

# LINE PRINTER CONTROLLER

## 88-LPC BOARD Documentation

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THEORY OF OPERATION  
SCHEMATIC DIAGRAM  
ASSEMBLY PROCEDURE  
ADDRESS SELECTION CHART

**mits**

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88-80LP  
 (Line Printer & Controller)  
 Parts List  
 Sept. 1975

BAG 1

1	74L00	101080
2	74L02	101072
4	74L04	101073
1	74L10	101081
1	74L30	101082
1	7472	101026
1	74Ls74	101088
1	74L123	101078
3	8T97	101040
2	8T98	101045
1	7805	101074

BAG 2

4	220 ohm $\frac{1}{2}$ w 5%	101925
4	330 ohm $\frac{1}{2}$ w 5%	101926
1	5.1K ohm $\frac{1}{2}$ w 5%	101944
4	10K ohm $\frac{1}{2}$ w 5%	101392
1	30K ohm $\frac{1}{2}$ w 5%	102089
1	2.2K ohm $\frac{1}{2}$ w 5%	101945

BAG 3

2	.001 uf 10v	100328
17	.1uf 10v	100348
1	10uf 20v	100352
1	30uf 10v	100369

BAG 4

1	Heatsink (Large)	101870
	Molex Connectors:	
3	Right Angle	101812
3	10-pin Plug	101768
30	Terminals	101769
2	37-pin Conn (Female)	102114
1	37-pin Conn (Male)	102115
1	37-pin Bracket	101795
1	37-pin Cover(Plastic)	101799
1	Edge Connector	101864
2	Card Guides	101714

BAG 5

8	1 $\frac{1}{4}$ " Wire	103002
5	#6-32x $\frac{1}{2}$ " Screw	100918
1	#6-32 Nut	100933
1	#6-32 LockWasher	100942
1	Twisted 18 Pr Cable 8 ft	103066
4	4-40x5/8 Screw	100904
4	4-40 Hexnut	100932
4	#4 Lockwasher	100941
1	8" Wire	103041

MISCELLANEOUS

1	PC Board	100179
1	LP Manual	101518
1	Okadata Printer with Controller	101781

# Theory of Operation

The 88-LPC provides communication between the Altair and the 88-LP line printer. The board can be jumpered for any one of 128 addresses and has full hardware interrupt capability. Address 2 should be selected if MITS software compatibility is required.

## I. Device Select Logic

When the CPU executes an I/O instruction (IN or OUT) it places the device address (byte 2 of the instruction) on the 8 lower address bus lines.

The 8 lower address bus lines are fed to IC's P and R. If byte 2 of the I/O instruction is equal to the address selected for the controller board, N-8 goes low, partially enabling M-1 and M-13. N-8 is the board select signal.

The remaining address bit, A<sub>0</sub>, selects either the control channel (M-13) or the data channel (M-1) depending on its state (high or low). If the address selected on the board is 2, 2 will select the control channel (A<sub>0</sub> = low) and 3 will select the data channel (A<sub>0</sub> = high).

## II. Control Channel

An output instruction to the control channel causes the following sequence:

M-13 goes high; SOUT (a CPU status signal indicating an output instruction) pulls D-9 high, D-8 and F-5 go low; soon after the SOUT status goes active, the CPU pulls  $\overline{PWR}$  low, indicating the data on lines D00-D07 is valid;  $\overline{PWR}$  pulls F-9 low and F-8 is low if the print head is at the HOME position (not printing); F-4 forces A-2 and A-13 high and G-1 low. (see timing diagrams)

The effect of the data from the accumulator follows (data lines D00-D05):

<u>Data Bit</u>	<u>Low</u>	<u>High</u>	<u>Function</u>
0		X	PRINT command
1		X	LINE FEED
2		X	CLEAR character buffer
3	X	X	Disable Interrupt Enable Interrupt
4			Not used
5			Not used

An input instruction from the control channel disables D-8 and enables D-6 with the SINP status signal and thus enables T1. (see timing diagrams) The status information that will be entered into the CPU accumulator follows:

<u>Data Bit</u>	<u>Low</u>	<u>High</u>	<u>Function</u>
0		X	Printer buffer is empty. (Note that this signal goes active <u>after</u> the first character has been output to the printer and inactive after the 80th character has been sent.)
	X		Buffer full
1		X	Not printing
	X		Print head in motion
2		X	Paper feeding normally
	X		Paper has jammed
3		X	Line Feed will be accepted if print head not in motion
	X		Line Feed is taking place

#### A. Interrupt

If D03 is low during an output to the control channel, A-1 goes high and A-3 low, flipping A-6 high and A-8 low (gates A-6 and A-8 are an RS flip-flop), which pulls the data input of D-type flip flop Bb low. After a line has been printed, HOME goes low triggering Cb and clearing Ba.

Ba-5 goes low to clock Bb. The data at Bb-12 will transfer to Ba-9 and invert at K-13 (the interrupt output). Thus if D03 is low, Bb-12 will go low, disabling the interrupt capability. When D03 is high, an interrupt occurs after each line is printed, and reset each time a print command is sent.

#### B. Print Command

A PRINT is issued either via the control channel or automatically when the printer buffer is full (80 characters). When the EMPTY signal returns inactive (the buffer is full), Ba-6 flips low, causing RUN to go low and printing begins.

To print a line of less than 80 characters, D00 of the control channel causes Ba-6 to go low. Ba is cleared as described above in A.

### III. Data Channel

When a character consisting of a 6-bit ASCII word is output to the data channel, it is transmitted to the printer as follows:

With N-8 low (board select) and A0 high (data channel select), M-1 and D-1 go high. D00-D05 are fed through the board via S and J. D-2 goes high with the output status (SOUT) and when data is valid, D-13 goes high (since PWR goes low) causing D-12 and H-5 to go low. This signal, STB, strobes the data on D00-D05 into the 80 character buffer in the printer. The line printer manual contains a chart showing the bit pattern for each character.

### IV. Manual Control

There are two switches on the top, front of the printer labeled LINE and FEED.

LINE: This switch causes the 88-LPC to be active or inactive. When the lamp within the push switch is lit, the 88-LPC is ON LINE, i.e. the computer has control of the printer.

FEED: This switch is used for manually advancing the paper. Each time it is pressed, the paper will feed one line. If the switch is held down, a line feed will occur approximately once every 100 milliseconds. Note that this switch works only when the printer is OFF line.

## V. Operating Procedure

- 1) Insert 88-LPC in Altair and connect to the line printer.
- 2) Turn Altair on.
- 3) Turn Line Printer on (on-off switch is on the left, back panel).
- 4) Depress FEED - paper should advance freely.
- 5) Depress LINE - light should come on.

