altair T.M. 88-PMC

PROM MEMORY CARD DOCUMENTATION

mits

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mits
2450 Alamo S.E. / Albuquerque, New Mexico 87106

88-PMC

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PROM MEM CARD

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JANUARY, 1976

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88-PMC

THEORY OF OPERATION

Theory of Operation

INTRODUCTION

The 88-PMC is a Programmable Read Only Memory (PROM) card, capable of providing up to 2K bytes of PROM memory using either the 1702 or 1702A type PROMs (8 bits by 256 bytes per PROM).

The card is designed with provisions for switching the V_{GG} power supply to reduce unnecessary power consumption, and it may be set for 0 to 3 wait states to accommodate different speed devices. All of the logic on the card is standard 7400 series TTL, except ICs I, L & K. ICs I & L are quad 2-input NOR gates with high noise immunity hysteresis inputs. IC K is a 6-bit comparator with the B inputs being high noise immunity bus inputs, and the T inputs being standard TTL.

There are four major functional blocks of circuitry on the PROM card:

A) The Address Decoding Circuit
B) The V_{GG} Switching Circuits
C) The PROMs
D) The Wait Circuitry

NOTE: References to integrated circuits shown on the schematic are made by letter to indicate the particular IC and by number to indicate a specific pin on the IC. For example "IC M-6" refers to pin number 6 on IC M.

Reference to a specific gate in an IC will be made by giving the letter of the IC followed by all of the pin numbers associated with that gate, the output pin being the last one. For example, the first NAND gate of IC M (7400) would be "IC M (1,2:3)".

The schematic itself is drawn with input signals entering on the left and output signals exiting on the right. The boxed numbers beside the signals refer to the pin numbers on the 8800 bus.

The following four sections describe the circuitry operation for the four major functional blocks of circuitry listed above. Refer to the schematics on pages 8 & 9 as necessary to follow the text.

ADDRESS DECODING

The 88-PMC decodes a 16 bit address in three phases as follows:

A) Decodes the 5 most significant address bits (A15-A11) to select a particular memory card.

B) Decodes the next 3 address bits (A10-A8) to select a particular PROM on the board.

C) Decodes the 8 least significant address bits (A7-A0) to select a particular byte in the selected PROM.

A) The upper five address bits are decoded by IC K, a six bit comparator (DM8131) with the sixth bit not used. The address lines from the 8800 bus are tied to the B inputs of IC K. The T inputs may be patched to either ground (logic 0) or V_{CC} (logic 1) using the address patching jumpers I1 through I5 and A11-A15 & $\overline{A11-A15}$.

When the address lines A15-A11 on the B inputs become identical with the bit pattern patched on the T inputs, the output line from IC K (K-9) will go active (low). This low signal is defined as Board Select ($\overline{BS}$) and indicates that the particular card has been selected.

B) The address bits A10-A8 are decoded by IC J (74154), a 4 line to 16 line decoder wired for 3 line to 8 line decoding.

The 8 output lines of the decoder (IC J) drive the Chip Select ($\overline{CS1-CS8}$) lines of the eight PROMs (IC A-IC H). This is used to select a particular PROM on the card. The 8 lines are also used to drive the V_{GG} switching circuits which will be discussed in the next section of this text.

C) The 8 least significant address bits (A7-A0) go directly to each of the PROMs in parallel. The decoding here, to a given byte on the selected PROM, is done by the PROM itself.

The final step in decoding is to enable the tri-state data drivers (IC W & IC V) which drive the input data bus lines (DI0-DI7) to the processor. The $\overline{BS}$ signal alone is not sufficient to enable the data drivers since it will be active if either the card is the one selected or if a coincident address input/output device has been selected.

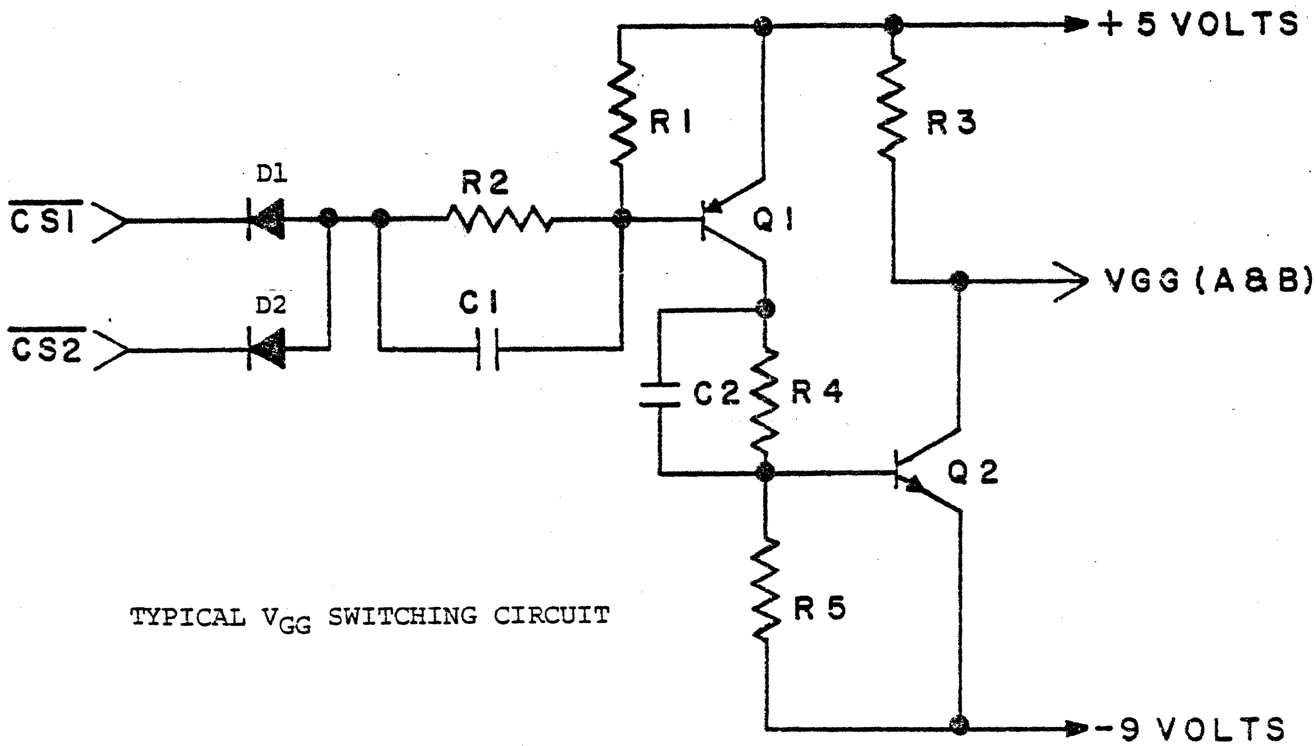
To insure that the card has actually been selected, the logical product of BS & SMEMR is used. SMEMR is the 8080 status signal which indicates the current machine cycle is a memory reference cycle and not an I/O cycle. The active low enabling signal to the data drivers (V-1,W-1) is defined as $\overline{G1}$. $\overline{G1}$ is generated by gating BS and SMEMR together at IC M (9,10:8).

