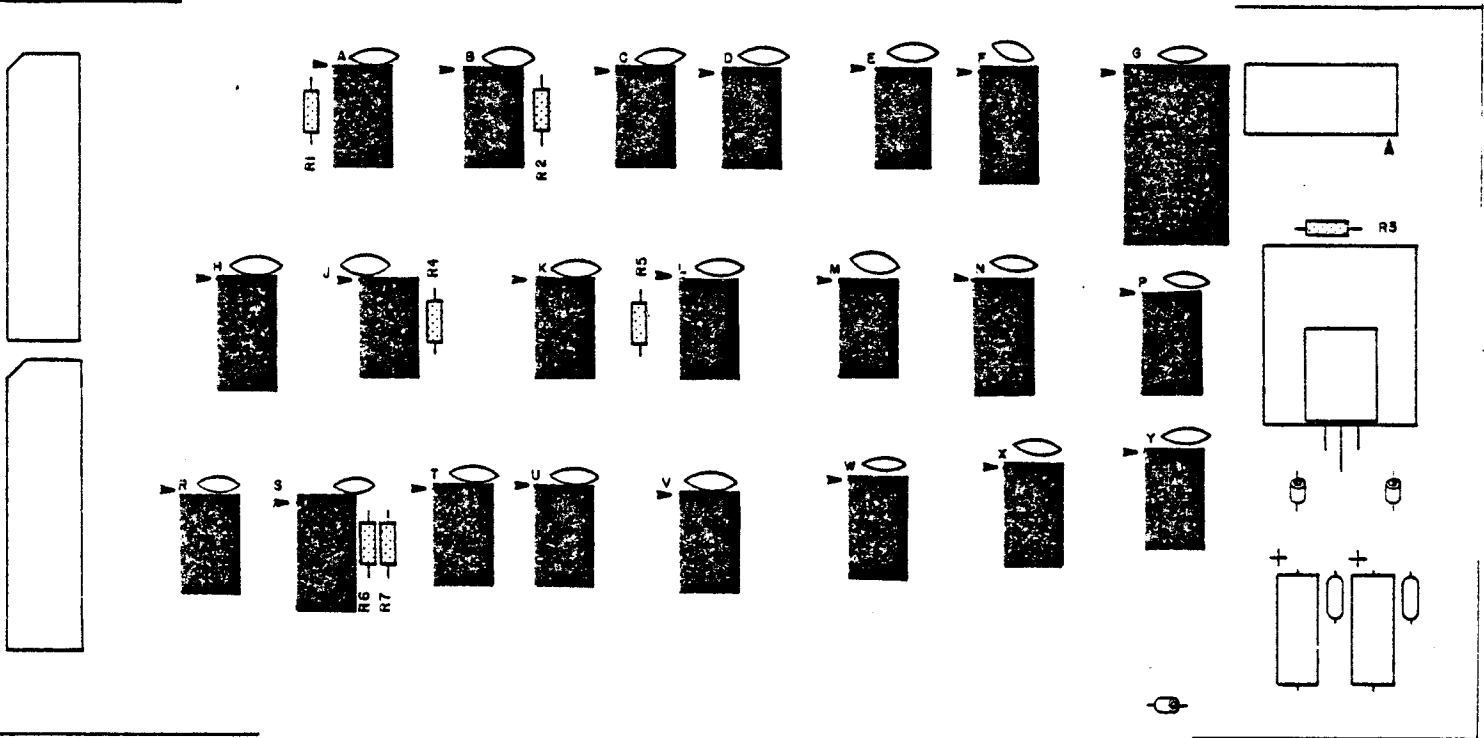
5-2. Interface IC Installation

5-11. RESISTOR INSTALLATION (Figure 5-3)

Install the 7 resistors, R1 through R7 (Bag 5), on the Interface Card according to the Resistor Installation Instructions given on page 5-6.

Resistor Values	
( ) R1 through R7	2.2K ohm (red, red, red) 1/2W or 1/4W

**NOTE**  
Save the excess resistor leads for use in Paragraph 5-15.



5-3. Interface Resistor Installation

5-12. SUPPRESSOR CAPACITOR INSTALLATION (Figure 5-4)

There are 22 suppressor capacitors (Bag 2) to be installed on the Interface Card. These capacitors are used for noise suppression. They are located next to the ICs on the silkscreen, but they have no individual component designations. Install the suppressor capacitors according to the Ceramic Disk Capacitor Installation Instructions given on page 5-7.

Suppressor Capacitor Values	
( ) 22 suppressor capacitors	0.1uf, 12V or 0.1uf, 16V