On the next page is a test program that should print one complete line of each of the 64 characters. Note that one line will be blank (space = 100000). Note also that this test uses addresses 2 & 3 (as noted by \*).

- 6) PAPER: We recommend using 20 lb., 4-part paper with 9-inch spacing between holes.

LINE PRINTER TEST PROGRAM

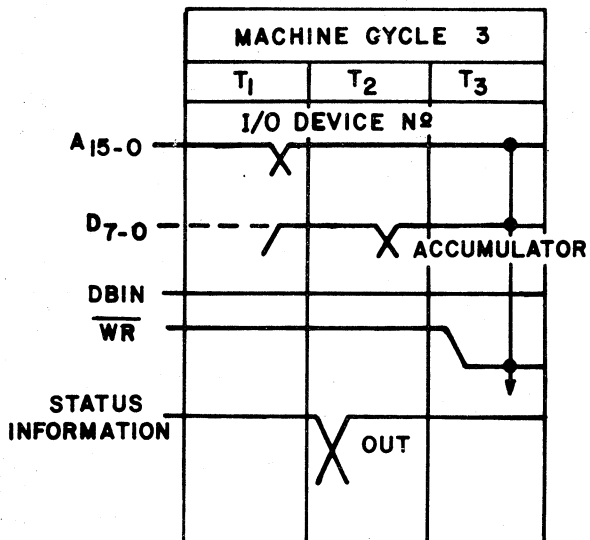
(Prints 64 lines - one of each character)

LOCATION	INSTRUCTION	REMARKS
0000000	006	
1	000	
2	170	
3	000	fill buffer with 80 identical characters (B register)
4	323	
5	003*	
6	333	
7	002*	
10	346	
11	001	
12	302	
13	002	
14	000	← buffer full, printing starts
15	333	
16	002*	
17	346	loop until printing stops
20	002	
21	312	
22	015	
23	000	
24	170	
25	376	if all 64 characters have been printed, then stop
26	077	
27	312	
→ 30	036	
31	000	
32	004	increment B register for next character - go back
33	303	and fill buffer
34	002	
35	000	
36	303	end of program
37	036	
40	000	

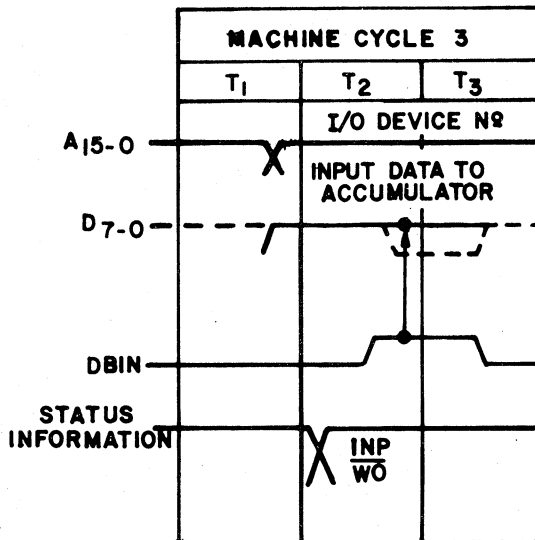
TIMING DIAGRAMS

88-LPC Board

OUTPUT INSTRUCTION



INPUT INSTRUCTION







**88-LPC Board**

**Assembly Manual**

# Assembly Procedure

## Integrated Circuit Installation

There are 17 integrated circuits (IC's) to be installed on the 88-Line Printer Controller Board. **Be certain that you choose the IC with the correct part number as you install each one.**

- ( ) Beginning with IC A -- part number 74L00 -- remove the IC from its holder. If there are any bent pins, straighten these using needle-nose pliers.
- ( ) Orient the IC 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.

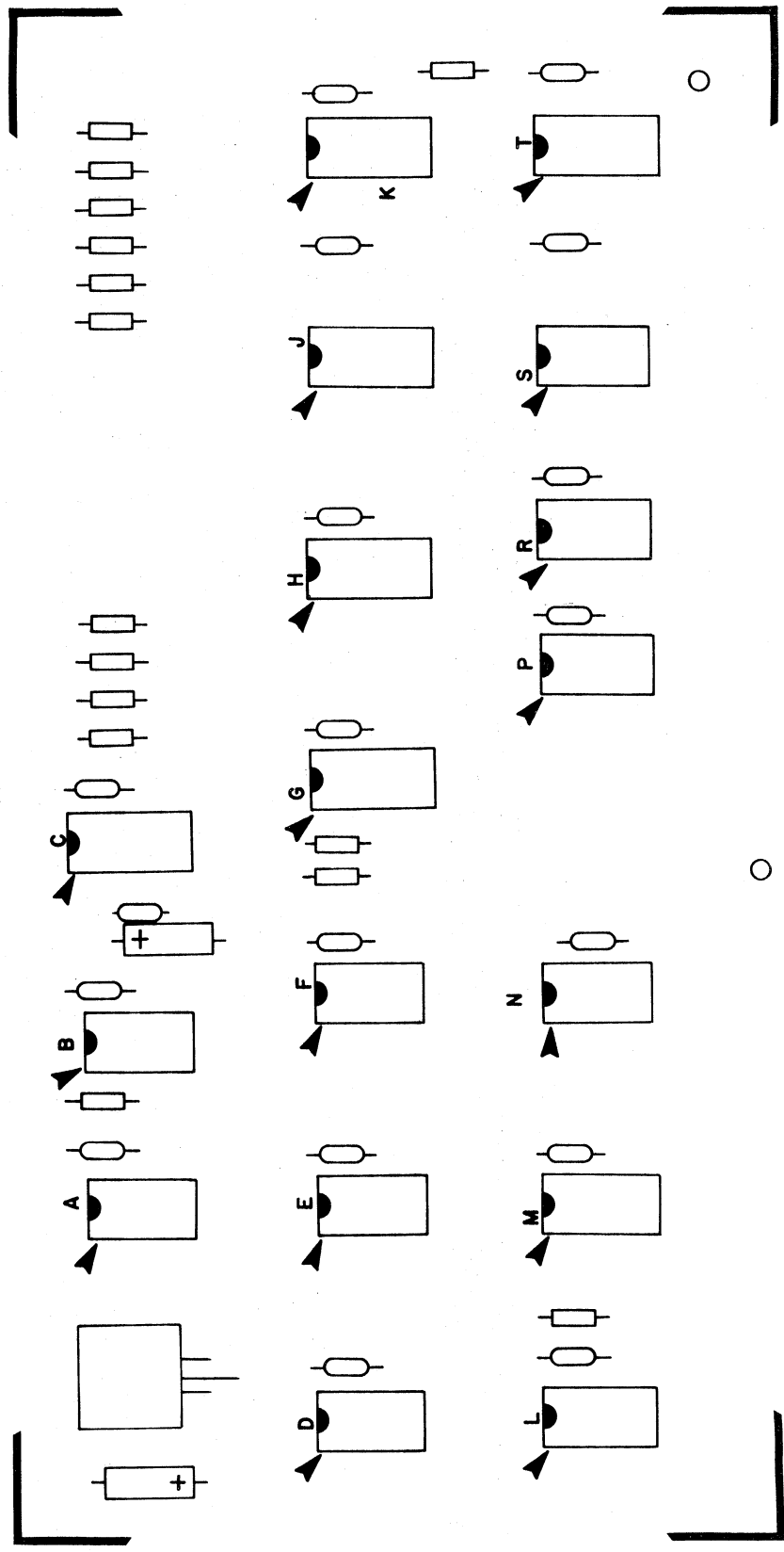
NOTE: If the IC does not have a notch on one end, refer to the IC Orientation Chart included with your manual for the identification of pin 1.