V_{GG} SWITCHING

Both the 1702 and 1702A PROMs have a power down option that can be used to reduce the amount of current drawn from the -9 volt power supply. This feature is implemented by switching the V_{GG} supply voltage to the PROMs between -9 volts for an "on" state to +5 volts for an "off" state. The current (I_{DD}) is reduced from 30-50 ma/PROM when in the on state to 5-10 ma/PROM when in the off state. This switching reduces the -9 volt current drain by as much as 80%.

The V_{GG} switching circuitry is set up to drive the PROMs in pairs. This allows only one pair of PROMs on the card to be in the "on" state at any one time, except for a slight possible overlap during the transition from one pair to another.

The switching is accomplished using a simple two transistor switch, or non-inverting level shifter, with associated components. There are four of these switching circuits on the card, each being identical. The first of these circuits, for PROMs A & B, is shown below reproduced with a slightly different component orientation from the schematic. The remaining three circuits are the same except for the particular PROMs they control.



TYPICAL V_{GG} SWITCHING CIRCUIT

The input to the circuit is the "diode and" product of the first two chip select signals ($\overline{CS1}$ & $\overline{CS2}$) generated by IC J. The output is tied to the V_{GG} input on the first two PROMs (IC A-16 & IC B-16).

When either $\overline{CS1}$ or $\overline{CS2}$ goes low (indicating either the first or second PROM has been selected), Q1 will turn on and cause Q2 to be turned on. When Q2 turns on, V_{GG} (A & B) will be pulled to -9 volts, turning on PROMs A & B. Otherwise, V_{GG} (A & B) will be held at +5 volts through resistor R3. The other three switching circuits control V_{GG} for the remaining PROMs in the same manner.

Typical turn-on time for the circuit is less than 30 nano-seconds. Typical turn-off time is roughly 3 micro-seconds, including the rise time. The turn-on time is fast enough that the overall access time is not affected. The turn-off time is slow enough to allow for momentary changes on address lines A8-A15 without completely turning off the PROM then in use. This might occur in such cases as an INP or OUT instruction being performed, or another board being momentarily addressed.

PROMS

The 88-PMC is designed for use with both 1702 and 1702A type PROMs. These two types of PROMs are interchangeable once they have been programmed. The PROMs themselves, however, are not an inherent part of the kit and must be purchased separately from MITS or supplied by the user.

The PROM card can hold up to eight PROMs, each containing 256 bytes (8 bits per byte). IC A is the first 256 bytes, IC B the second 256, and so on through IC H. This allows a maximum of 2048 bytes of PROM memory per 88-PMC.

The PROMs are connected to the rest of the card as follows.

The lower 8 address lines are bussed to all of the PROMs in parallel. This allows access to any of the 256 bytes within each PROM. The 8 output data lines are also paralleled to the data bus drivers (IC V & IC W).

The data output lines from the PROMs are tri-stated while the $\overline{\text{Chip Select}}$ ($\overline{CS}$, pin 14) input to the PROMs are high. When the card is selected, IC J will select one of the 8 PROMs by pulling its $\overline{CS}$ line low. This will un-tri-state the output drivers for that particular PROM, allowing it to drive the data drivers.

Pin 24 on the PROMs is tied to the -9 volt supply. Pin 16 on the PROMs is tied to the V_{GG} power supply switching circuits discussed previously. The remaining pins are tied to V_{CC} (+5 volts).

More specific information on PROMs supplied by MITS will be supplied with the PROMs themselves.

WAIT CIRCUITRY

The wait circuitry provides for synchronization of the 8080 CPU with different speed PROMs. This is accomplished by allowing the card to insert from 0 to 3 wait states to each machine cycle in which it is accessed.

In general, the following table will apply; where T_{AC} is the total access time for the PROMs being used:

$T_{AC} \leq .5us$	use	0	wait states	(J6-$\overline{QA}$: J7-$\overline{QB}$)
$.5us < T_{AC} \leq 1.0us$	use	1	wait state	(J6-QA : J7-$\overline{QB}$)
$1.0us < T_{AC} \leq .15us$	use	2	wait states	(J6-$\overline{QA}$: J7-QB)
$1.5us < T_{AC} \leq 2.0us$	use	3	wait states	(J6-QA : J7-QB)

The wait circuitry consists of a ripple counter (IC T), an R-S flip-flop (1/2 of IC M) which controls the PRDY line, and the SET-RESET gating to the flip-flop.

If the input signal on IC M-1 is defined to be $\overline{SET}$ and the input signal on IC M-5 is defined to be $\overline{RESET}$, then the gating done by IC P generates the following logical functions:

(Where • = logical AND & + = logical OR)

SET = ϕ1 • PSYNC • BS Where: ϕ1 is the Phase 1 clock from the 8800 bus (#25), PSYNC is the machine cycle sync pulse from the 8800 bus (#76) and BS is the Board Select signal from IC K on the card.

RESET = R1 + R2 + R3 Where: R1 is the input signal on IC P-1, R2 is the input signal on IC P-13 and R3 is the input signal on IC P-2;

And: R1 = J6 • J7 • Q1 Where J6 & J7 are the patching jumpers to the ripple counter.

R2 = $\overline{SMEMR}$ Where SMEMR is the 8080 status signal indicating a memory reference cycle, input from the 8800 bus (#47).

R3 = POC + PRESET   Where $\overline{POC}$ is the Power-On-Clear signal input from the 8800 bus (#99) $\overline{PRESET}$ is the $\overline{RESET}$ signal input from the 8800 bus (#75).