**NOTE**  
Save the clipped off capacitor leads for use as jumper wires in Paragraph 5-14.

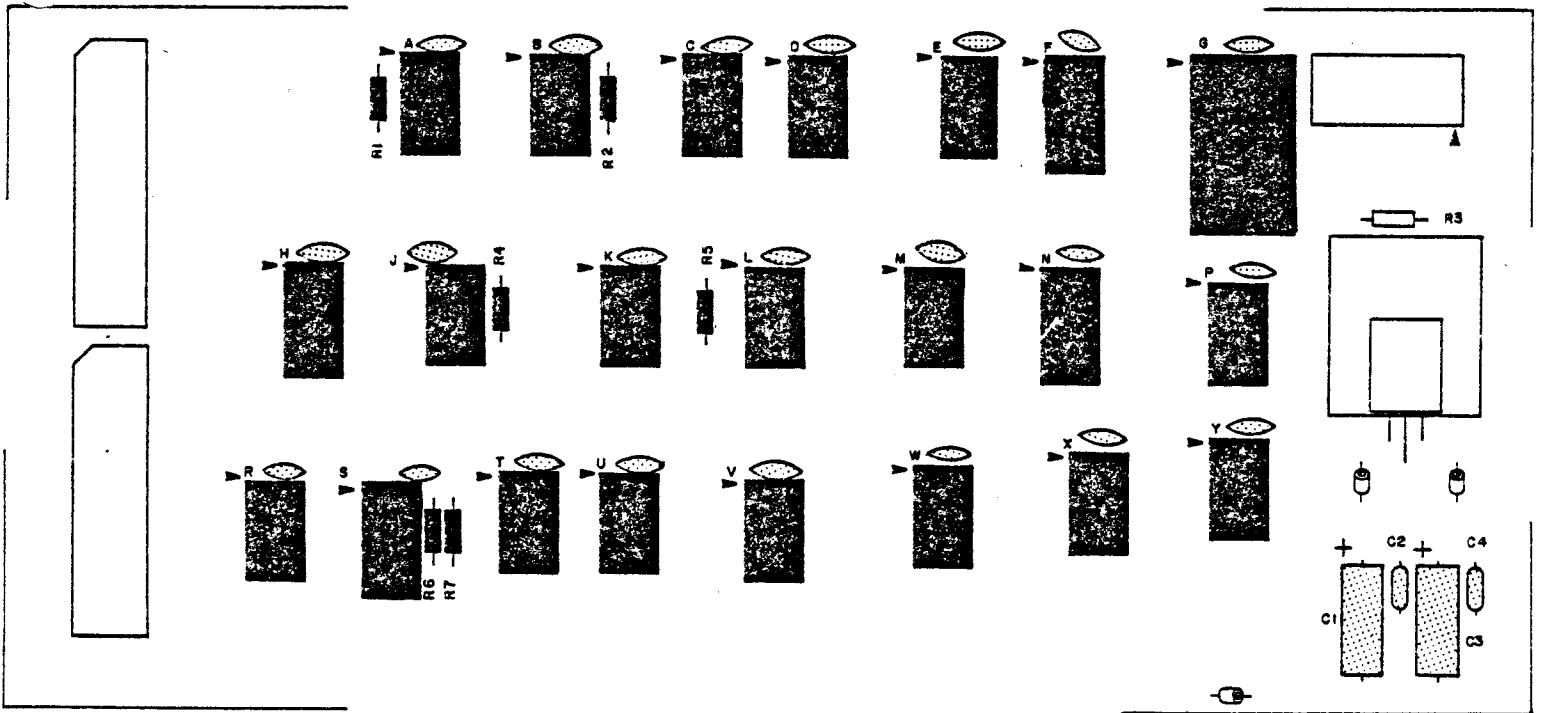
5-13. CAPACITOR INSTALLATION (Figure 5-4)

Install the two electrolytic capacitors, C1 and C3 (Bag 2), and the two ceramic disk capacitors, C2 and C4 (Bag 2), according to the instructions given on page 5-7.

The chart below lists the 4 capacitors and their values.

Capacitor Values	
( ) C1, C3*	20uf - 35uf, 12V - 20V, electrolytic
( ) C2, C4	0.1uf, 12V or 0.1uf, 16V, ceramic disk

\*C1 and C3 may have any value within the range shown.



5-4. Interface Suppressor Capacitor and Capacitor Installation

5-14. JUMPER CONNECTIONS (Figure 5-5)

5-15. FERRITE BEAD INSTALLATION (Figure 5-6)

There are two jumper wires to be installed on the Interface Card. Use the capacitor leads saved from the Suppressor Capacitor Installation. Cut two leads, to 1-inch lengths, and jumper the following pads on the Interface Card.