- ( ) When you have the correct orientation, start the pins on one side of the IC into their respective holes on the silk-screened side of the PC board. **DO NOT PUSH THE PINS IN ALL THE WAY.** If you have difficulty getting the pins into the holes, use the tip of a small screwdriver to guide them.

- ( ) Start the pins on the other side of the IC into their holes in the same manner. When all of the pins have been started, set the IC in place by gently rocking it back and forth until it rests as close as possible to the board. Make sure that the IC is perfectly straight and as close as possible to the board; then tape it in place with a piece of masking tape.
- ( ) 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.
- ( ) Turn the board over again and remove the piece of masking tape.

Referring to the component layout, use the same procedure to install each of the IC's. Be sure that you have the correct part number and the correct orientation as you install each one.

- ( ) IC A is a 74L00
- ( ) IC B is a 74LS74
- ( ) IC C is a 74L123
- ( ) IC D is a 74L10
- ( ) IC's E, P, R & S are 74L04's
- ( ) IC's F & M are 74L02's
- ( ) IC's G, H & T are 8T97's
- ( ) IC's J & K are 8T98's
- ( ) IC L is a 7472
- ( ) IC N is a 74L30



## Resistor Installation

There are 15 resistors to be installed on the 88-LPC board.

NOTE: Resistors are color coded according to their value. The resistors in your kit will have four or possibly five bands of color. The fourth band in both cases will be gold or silver, indicating the tolerance. In the following instructions we will be concerned only with the three bands of color to one side of the gold or silver band. Be sure to match these three bands of color with those called for in the instructions as you install each resistor.

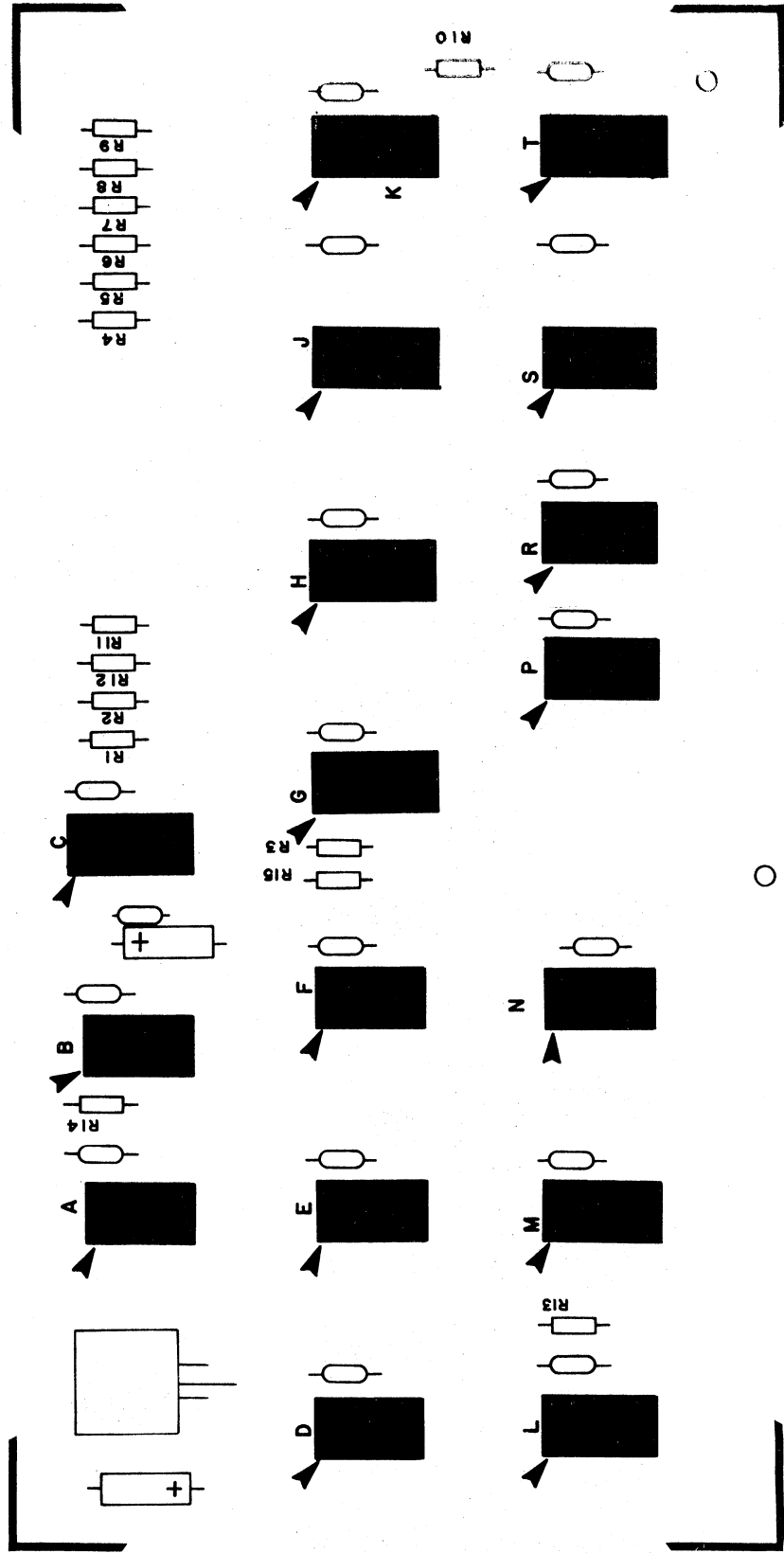
As each resistor is installed, use needle-nose pliers to bend the leads at right angles to match their respective holes on the PC board. (see component layout)

NOTE: All of the resistors on the board will be 1/2W or 1/4W.