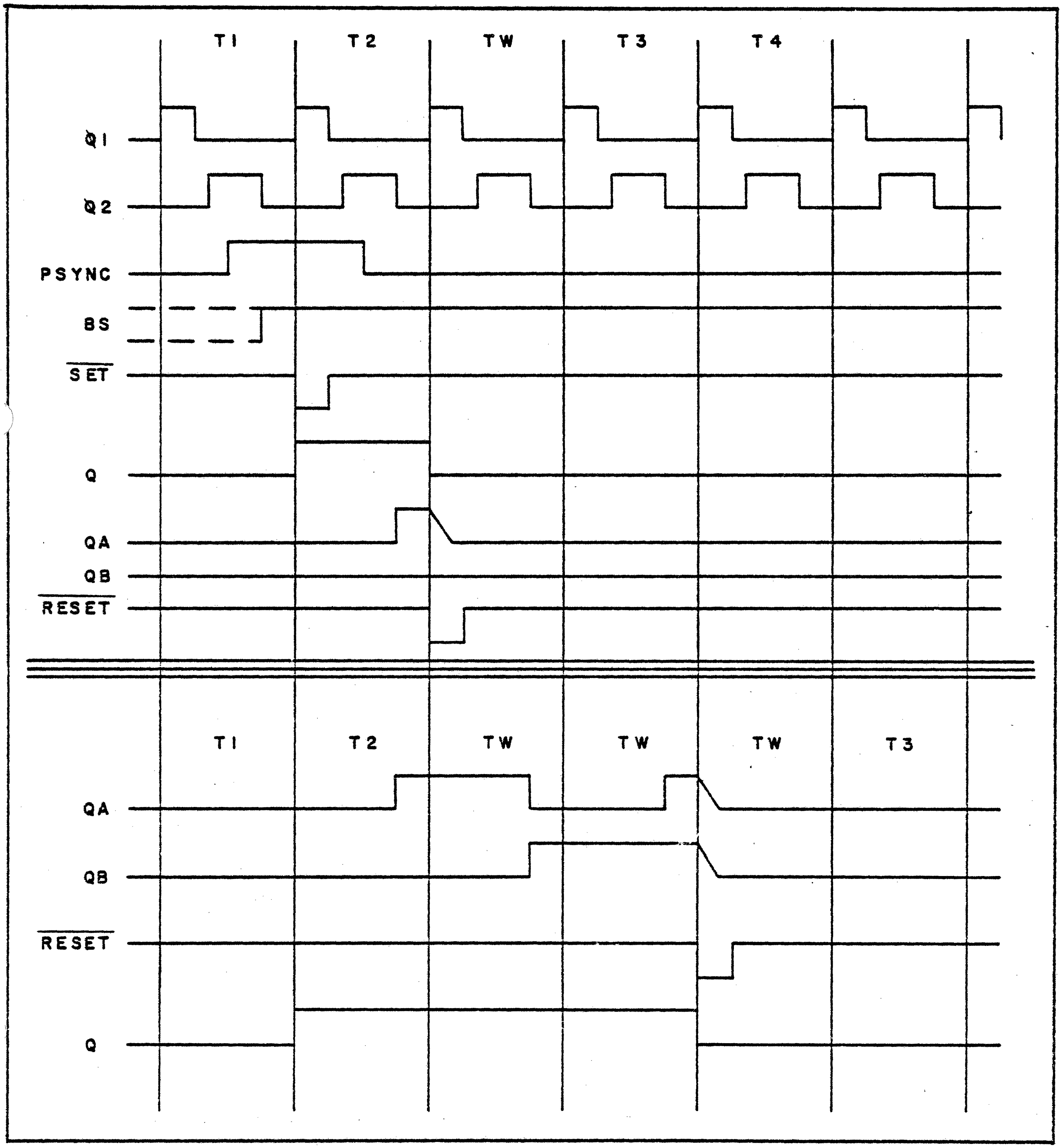
The following description refers to both the schematic and the Wait Circuit Timing Diagram, page 7.

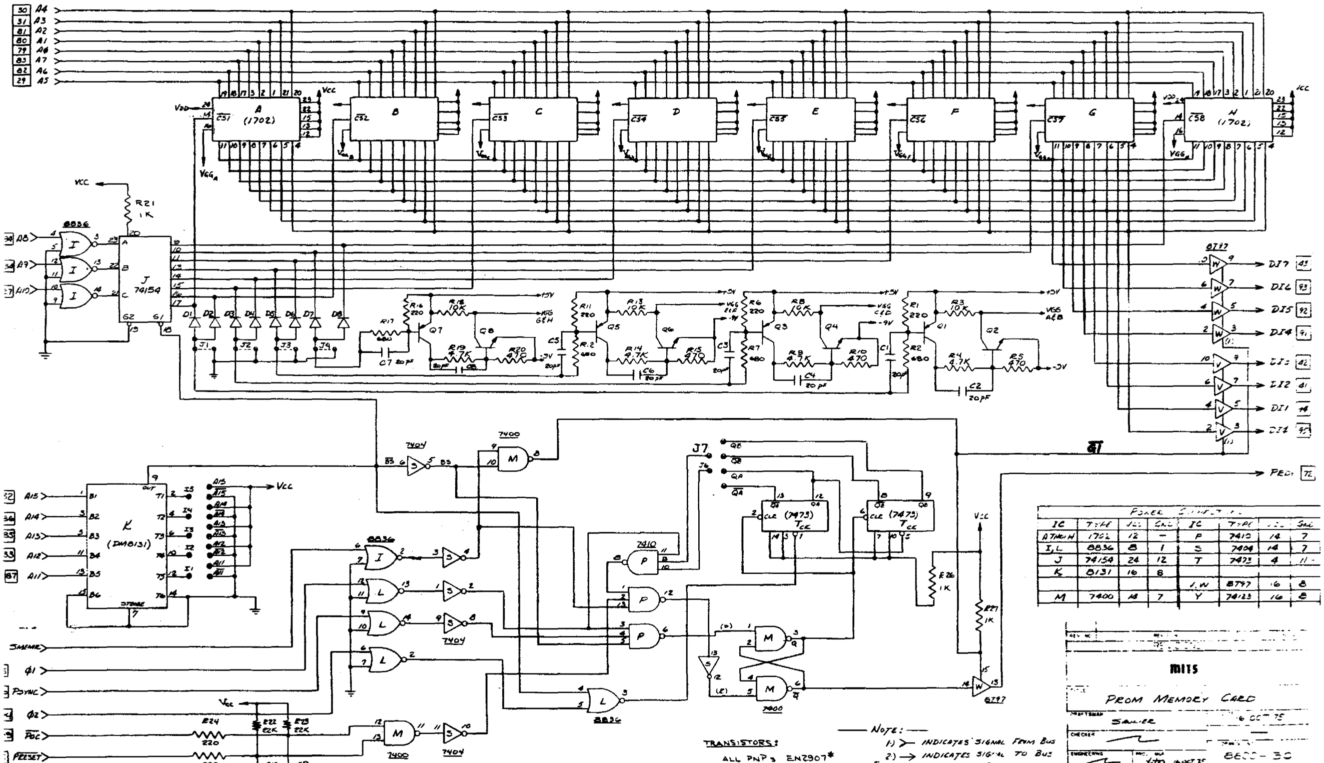
If the particular card has been selected, BS will be true and a $\overline{SET}$ pulse (coincident with but inverted from Φ1) will be transmitted to the R-S flip-flop (IC M-1). When the flip-flop sets, $\overline{Q}$ on IC M-6 will go low and Q on IC M-3 will go high, releasing the clear input to the ripple counter (IC T-2 & T-6).