Jumper Connections

( ) JC to JD

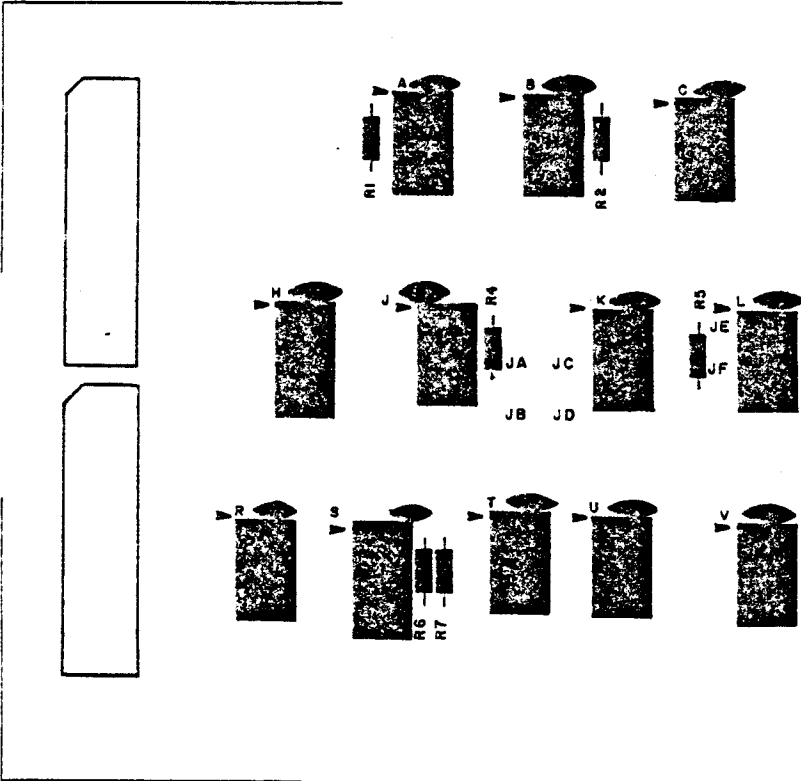
( ) JE to JF

NOTE

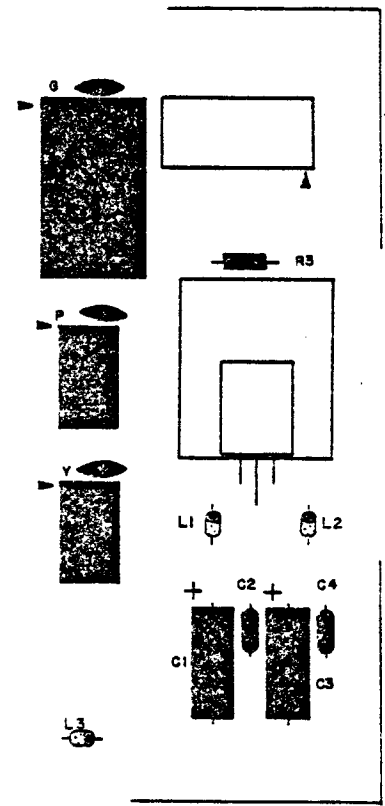
Do not jumper JA to JB here.

Install the three ferrite beads, L1 through L3 (Bag 3), according to the following instructions.

1. Using the resistor leads saved from Paragraph 5-11, cut three 1-inch lead lengths.
2. Insert a lead through the bead, and bend the ends so they conform to their designated holes on the Interface Card.
3. Insert the leads into the card, and solder to the foil (bottom) side of the card. Be sure not to leave any solder bridges and clip off any excess lead lengths.



5-5. Interface Jumper Connections



5-6. Interface Ferrite Bead Installation

# INSERT PAGE

Altair 8800b

## Interface Card Assembly Procedure

Addendum to page 5-16, Jumper Connections

If the D/C Interface Board jumpers are installed according to the instructions given on page 5-16, the front panel data lights will display outputs to channel 377<sub>8</sub> (255<sub>10</sub>). If jumper JE-JF is removed, the data lights will display outputs to all channels. For a more detailed discussion of these jumper options, refer to the Theory of Operation Manual, page 3-60, and Figure 3-15 (sheet 3).



5-16. VOLTAGE REGULATOR INSTALLATION  
(Figure 5-7)

Install the voltage regulator, VR1 (Bag 1), and heat sink on the Interface Card according to the following instructions.

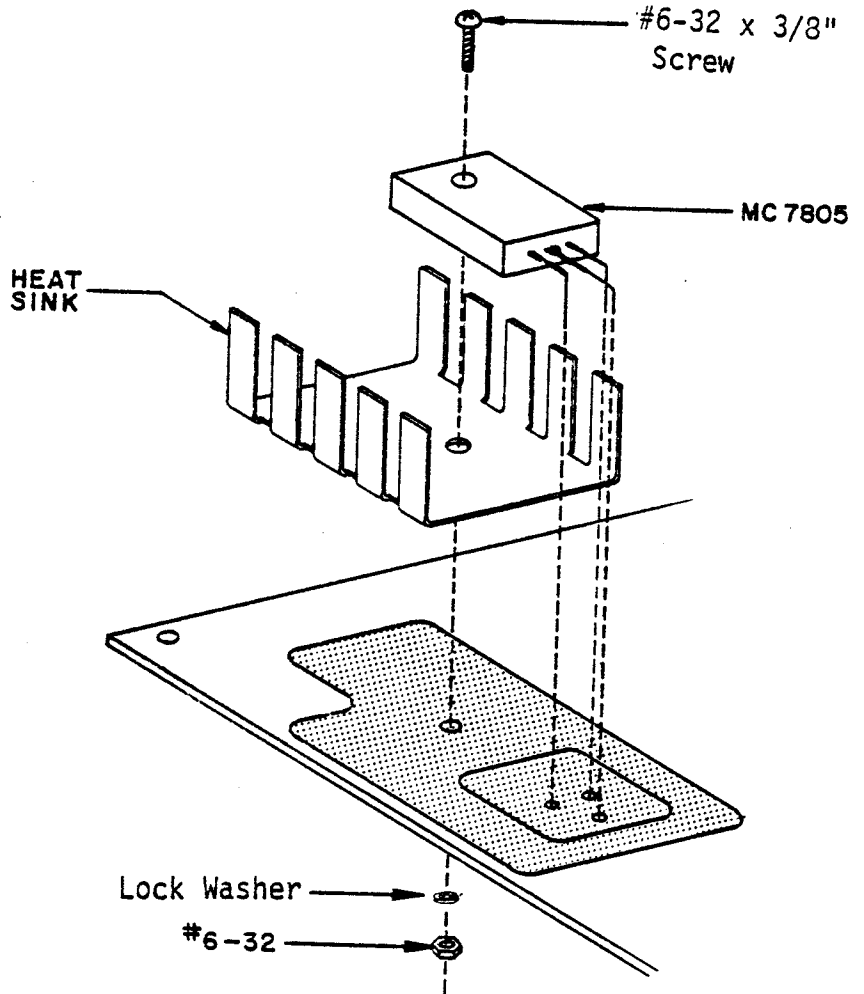
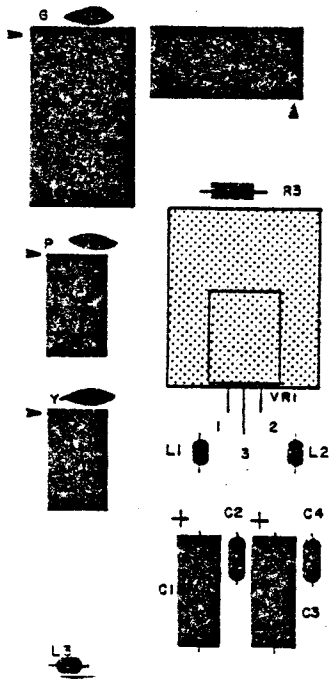
1. Set the regulator in place on the silk-screened side of the Interface Card, aligning the leads with their designated holes.
2. Use needle-nose pliers to bend each of the three leads at a right angle to conform to its proper hole on the card.