- ( ) Install resistor R1 (5.1K ohm, green-brown-gold) into the correct holes on the silk-screened side of the PC board.
- ( ) Holding the resistor in place with one hand, turn the board over and bend the two leads slightly outward.
- ( ) Solder the leads to the foil pattern on the back side of the board; then clip off any excess lead lengths.

Referring to the component layout, install the remaining resistors in the same manner. Be sure you have the correct color coding for each one as you install them.

- ( ) R1 is a 5.1K ohm, green-brown-red
- ( ) R2 is a 30K ohm, orange-black-orange
- ( ) R3, R10, R14 and R15 are 10K ohm, brown-black-orange
- ( ) R4, R6, R8 and R11 are 220 ohm, red-red-brown
- ( ) R5, R7, R9 and R12 are 330 ohm, orange-orange-brown
- ( ) R13 is 2.2K ohm, red-red-red



## Capacitor Installation

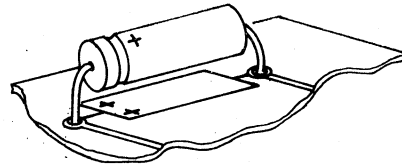
There are 18 ceramic disk and 2 electrolytic capacitors to be installed on the 88-LPC board.

Refer to the component layout and install the ceramic disk capacitors (C3 through C20) according to the following procedure.

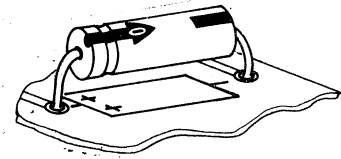
- ( ) Beginning with C3 -- a  $.001\mu\text{F}$  capacitor -- straighten the two leads and align them as necessary to fit their respective holes on the PC board.
- ( ) Insert the capacitor into the correct holes from the silk-screened side of the board. Push the capacitor down until the ceramic insulation almost touches the foil pattern.
- ( ) Holding the capacitor in place, turn the board over and bend the leads slightly outward.
- ( ) Solder the two leads to the foil pattern on the back side of the board; then clip off any excess lead lengths.

Install the remaining ceramic disk capacitors in this manner. All of them (C4 through C20) will be  $.1\mu\text{F}$  in value.

The 2 electrolytic capacitors have polarity requirements which must be noted before installation. The 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 (see drawing):



ELECTROLYTIC  
CAPACITOR



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 is a negative (-) sign and the capacitor must be oriented so the arrow points to the negative polarity side.

Referring to the component layout, install the electrolytic capacitors C1 and C2 on the board.

- ( ) Bend the two leads of capacitor C1 ( $30\mu\text{F}$ ) at right angles to match their respective holes on the board. Insert the capacitor into the holes on the silk-screened side of the board. Be sure to align the positive polarity side with the "+" signs printed on the board.
- ( ) Holding the capacitor in place, turn the board over and bend the two leads slightly outward. Solder the leads to the foil pattern and clip off any excess lead lengths.
- ( ) Install capacitor C2 ( $10\mu\text{F}$ ) in the same manner.

ATTENTION!

SUPPLEMENT to Page 6

- CAPACITOR INSTALLATION -

88-LPC Board Assembly Manual

There is an additional ceramic capacitor to be installed on the 88-LPC board that is not shown on the silk screen. It is .001uF in value and is to be positioned just to the left of IC F.

Take care not to short the leads with any of the lands on the board. Placing masking tape on the board to protect the lands will help prevent this.

- ( ) Insert one of the leads into the hole just opposite pins 2 & 3 of IC F.
- ( ) Insert the other lead into the hole in the large pad of the land that goes to pin 8 of IC F.
- ( ) Complete the installation using the procedure on page 6 for ceramic disk capacitor installation.