As soon as $\overline{G1}$ goes active (low) enabling IC W, the $\overline{Q}$ output will be transmitted through IC W (14:13), causing PRDY to be pulled low. This causes the 8080 CPU to enter a series of wait states (.5us each) until PRDY is released.

Since BS is true (high), clocking pulses are being supplied to the input of the ripple counter (IC T-1 : Clock= BS•Φ2); since the clear input has been released, the ripple counter will start to count. It will continue to count until, according to how J6 & J7 are patched, the gate IC P (9,10,11:8) transmits Φ1 as a $\overline{RESET}$ pulse to the flip-flop. When the flip-flop resets, PRDY is released and the counter is stopped by pulling the clear input low.

WAIT CIRCUIT TIMING DIAGRAM





Power Supply							
IC	Type	Vcc	Gnd	IC	Type	Vcc	Gnd
A thru H	1702	12	—	P	7410	14	7
I, L	8836	8	1	S	7404	14	7
J	74154	24	12	T	7475	4	11
K	8131	16	8				
				I, W	8T97	16	8
M	7400	14	7	Y	74123	16	8

TRANSISTORS:

ALL PNPs EN2907*

ALL NPNs CS4410†

*or PN2907 †or 2N4410

NOTE:

1.) ≻— INDICATES SIGNAL FROM BUS

2.) → INDICATES SIGNAL TO BUS

3.) —● ●— INDICATES PATCH POINT

MITS

PROM MEMORY CARD

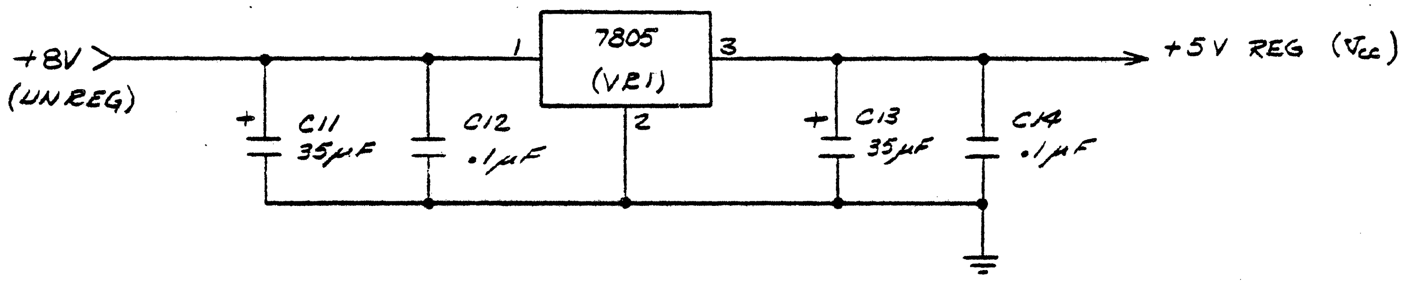
DRAFTSMAN: SALLER 16 OCT 75

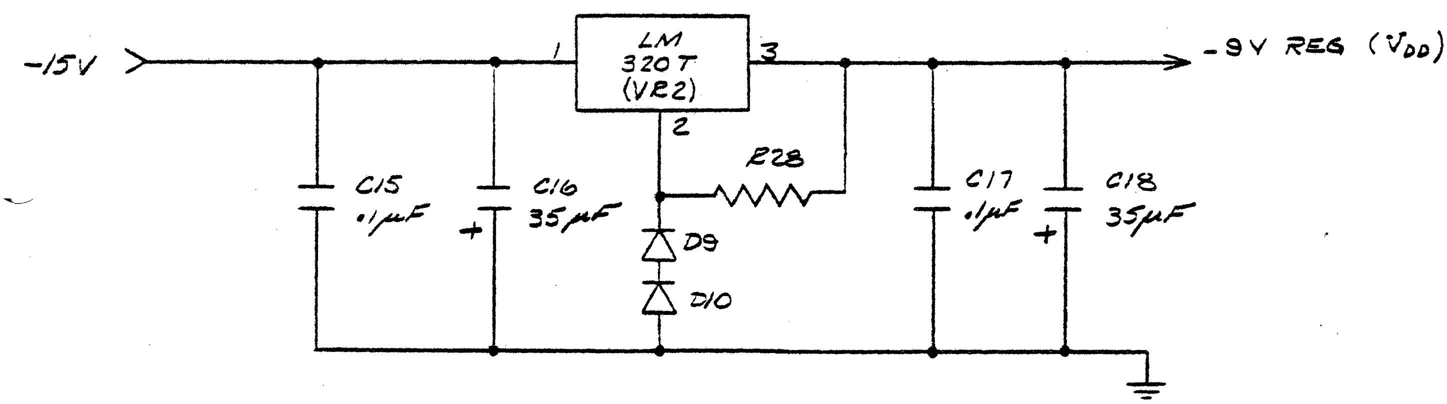
CHECKER

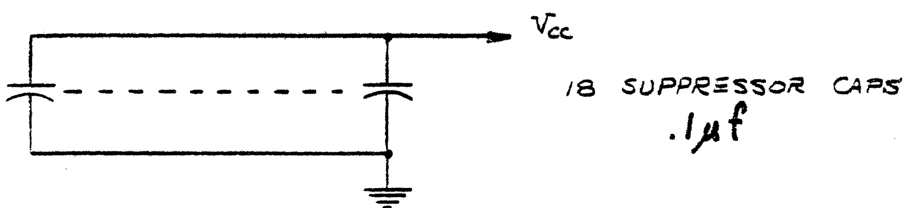
ENGINEERING

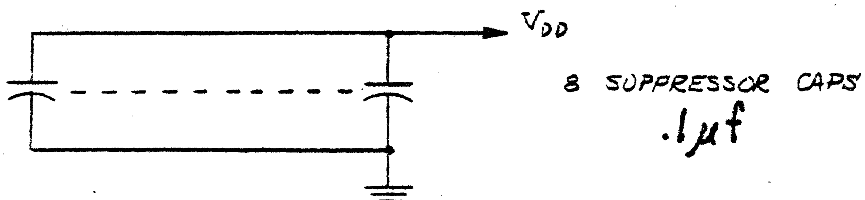
PROJ. MGR. 16 OCT 75

8800-30


+8V
(UNREG)
C11
35μF
C12
.1μF
7805
(VR1)
1
2
3
C13
35μF
C14
.1μF
+5V REG (V_{cc})


-15V
C15
.1μF
C16
35μF
LM
320T
(VR2)
1
2
3
R28
D9
D10
C17
.1μF
C18
35μF
-9V REG (V_{DD})


V_{cc}
18 SUPPRESSOR CAPS
.1μf


V_{DD}
8 SUPPRESSOR CAPS
.1μf

88-PMC

ASSEMBLY PROCEDURE

INTEGRATED CIRCUIT INSTALLATION

To prepare ICs for installation:

Referring to the component layout, remove the IC with the correct part number from its holder. If there are any bent pins, straighten them with a needle-nose pliers. Ensure that you choose the IC with the correct part number as you install each one.