3. Referring to Figure 5-7, set the regulator and heat sink in place on the silk-screened side of the card. Secure them in place with a #6-32 x 3/8 inch screw, a #6 lockwasher, and a #6-32 nut.
4. Solder the three leads to the foil (bottom) side of the card. Be sure not to leave any solder bridges.
5. Clip off any excess lead lengths.

Voltage Regulator Part Number	
( ) VR1	7805

**NOTE**

Use heat sink grease when installing this component. Apply the grease to all metal surfaces which come in contact with each other.



5-7. Interface Voltage Regulator Installation

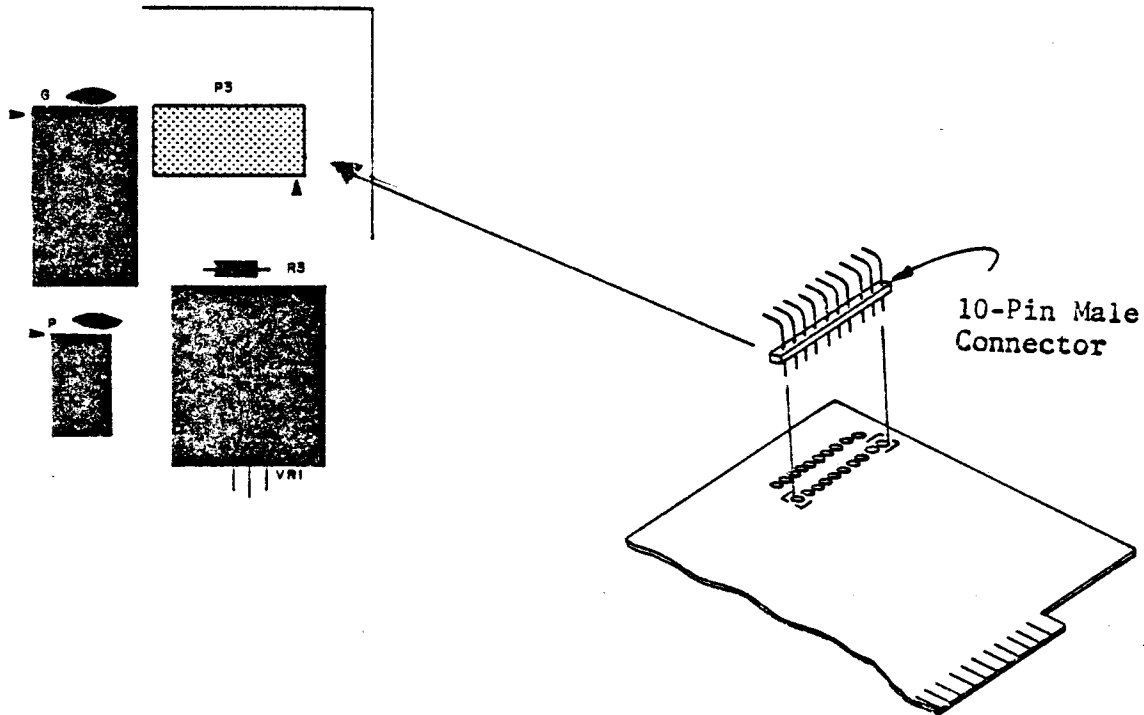
5-17. MALE CONNECTOR INSTALLATION  
(Figure 5-8)

Install one 10-pin Male Connector, P3 (Bag 3), on the Interface Card according to the following instructions.

1. Orient the connector as shown in Figure 5-8, with the bent pins pointing towards the top of the card.
2. Insert the short pins into the 10 designated holes on the silk-screened side of the card.

3. Solder each pin to the foil (bottom) side of the card. Be sure not to leave any solder bridges.
4. Clip off any excess lead lengths.

5. The arrow on the silkscreen points to Pin #1. After installing the male connector, clip off pin #2 of the connector. This is done for keying purposes. Further keying instructions are given in Paragraph 5-76.



5-8. Interface Male Connector Installation

5-18. RIBBON CABLE PLUG INSTALLATION (FIGURE 5-9)