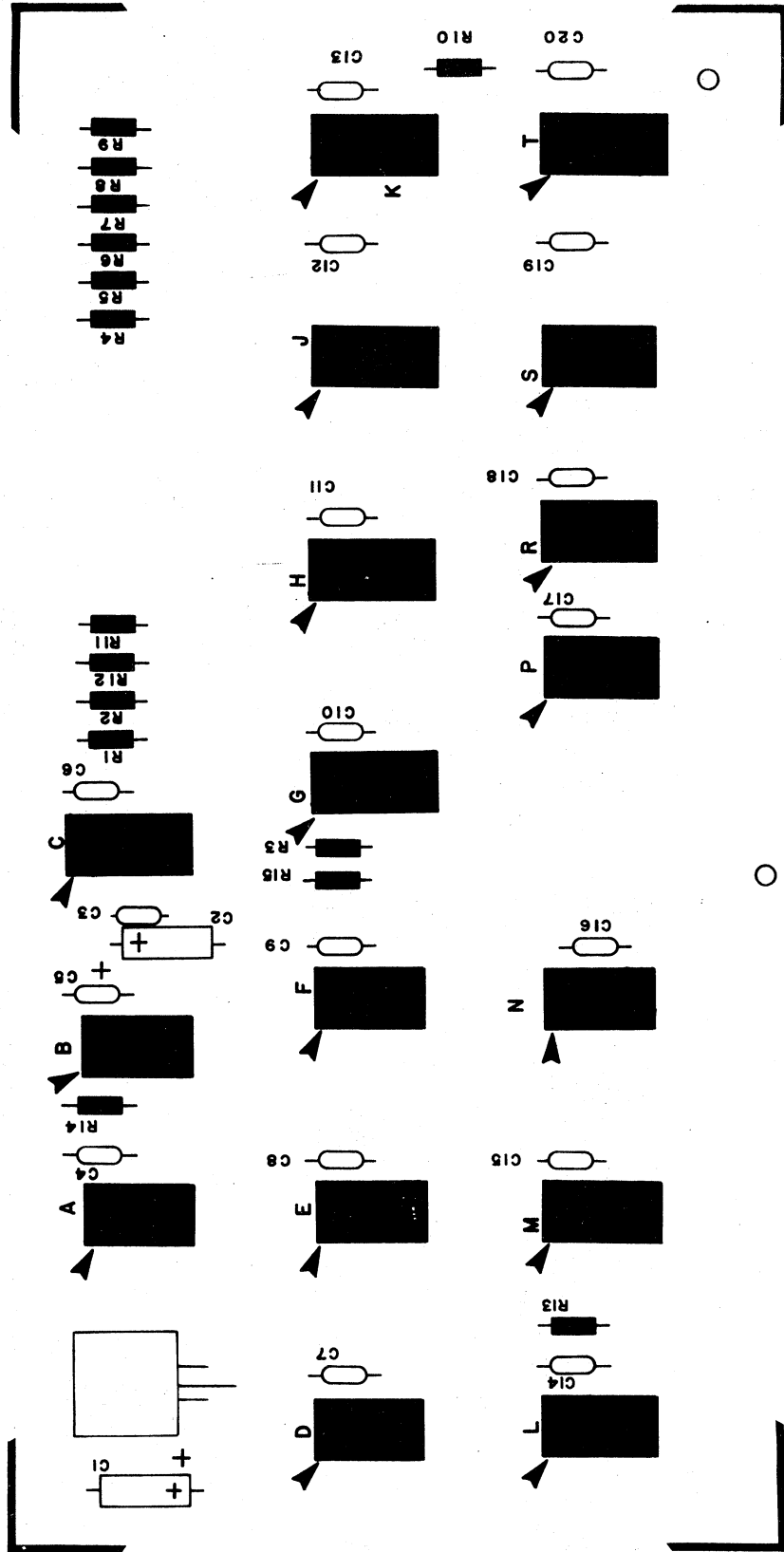


( ) C1 is 30  $\mu$ F

( ) C2 is 10  $\mu$ F

( ) C3 is .001  $\mu$ F

( ) C4 through C20 are .1  $\mu$ F

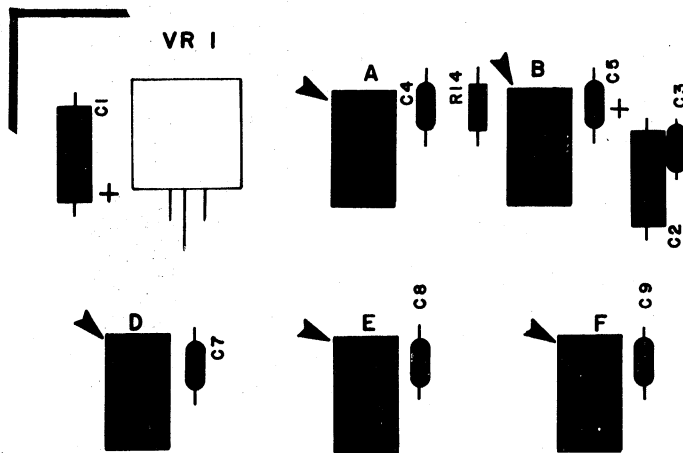
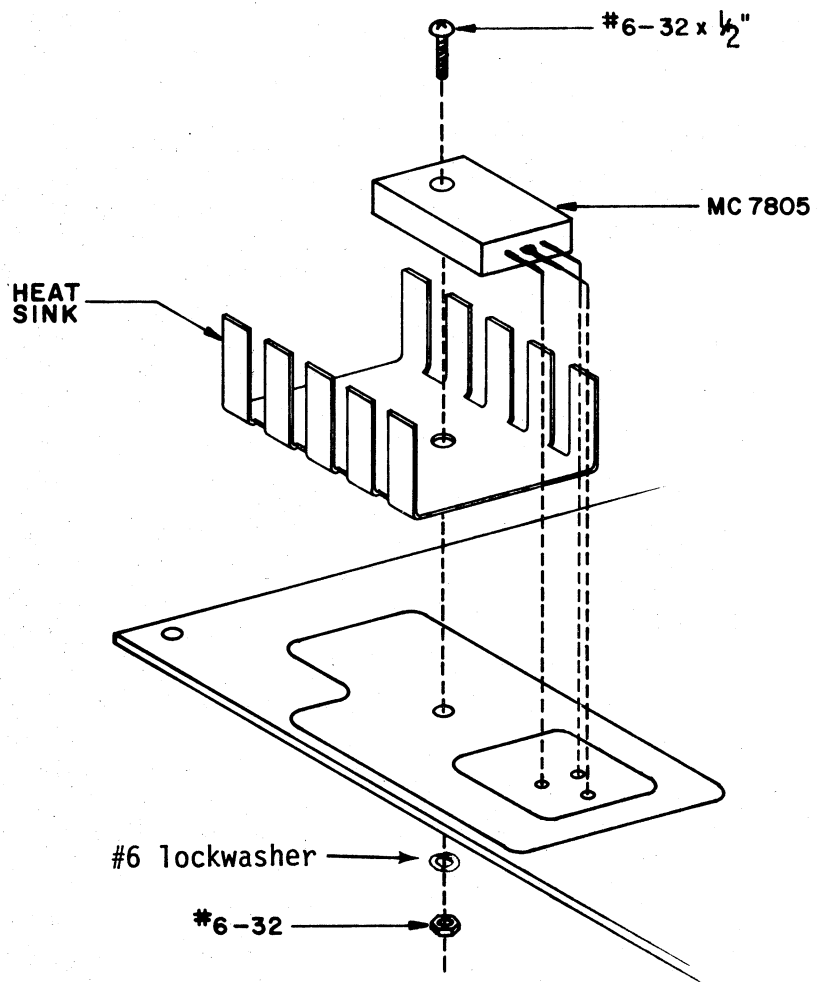


## Voltage Regulator Installation

There is one MC7805 5-volt regulator to be installed on the 88-LPC board.

- ( ) Set the MC7805 in place on the board and align the mounting holes. (see drawing, next page)
- ( ) Use a pencil to mark the point on each of the three leads where they line up with their respective holes on the board.
- ( ) Use needle-nose pliers to bend each of the three leads at a right angle on the points where you made the pencil marks.
- ( ) Referring to the drawing, set the regulator and heat sink in place on the silk-screened side of the board. Secure them to the board using a #6-32 x 1/2" screw and #6-32 nut. Hold the regulator in place as you tighten the nut to keep from twisting the leads.
- ( ) Turn the board over and solder the three leads to the foil pattern on the back side of the board. Be sure not to leave any solder bridges.
- ( ) Clip off any excess lead lengths.

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



## Hardwire Connections

There are seven address selection jumpers and one optional interrupt jumper to be connected on the 88-LPC Board.

- ( ) Prepare seven 1 1/2" wires and one 8" wire by removing 1/8" of insulation from the ends and tinning the exposed portions with a thin coat of solder.

### Address Selection

- ( ) Connect pads E1 through E7 to pads A1 or  $\overline{A1}$  through A7 or  $\overline{A7}$  according to the information in the I/O Address Selection Chart to obtain the octal address listed in the left column.

NOTE: The connections labeled I1 through I7 on the chart correspond to the pads labeled E1 through E7 on the 88-LPC board.

- ( ) Insert the wires into the correct holes from the silk screened side of the board. Be sure not to insert any of the insulated portion into the hole.
- ( ) Turn the board over and solder the wires to the foil pattern on the back side of the board.

Refer to the Theory of Operation section for further explanation of this function.