All ICs are damaged easily and should be handled carefully. Always try to hold the IC by the ends, touching the pins as little as possible.

All ICs must be oriented so that the notched end is toward the end with the arrowhead printed on the 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 Orientation Chart included with your manual for the identification of Pin 1.

Install the ICs according to the following procedure:

1. After the IC is correctly oriented, 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.

2. 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 into place by gently rocking it back and forth until it rests as closely as possible to the board. After you are certain that the IC is perfectly straight and as close to the board as possible, tape it in place with a piece of masking tape.

3. 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.

4. Turn the board over again, and remove the piece of masking tape.

Referring to the component layout and the illustration on this page, use the following procedure to install each socket.

1. Be certain that the socket pins are straight. If any of the pins are bent, CAREFULLY straighten them using needle-nose pliers.

2. Set the socket into place and secure it with a piece of masking tape.

3. Turn the board over and solder each pin to the foil pattern of the back of the board. Be sure that EACH pin is soldered, and be careful not to leave any solder bridges.

4. Turn the board over again, and remove the masking tape.

Install all 8 sockets in this manner.

IC Installation

( ) A through H install 24-pin sockets

( ) IC J = 74154

( ) IC I = 8836

( ) IC K = 8131

( ) IC L = 8836

( ) IC S = 7404

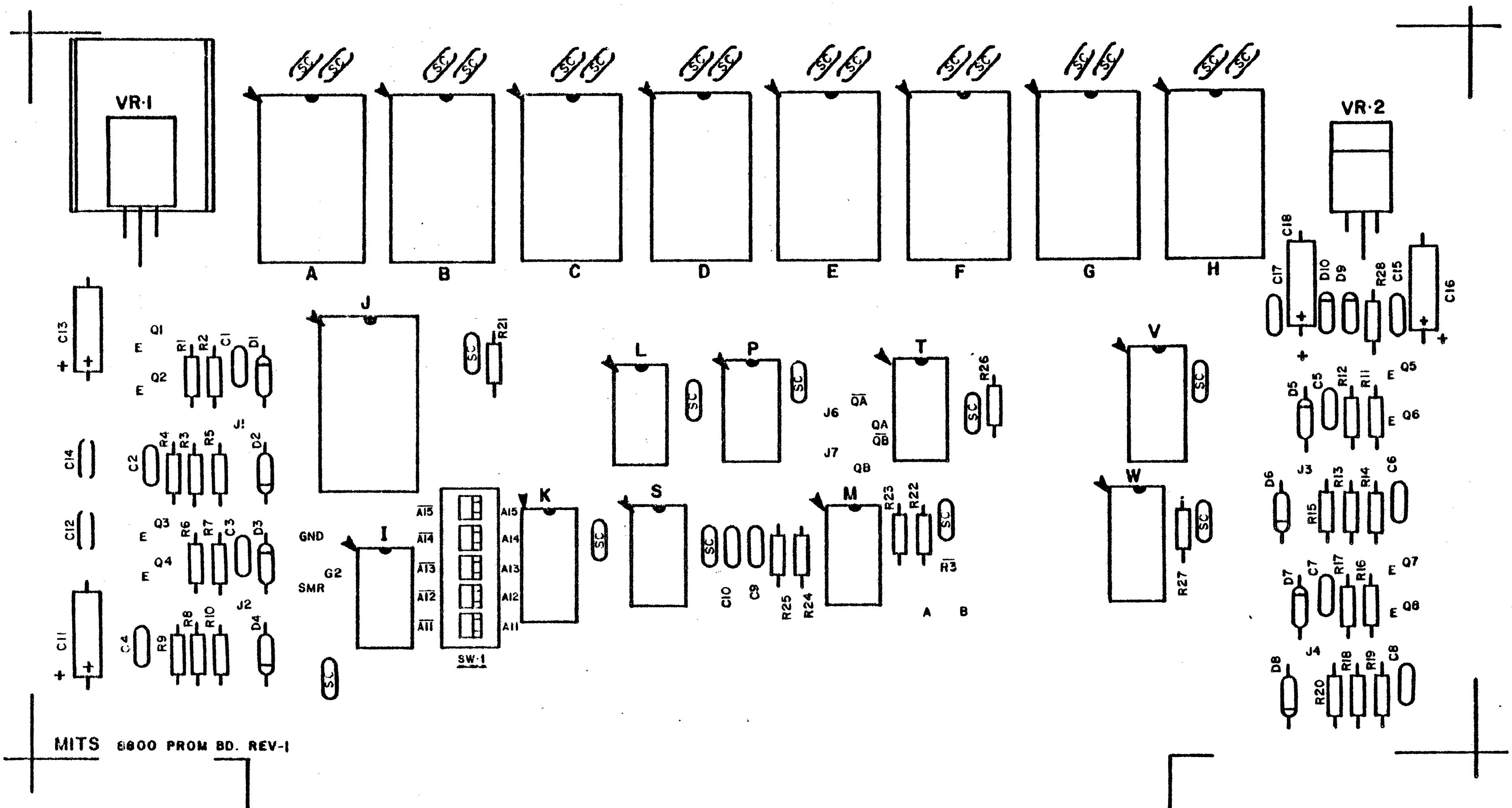
( ) IC P = 7410

( ) IC M = 7400

( ) IC T = 7473

( ) IC V = 8T97

( ) IC W = 8T97



RESISTOR INSTALLATION

There are 28 resistors to be installed on the 8800 PROM 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.

Using needle-nose pliers, bend the leads of the following resistors at right angles to match their respective holes on the PC board. (see component layout)

NOTE: All resistors on the PROM Board may be either 1/4 or 1/2 Watt unless noted otherwise.

( ) Install each resistor 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.

NOTE: Save the component leads that you clip off for use later in the assembly procedure.