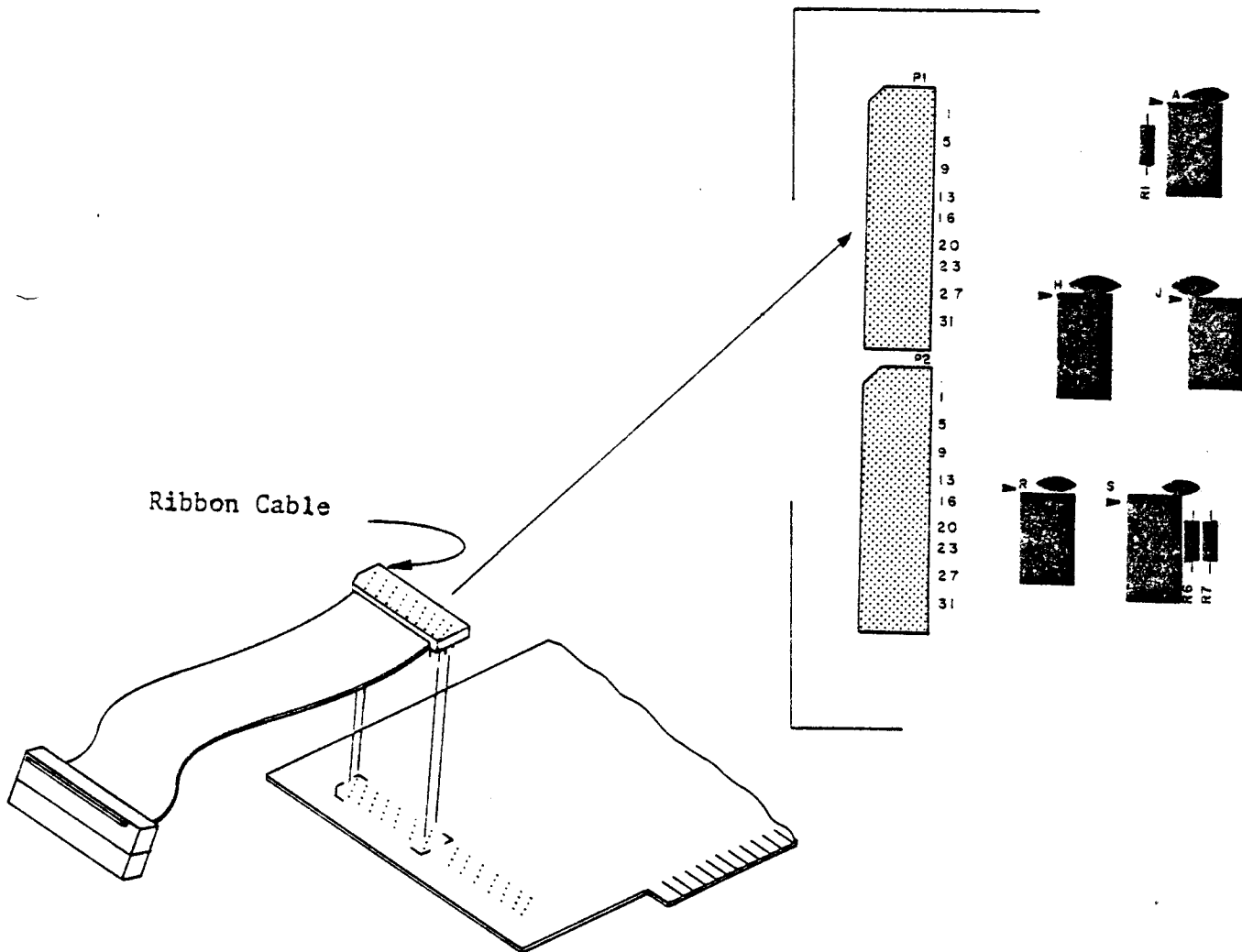
Install the two ribbon cable plugs, P1 and P2 (Bag 4), on the Interface Card according to the following instructions.

1. Orient the Ribbon Cable Plug as shown in Figure 5-9, so that the socket end of the plug hangs over the left side of the card.

2. Insert the pins into their proper holes and solder each pin to the foil (bottom) side of the card. Be sure not to leave any solder bridges.

NOTE

The socket end of the Ribbon Cable Plug will be connected later in Paragraph 5-75.



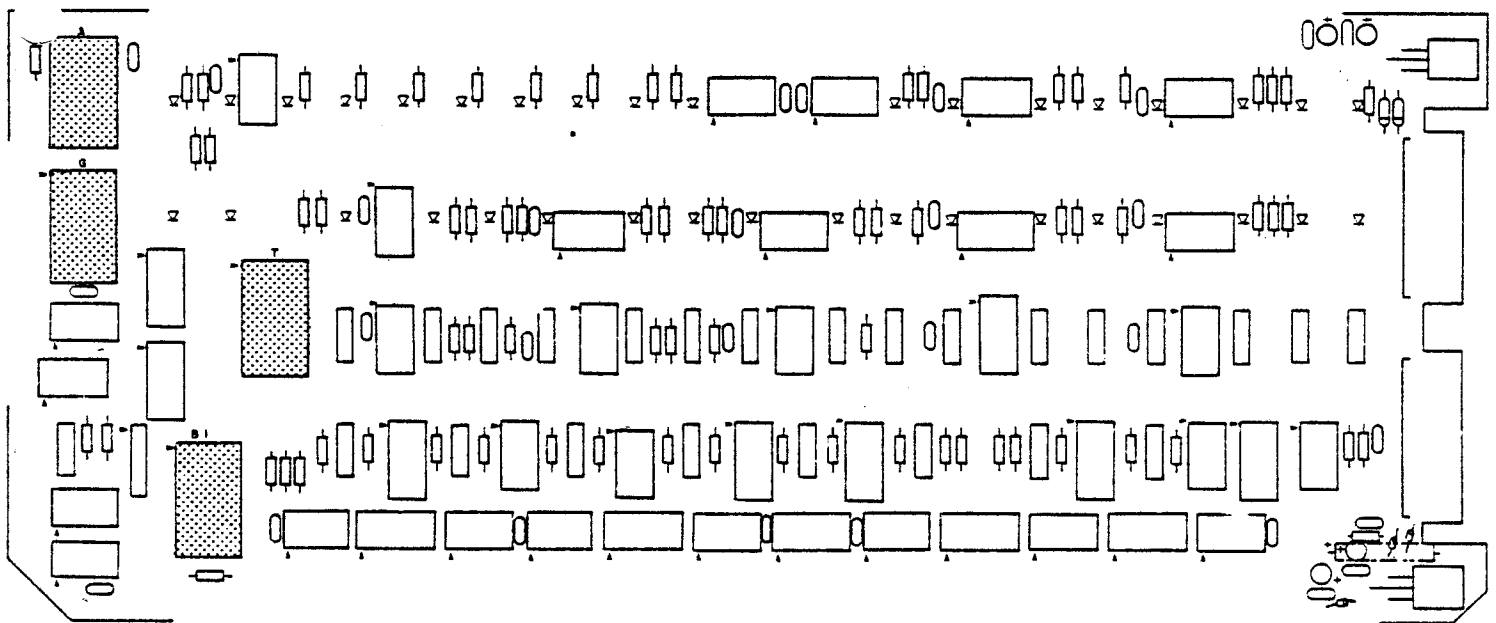
5-9. Interface Ribbon Cable Plug Installation