### Vectored Interrupt

This is an optional function on the 8800 system, and need not be used at all. If it is to be used, it must be used in conjunction with the 88-VI vectored interrupt card. There is one exception to this which will be explained towards the end of this section.

The 88-LPC Board has provisions for vectored interrupt hardwire connections. This provides the user with the option of selecting a priority level for the line printer.

The vectored interrupt offers 8 levels of priority, 0 through 7, with 7 being the highest priority level.

There is a pad below IC T labeled E8 and there are eight pads at the bottom of the board labeled "VI" and numbered "0" through "7." The eight numbered pads correspond to the eight priority levels respectively.

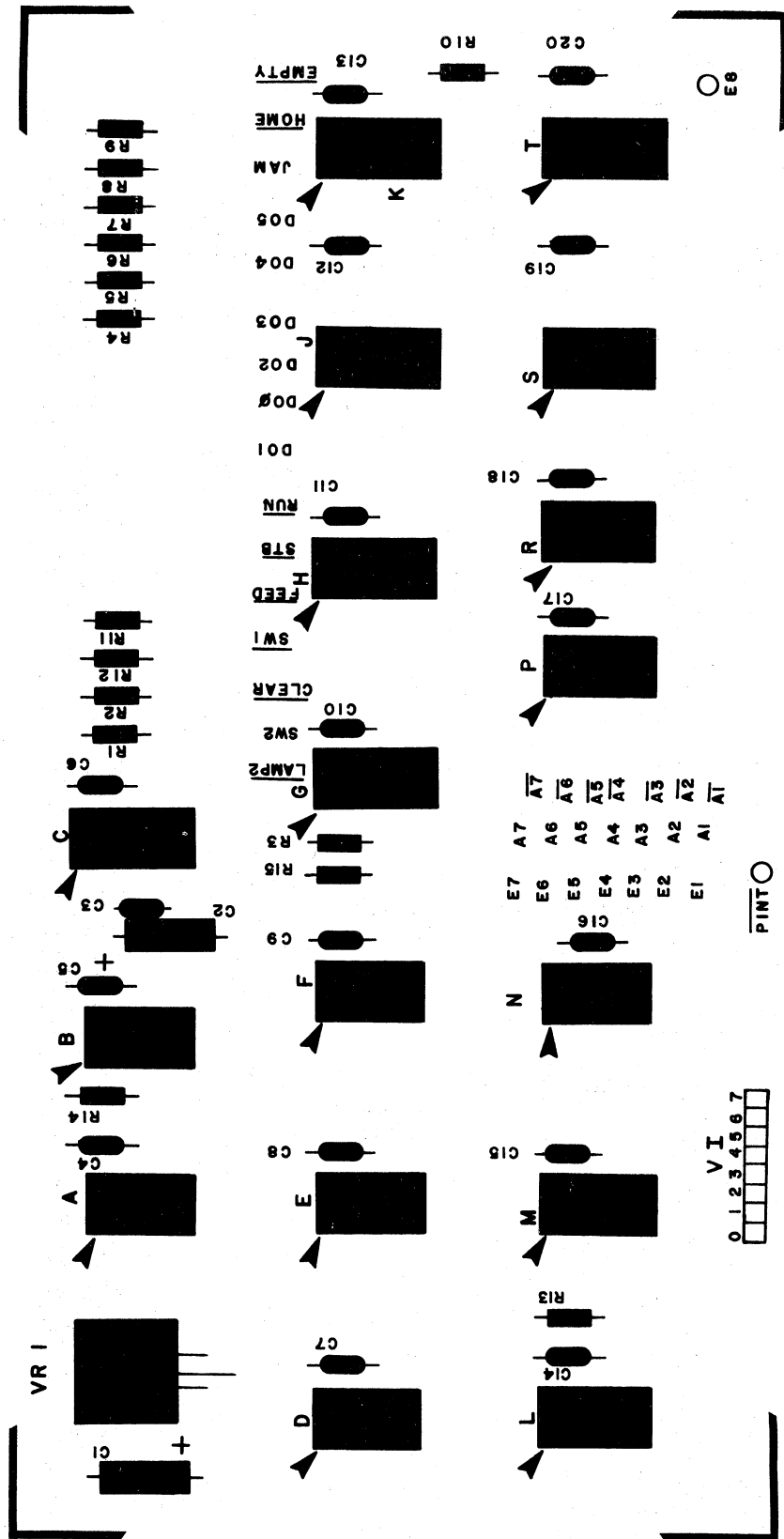
- ( ) Connect pad E8 to the desired vectored interrupt priority by inserting the ends of the 8" wire into the proper holes from the silk screened side of the board. Be careful not to insert any of the insulated portion of the wire.
- ( ) Turn the board over and solder the wire leads to the foil pattern.

It is possible to obtain a single level of interrupt priority on this board without the necessity of the 88-VI Vectored Interrupt card.

This may be used only on one of the I/O cards in your system.

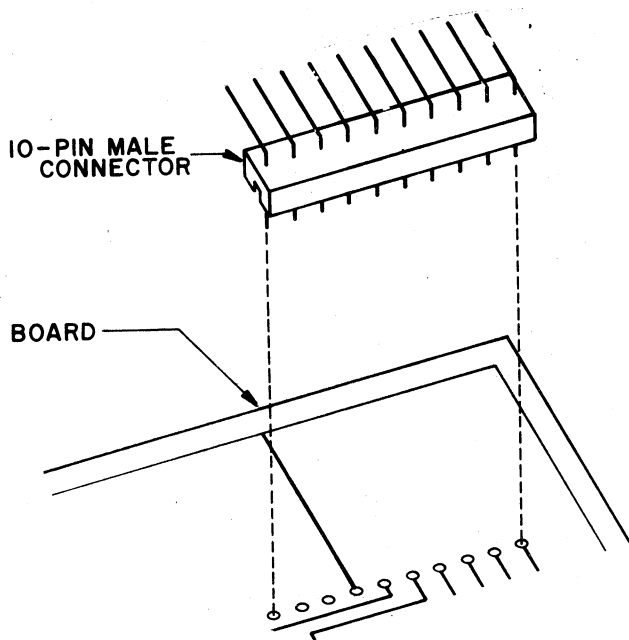
- ( ) To obtain a single level of interrupt priority, use the 8" wire to connect pad E8 to pad PINT, employing the above procedure.

Remember, only one I/O board in your system may be connected in this manner.



## Male Connector Installation

There are three 10-pin male connectors to be installed on the 88-LPC board. The connectors will be installed in the 30 holes on the board labeled LAMP through EMPTY.



- ( ) Referring to the above drawing for proper orientation, install the three 10-pin connectors into the holes from the silk-screened side of the board. Be sure to insert the side with the shorter, straight pins.
- ( ) Holding the connectors in place, turn the board over and solder all 30 pins to the foil pattern on the back side of the board.