Resistor Installation

( ) R1, R6, R11, R16, R24 & R25 are 220-ohm (red-red-brown)

( ) R2, R7, R12 & R17 are 680-ohm (blue-grey-brown)

( ) R3, R8, R13 & R18 are 10K-ohm (brown-black-orange)

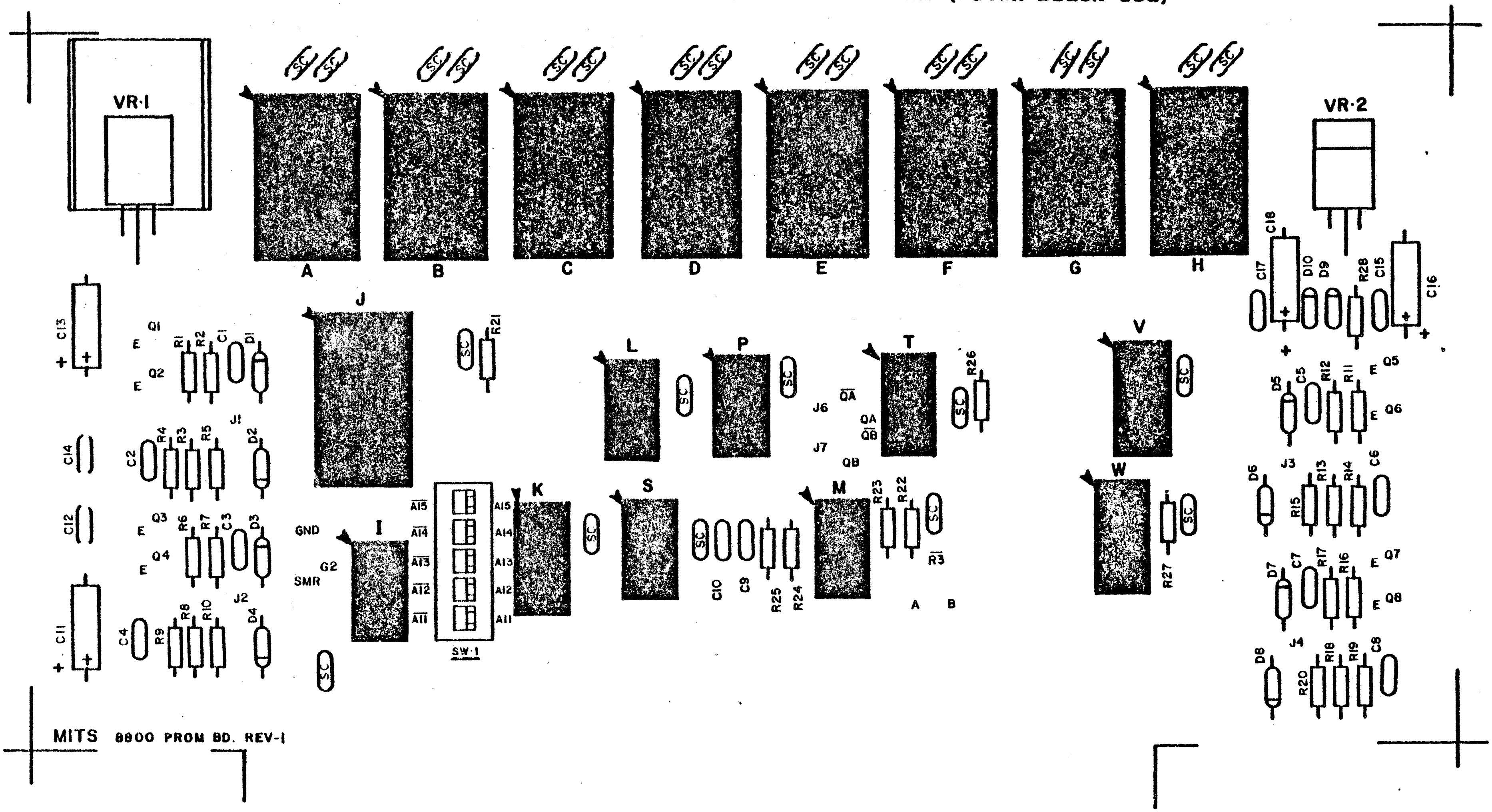
( ) R4, R9, R14 & R19 are 4.7K-ohm (yellow-violet-red)

( ) R5, R10, R15 & R20 are 470-ohm (yellow-violet-brown)

( ) R21, R26 & R27 are 1K-ohm (brown-black-red)

( ) R22 & R23 are 22K-ohm (red-red-orange)

( ) R28 is 1K-ohm (brown-black-red)



CAPACITOR INSTALLATION

There are 40 ceramic disk capacitors and 4 electrolytic capacitors to be installed on the 8800 PROM Board.

Refer to the component layout and install the ceramic disk capacitors according to the following procedure.

( ) Choose the capacitor with the correct value as called for in the instructions. Straighten the two leads as necessary and bend them 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.

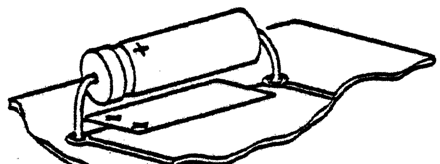
( ) Holding the capacitor in place, turn the board over and bend the two leads slightly outward.

( ) Solder the two leads to the foil pattern on the back side of the board; then clip off any excess lead lengths.

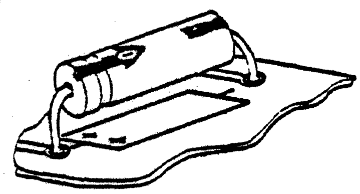
Install all of the ceramic disk capacitors in this manner. Be sure that you have the correct value capacitor as you install each one.

The four electrolytic capacitors for the PROM Board have polarity requirements which must be noted before installation. Those 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 above right)

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.



ELECTROLYTIC
CAPACITOR



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

( ) Bend the two leads of the capacitor with the correct value 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 the remaining electrolytic capacitors in the same manner.