5-19. DISPLAY/CONTROL BOARD ASSEMBLY

5-20. IC SOCKET AND IC INSTALLATION  
(Figure 5-10)

There are 4 ICs, A, G, T, B1 (Bag10), to be installed with sockets on the Display/Control Board. Install these sockets and ICs according to the Integrated Circuit Installation Instructions, Section B, given on page 5-10.

Silkscreen Designation	IC Part Number	Socket Size
( ) A, T, B1	8212	24-pin
( ) G	1702A*	24-pin
*IC G is a programmed PROM IC labelled "B D/C".		

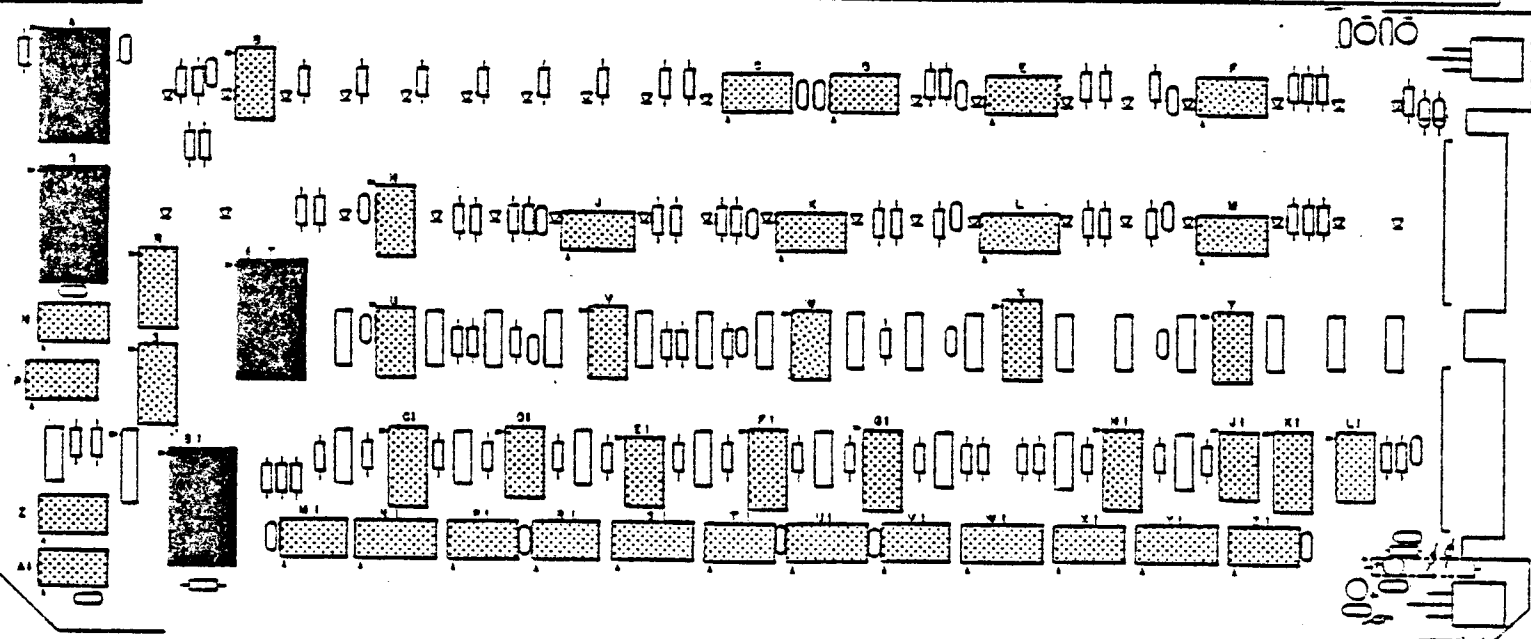


5-10. Display/Control IC Socket and IC Installation

5-21. IC INSTALLATION (Figure 5-11)

Install the following 42 integrated circuits (Bag 1) on the Display/Control Board according to the Integrated Circuit Installation Instructions, Section A, given on page 5-10.

IC Part Numbers	
( ) B,D,E,F,H,K,M	7407
( ) U,W,Y,V1,Z1	7405 or 74LS05
( ) C1,N1,F1,U1, G1,W1,H1,Y1	74LS175
( ) L1,M1	74LS74
( ) K1	74367 or 8097 or 8T97
( ) R,S	8T98
( ) P	7493
( ) P1,Z	7400 or 74LS00
( ) C,J1,E1,R1	74LS04
( ) A1	74LS14
( ) J	74L10
( ) V,D1,T1	7410 or 74LS10
( ) X1,N	74LS30 or 74L30
( ) L,X	4040
( ) S1	4009, 4049 or 4449



5-11. Display/Control IC Installation

5-22. RESISTOR INSTALLATION  
(Figure 5-12, page 5-24)

There are 76 resistors (Bags 2, 3 and 4) to be installed on the Display/Control Board. Install these resistors according to the Resistor Installation Instructions given on page 5-6.