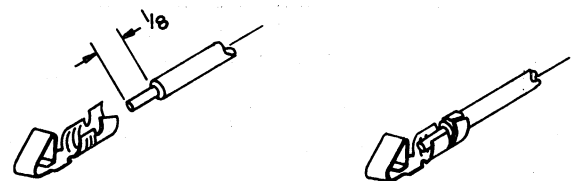
## Cable Preparation

- ( ) Cut a 2-foot length of twisted pair cable from the 8-foot length supplied with your kit. Set the 6-foot piece aside for later use.
- ( ) Take the 2-foot length of cable and place a piece of masking tape around one end, 1" from the end. Put another piece of tape around the sheath, 4" from the other end. Peel the cable sheath back as far as the tape from both ends so that the 18 twisted pairs of wires are exposed.

- ( ) Strip 1/8 inch of insulation from each wire at both ends. Tin all the wires by applying a thin coat of solder at both ends.

## 37-Pin Connector Installation

Select one of the 37-pin female connectors from your kit. This connector is to be wired to the end of the cable that has 1 inch of wire exposed. As you solder each wire to the connector, attach a connector pin (see drawing) to the other end of that wire.



Starting with the twisted pair at one edge of the cable, attach the wires in order, working toward the other edge. The columns on the next page labeled "Colored Wire" and "Black Wire" refer to the two wires that make up each twisted pair. Use the following procedure to solder each wire to its proper pin on the connector. (Seven pins will not be used.)

**NOTE:** These procedures must be done carefully with close attention to detail. You may wish to prop the connector between blocks of wood (or in a vice) so that you will have both hands free while working with the connector.

- ( ) Prepare the connector by heating each pin with your soldering iron and filling the hollow space with solder.
- ( ) Connect the wires to the pins in the order given on the next page. Make each connection by re-melting the solder in the pin, inserting the wire up to the insulation, and removing the heat from the pin while

holding the wire in place until the solder cools. Do not melt any of the insulation.

- ( ) Attach a connector pin to the other end of each wire after it is soldered to the connector. Some of the wires are not used and are to be clipped off at the cable sheath. In these cases, clip off both ends of the wire at the sheath.

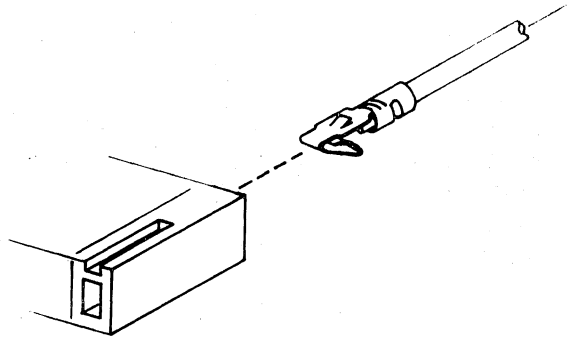
	<u>COLORED WIRE</u>	<u>BLACK WIRE</u>
( ) First twisted pair	pin 1	pin 20
( ) Second twisted pair	pin 2	pin 21
( ) Third twisted pair	pin 3	pin 22
( ) Fourth twisted pair	clip off	clip off
( ) Fifth twisted pair	pin 5	pin 24
( ) Sixth twisted pair	pin 6	clip off
( ) Seventh twisted pair	pin 7	pin 26
( ) Eighth twisted pair	pin 8	pin 27
( ) Ninth twisted pair	pin 9	pin 28
( ) Tenth twisted pair	pin 10	pin 29
( ) Eleventh twisted pair	pin 11	pin 30
( ) Twelfth twisted pair	clip off	clip off
( ) Thirteenth twisted pair	pin 13	clip off
( ) Fourteenth twisted pair	pin 14	pin 33
( ) Fifteenth twisted pair	pin 15	pin 34
( ) Sixteenth twisted pair	pin 16	pin 35
( ) Seventeenth twisted pair	pin 19	pin 36
( ) Eighteenth twisted pair	pin 18	pin 37



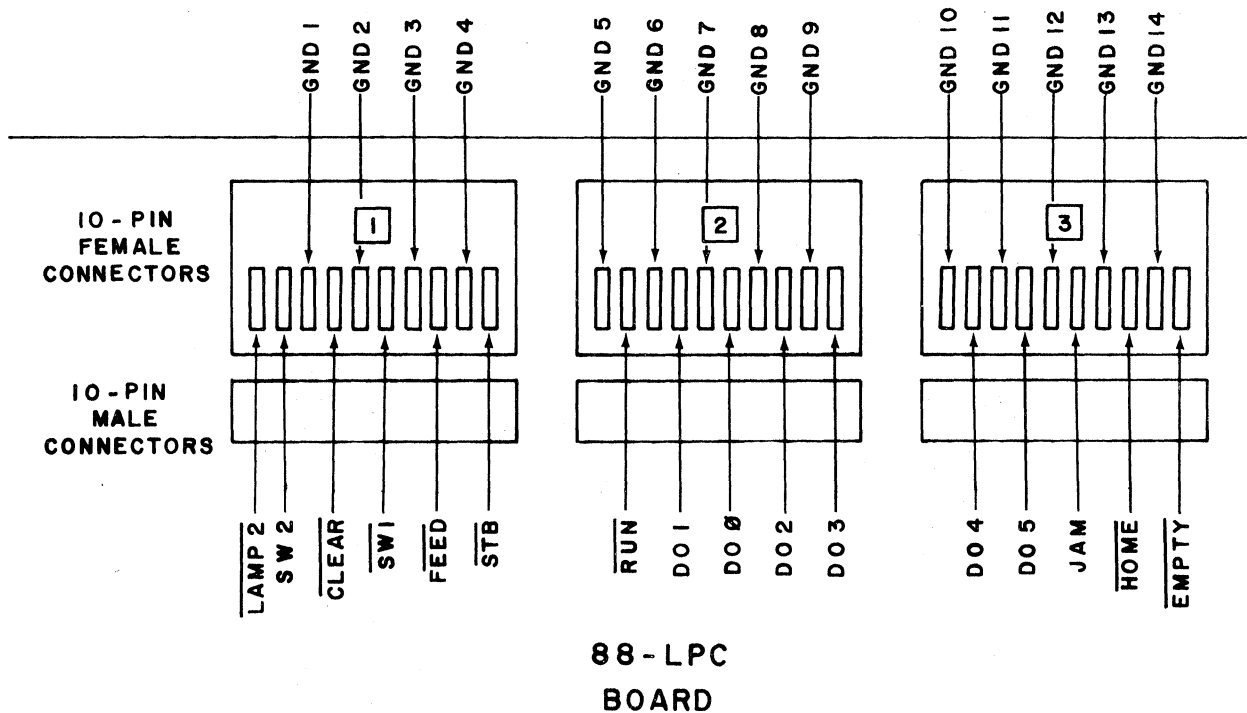
## Wire 10-Pin Female Connectors

The connector pins you have attached to the 4-inch exposed wires will be inserted into the three 10-pin female connectors, as shown in the drawing, right.