Disk Capacitor Installation

( ) C1 through C8 are 20pf

( ) C9 & C10 are .001uf

( ) C12 & C14 are .luf-12v or 16v

( ) C15 is .luf-50v

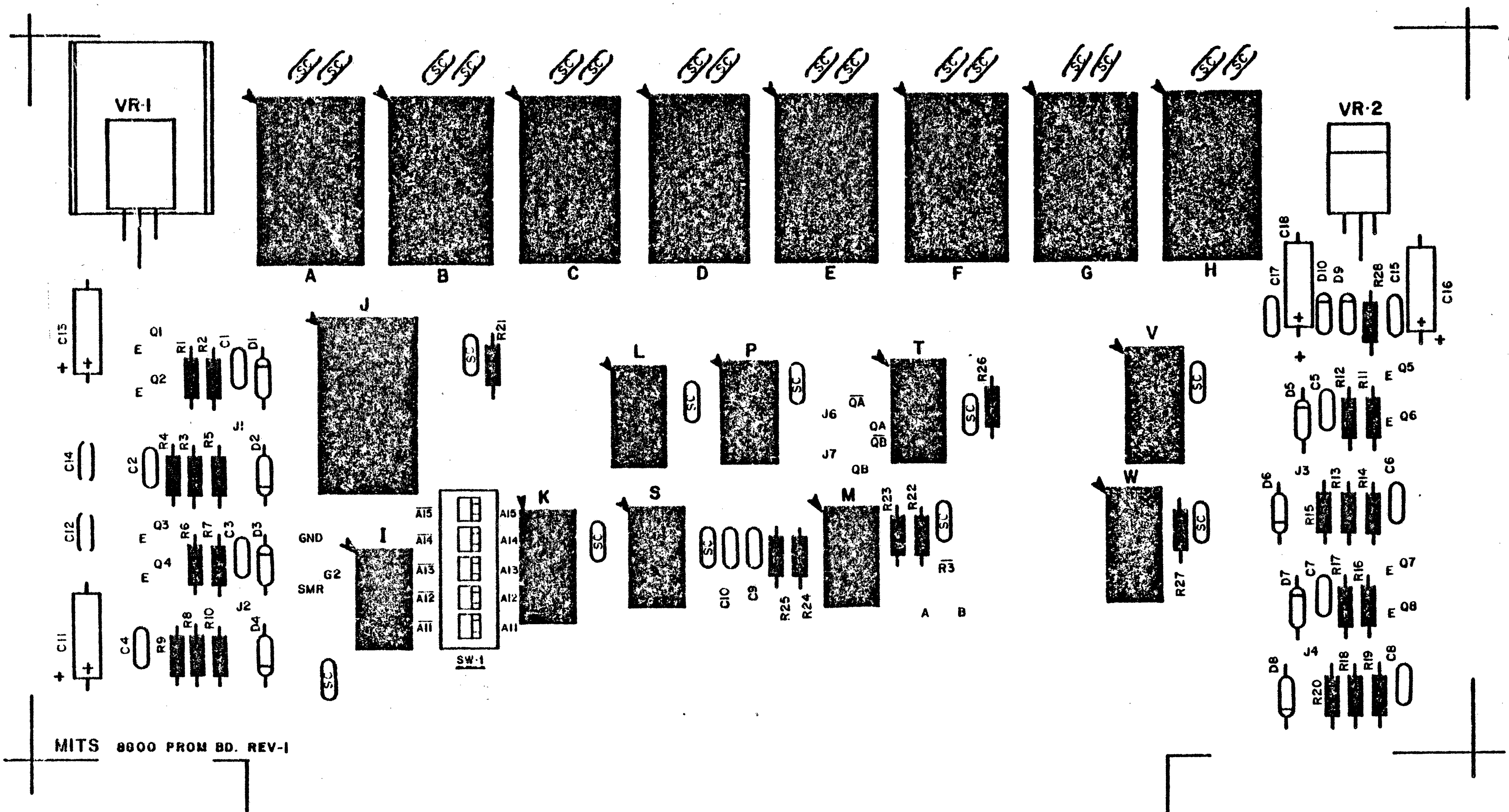
( ) C17 is .luf-16v or 12v

( ) SC capacitors (26) are .luf 12v or 16v

Electrolytic Capacitor Installation

( ) C11, C13 & C18 are 35uf-16v

( ) C16 is 10uf-25v



DIODE INSTALLATION

There are ten 1N914 diodes to be installed on the 8800 PROM Board.

NOTE: Diodes are marked with a band on one end indicating the cathode end. The diode must be oriented so that the end with the band is towards the band printed on the board when being installed.

( ) Referring to the component layout, bend the leads of diode D1 (1N914) at right angles to match the correct holes on the board.

( ) Insert the diode into the correct holes from the silk-screened side of the board. Turn the board over and bend the two leads slightly outward.

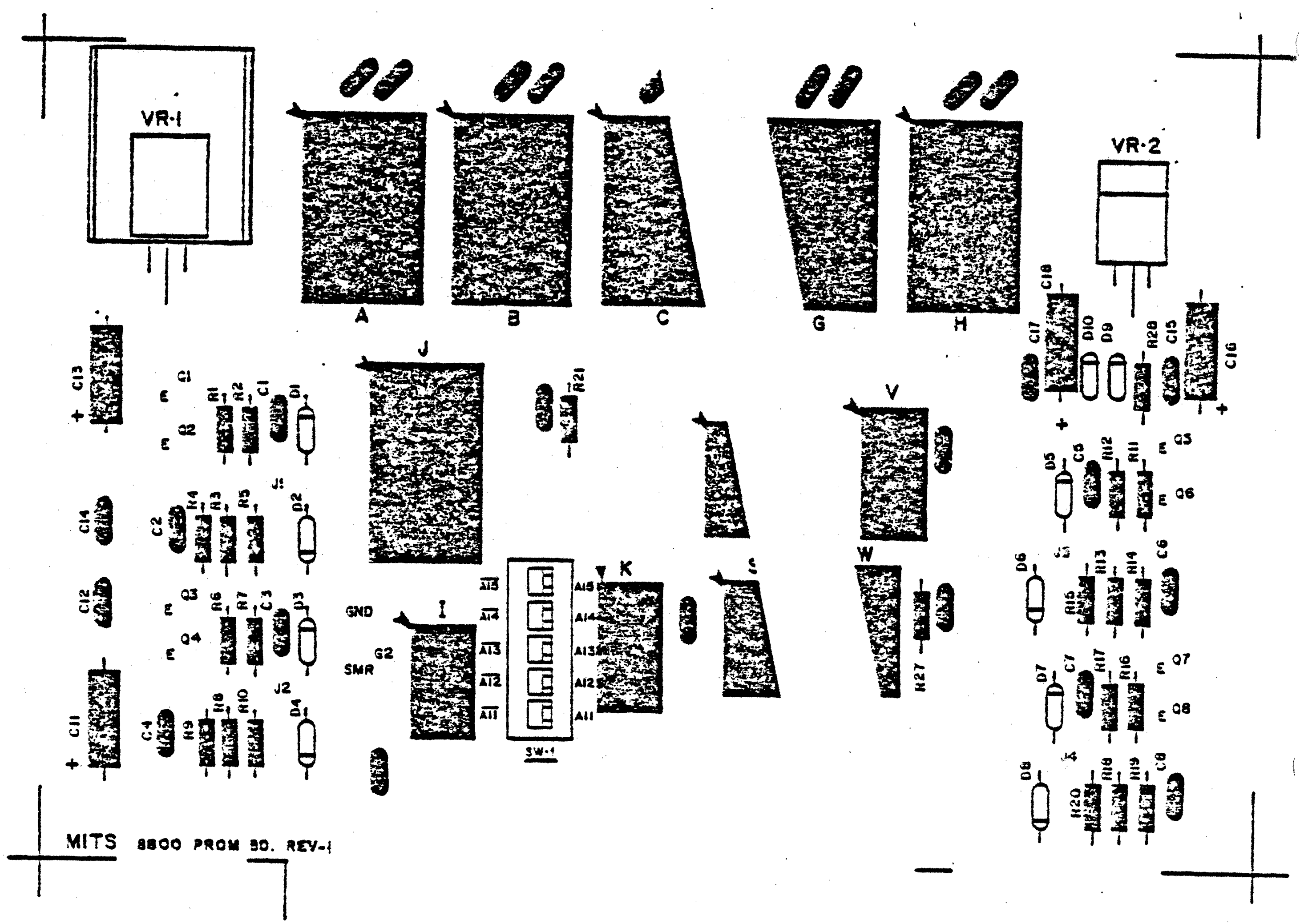
( ) Solder the leads to the foil pattern on the back side of the board; then clip off any excess lead lengths.