NOTE

Save any excess resistor leads for jumper connections in Paragraph 5-24 and for ferrite bead installation in Paragraph 5-28.

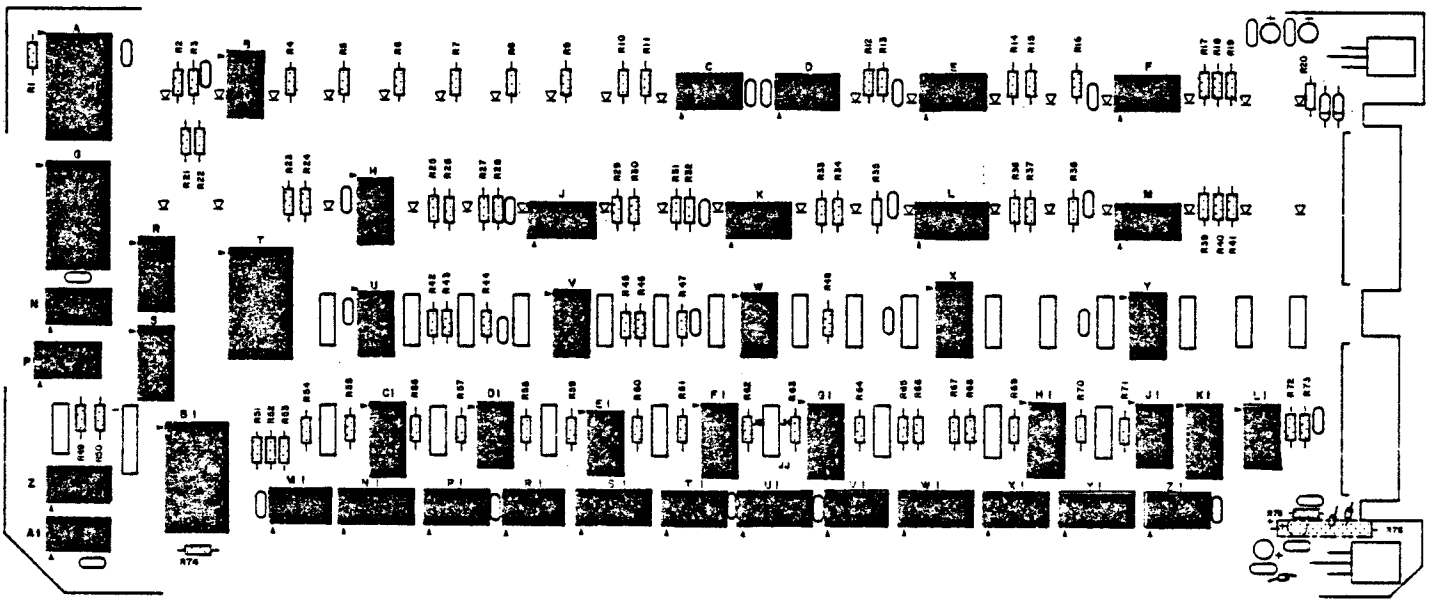
Do NOT install R76 at this time.  
It will be installed on the back of the board when the Voltage Regulator installation (page 5-30) has been completed.

Resistor Values	
( ) R2-R19, R21, R22, R24-R26, R28-R30, R32-R41, R73	220 ohm (red, red, brown) 1/2W
( ) R50, R75	100 ohm (brown, black, brown) 1/2W
( ) R66	470 ohm (yellow, violet, brown) 1/2W
( ) R20	1K ohm (brown, black, red) 1/2W
( ) R1, R23, R27, R31, R42-R49, R51-R65, R67-R72, R74	2.2K ohm (red, red, red) 1/2W
( ) R76	5 ohm (wire wound resistor; has no color codes) 5W*

\* Due to supply variations, the 5 ohm, 5 watt resistor supplied with your kit will be one of three sizes:

- a) Diameter = .22", length = .7"
- b) Diameter = .17", length = .9"
- c) Diameter = .3", length = .9"

Size "A" and size "B" resistors should be installed on the back of the board in the position shown on the silkscreen. Size "C" resistors should also be installed on the back of the board, however, the resistor leads must be left long enough so that the resistor will fit underneath the mother board. The resistor can be positioned correctly by holding the Display/Control Board vertically against a table top and bending the resistor down until it is flush against both the board and the table top. Be sure to insulate the resistor leads with tubing so that there are no bare leads exposed. Be especially careful to see that the resistor lead cannot short to the mounting screw of the 5 volt regulator.



### 5-12. Display/Control Resistor Installation

#### 5-23. RESISTOR PACK INSTALLATION (Figures 5-13 and 5-14)

According to supply variations, your kit will contain either one resistor pack, RP1 (Bag 2), or 5 individual 4.7K-ohm resistors to be substituted for RP1.

**NOTE**

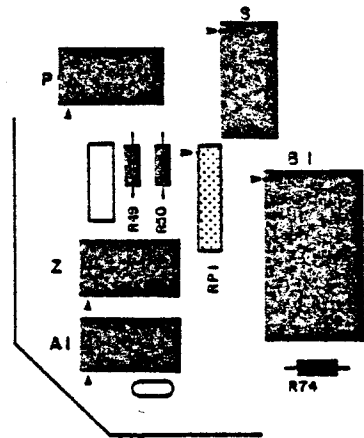
It is necessary to clip off the last three leads on the resistor pack at the end furthest from the small dot. There are no holes on the PC board for these leads, and these three resistors are not used.