Each of the holes on the female connectors will correspond to a labeled connection on the board or to a ground connection. The identification of each hole is indicated with an arrow in the diagram below. The identification of the correct wire for each hole is indicated on the chart on the next page.



- ( ) Use masking tape to label the three 10-pin female connectors "1", "2" and "3". Orient the connectors as shown in the diagram.
- ( ) Begin at the same side of the cable as before and insert the wires in the same order, beginning with the first twisted pair. As you insert each wire, refer to the diagram and to the chart to make sure you are inserting the wire into the correct hole.

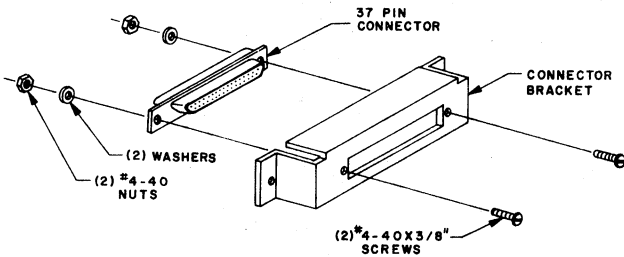


	<u>CONNECTOR #</u>	<u>COLORED WIRE</u>	<u>BLACK WIRE</u>
( ) First twisted pair	1	<u>SWT</u>	GND 2
( ) Second twisted pair	3	<u>HOME</u>	GND 13
( ) Third twisted pair	3	<u>EMPTY</u>	GND 14
( ) Fourth twisted pair	-	clipped off	clipped off
( ) Fifth twisted pair	1	<u>CLEAR</u>	GND 1
( ) Sixth twisted pair	1	SW2	clipped off
( ) Seventh twisted pair	3	JAM	GND 12
( ) Eighth twisted pair	1	<u>STB</u>	GND 4
( ) Ninth twisted pair	2	D01	GND 6
( ) Tenth twisted pair	2	D03	GND 9
( ) Eleventh twisted pair	3	D04	GND 10
( ) Twelfth twisted pair	-	clipped off	clipped off
( ) Thirteenth twisted pair	1	<u>LAMP 2</u>	clipped off
( ) Fourteenth twisted pair	2	D00	GND 7
( ) Fifteenth twisted pair	2	<u>RUN</u>	GND 5
( ) Sixteenth twisted pair	1	<u>FEED</u>	GND 3
( ) Seventeenth twisted pair	2	D02	GND 8
( ) Eighteenth twisted pair	3	D05	GND 11

## Mount 37-Pin Connector

When all of the wires have been connected, the 37-pin female connector will be mounted to the back panel of the Altair with a connector bracket. There are spaces provided on the back panel for mounting 25-pin connectors. The 37-pin connector bracket will mount over two of these spaces on the outside of the back panel.

- ( ) Before mounting the 37-pin connector, first put the cable and the 10-pin female connectors inside the 8800 case by passing them through one of the spaces in the back panel. (Since the bracket covers up two spaces, you will want to choose a space that doesn't have another connector mounted next to it.)

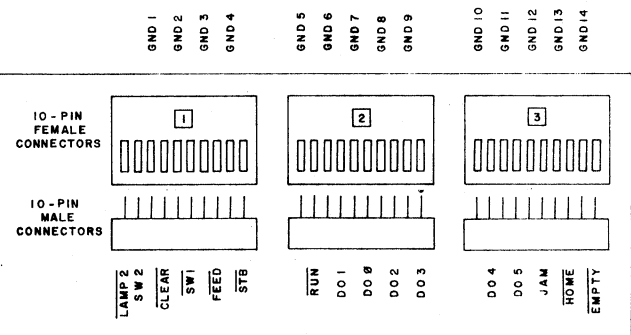
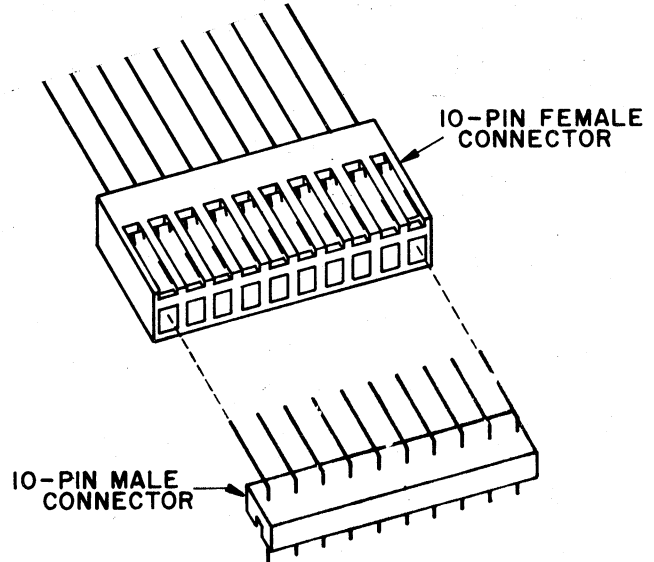


- ( ) Referring to the drawing above, insert the connector into the back of the bracket. Fasten it to the bracket with two #4-40 x 3/8 inch screws, two washers and two #4-40 nuts.

- ( ) Mount the bracket to the back panel using two #4-40 x 5/8 inch screws, two #4-40 nuts and two #4 lock-washers.

## Female Connector Installation

The three 10-pin female connectors must be installed onto the three male connectors on the PC board. Refer to the two diagrams below for proper orientation and correct placement of the connectors.



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- ( ) Install the three female connectors onto the male connectors on the board.

Leave the labels on the connectors for future reference, in case the board has to be removed.

## Line Printer Interconnect

- ( ) To connect the line printer to the Altair, attach the male connector on the 6-foot cable to the female connector mounted on the back panel of the Altair.
  
- ( ) Connect the female connector on the 6-foot cable to the male connector on the line printer. To do this, raise the cover on the line printer case top and remove the platten and pin feed apparatus. Then remove the entire case top by taking out the four screws that hold it in place. The 37-pin male connector is at the front, left-hand side of the line printer. Bring the female connector through the opening in the left side of the case and connect it to the male connector.

NOTE: As you reassemble the case top, make sure you insert the placement pins on the platten into their slots on either side of the line printer. If the platten isn't placed properly, the cover won't close.