A. Resistor Pack (Figure 5-13). Use the following instructions to install the resistor pack as shown in Figure 5-13.

Resistor Pack	Value
( ) RP1	4.7K ohms

1. The resistor pack has a small dot printed at one end. This dot must correspond with the dot printed on the PC Board. Insert the resistor pack perpendicular to the silk-screened side of the board, aligning the small dots.

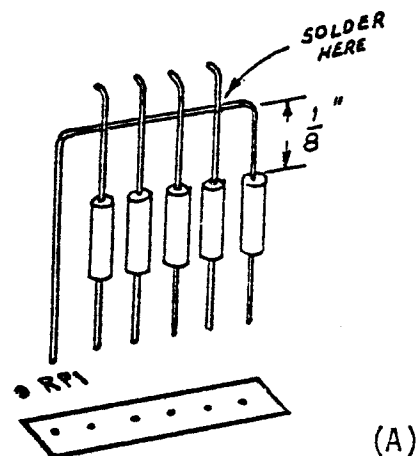
2. Solder each pin of the resistor pack to the foil (bottom) side of the board. Be careful not to leave any solder bridges.



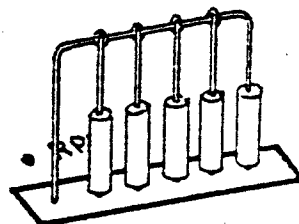
5-13. Display/Control Resistor Pack Installation

- B. Substitute Resistors (Figure 5-14). If your kit is not supplied with a resistor pack, use the following instructions to install the 5 substitute resistors.

1. The resistor pack designation on the silkscreen has 5 holes. The left-most hole is marked on the silkscreen with a small dot. Vertically insert one resistor into the right-most hole on the board. Bend the top lead at a right angle as shown in Figure 5-14A until it is parallel with the board. Then bend the end of the lead at a right angle so that it may be inserted into the left-most hole marked with a small dot.
2. Solder the two inserted leads to the foil (bottom) side of the board.
3. Insert the remaining four resistors vertically into the designated holes on the silkscreen. Solder each of the top leads to the common horizontal lead as shown in Figure 5-14A. It may be helpful to bend the top leads against the horizontal lead for better contact before soldering.
4. Solder the inserted leads of the four resistors to the foil (bottom) side of the board. Clip off all excess leads from the top and bottom of the resistors. The properly completed resistor assembly is shown in Figure 5-14B.



(A)



(B)

5-14. Display/Control Substitute Resistor Assembly



5-24. JUMPER CONNECTIONS (Figure 5-15)

There are two jumper wires to be installed on the Display/Control Board. Use the resistor leads saved from Paragraph 5-22 as jumper wires. Cut two leads to 1-inch lengths and jumper the following pads on the Display/Control Board.

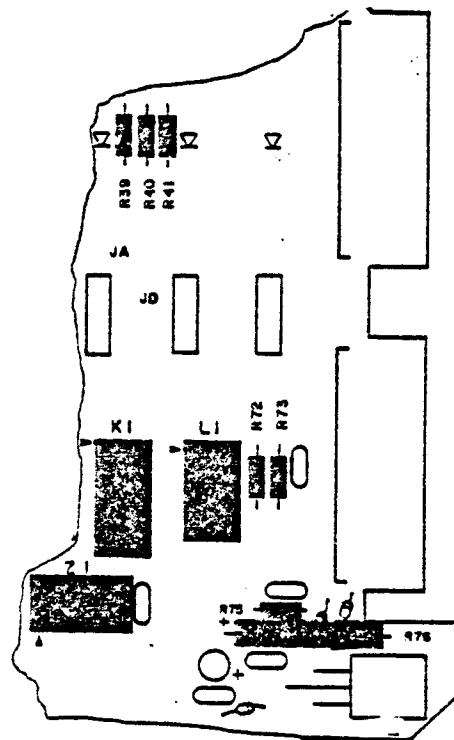
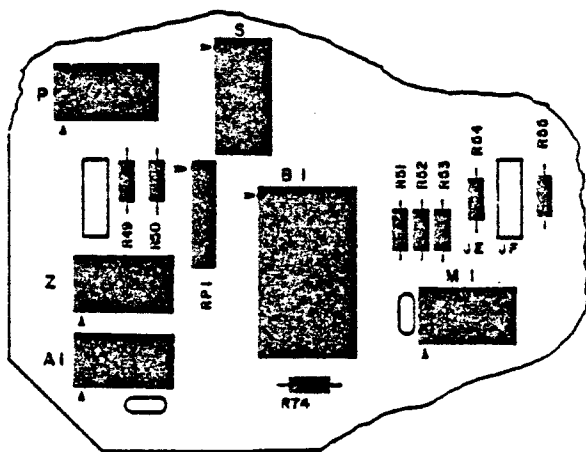
Jumper Connections
( ) JE to JF
( ) JA to JD

**NOTE**

The above jumper connections are used for standard operations. Jumpers JE to JF control SINGLE STEP (and SLOW) operation by causing the machine to execute either a complete instruction cycle or a single machine cycle each time the SINGLE STEP switch is pressed. If the jumper is installed, a complete instruction cycle will be executed. If the jumper is removed, a machine cycle will be executed. Jumpers JD to JA, JD to JB, or JD to JC control the speed of the SLOW function. For a complete description of these jumper options, refer to the Theory of Operation Manual, pages 3-59 and 3-60 and to Figure 3-16 (sheets 1 and 2).

**NOTE**

Do NOT jumper JH, JJ, or JG at this time. These connections are used for special applications concerning the RESET switch. Refer to Figure 3-16, sheet 2 of 3, zone A2. Note that connection JJ to JG is a land on the PC Board.



5-15. Display/Control Jumper Connections