Install the remaining 1N914 diodes in the same manner. Be sure that the band on the diode is aligned with the band printed on the board as you install them. Failure to orient these diodes correctly may result in permanent damage to your unit.

NOTE: Save diode leads for later use.

Diode Installation

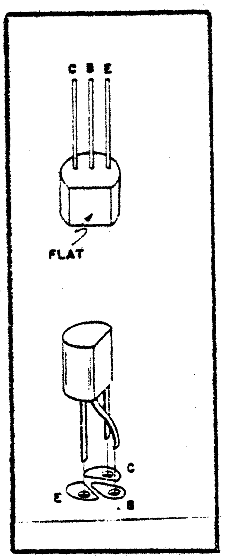
( ) D1 through D10 are 1N914



TRANSISTOR INSTALLATION

There are 8 transistors to be installed on the 8800 PROM Board, 4 PN2907s (PNP) and 4 2N4410s (NPN). Read the following procedure carefully, and be sure you use the correct transistor in each position.

1. Before installing transistors, note its shape and the position of its three leads. Transistors are semi-circular with one flat edge. The three leads of the transistor, base (B), emitter (E), and collector (C) are positioned as in the following illustration.



Note that when you are looking at the flat side of the transistor with the leads pointing downward, the emitter is to the left of the base or center lead and that the collector is to the right of the base lead.

2. The correct hole for the emitter is on the component layout. Orient the transistor so that the emitter aligns with the correct hole on the board. Bend the center lead slightly, toward the flat edge, so that it lines up with its hole on the board.

3. Insert the transistor from the silk-screened side of the board, being careful that the base lead fits easily into its hole. The emitter and collector leads should fit into their respective holes without bending. None of the leads should cross over each other.

4. Holding the transistor in place, turn the board over, and bend the three leads slightly outward.

5. Solder the leads to the foil pattern on the back side of the board. Clip off any excess lead lengths.

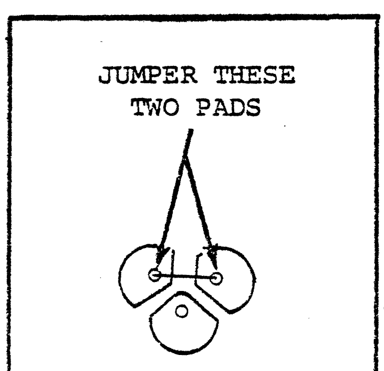
Install transistors Q1 through Q8 (see component layout) according to the above procedure.

Board Modification

There are two sets of transistor pads to the right of resistor R21, just below the socket for IC C, which are not indicated on the silk-screen.

The emitter and collector pads on both of these must be jumpered together.

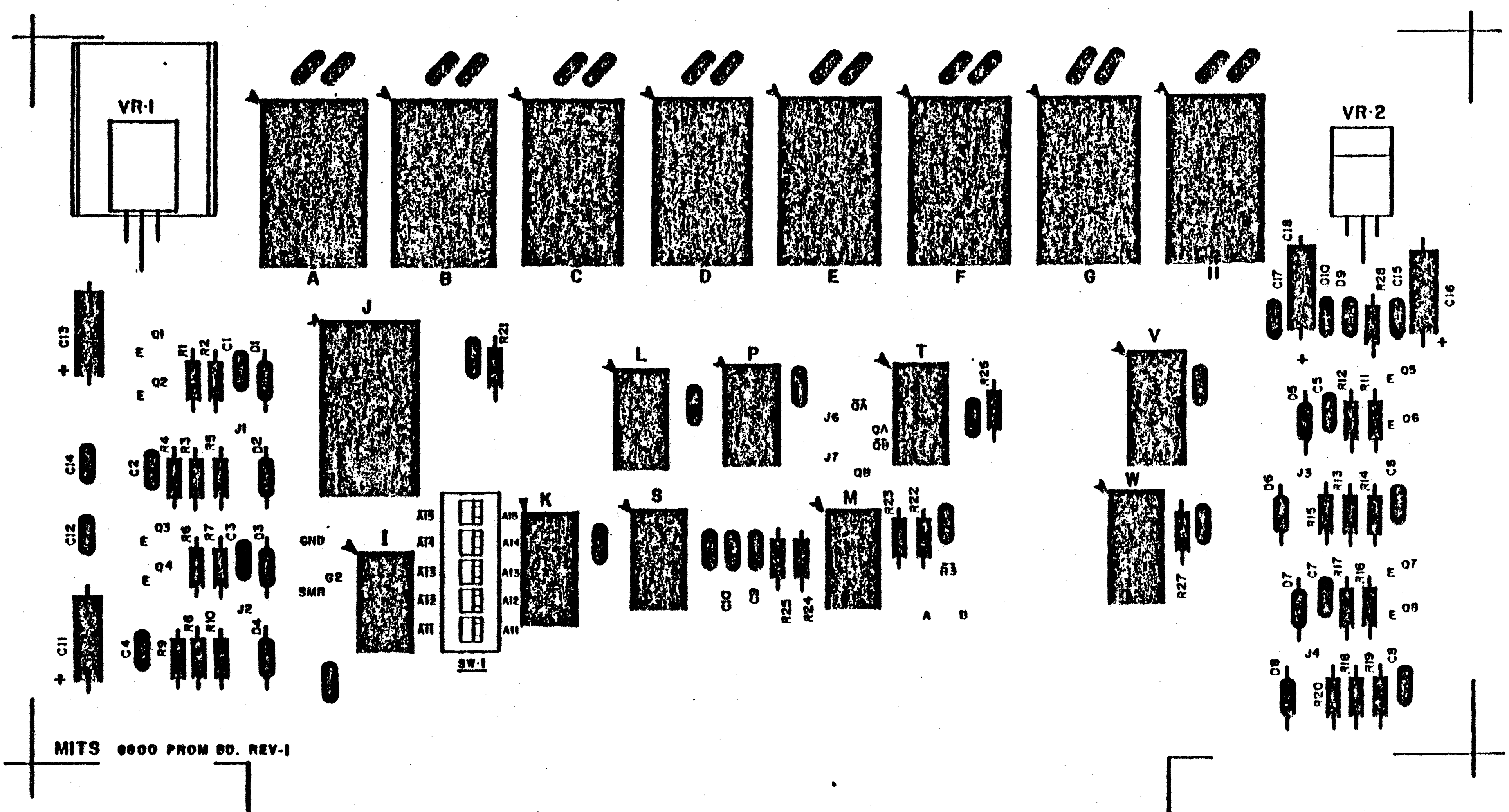
Using the diode leads saved earlier, refer to the drawing below and install these two jumpers.



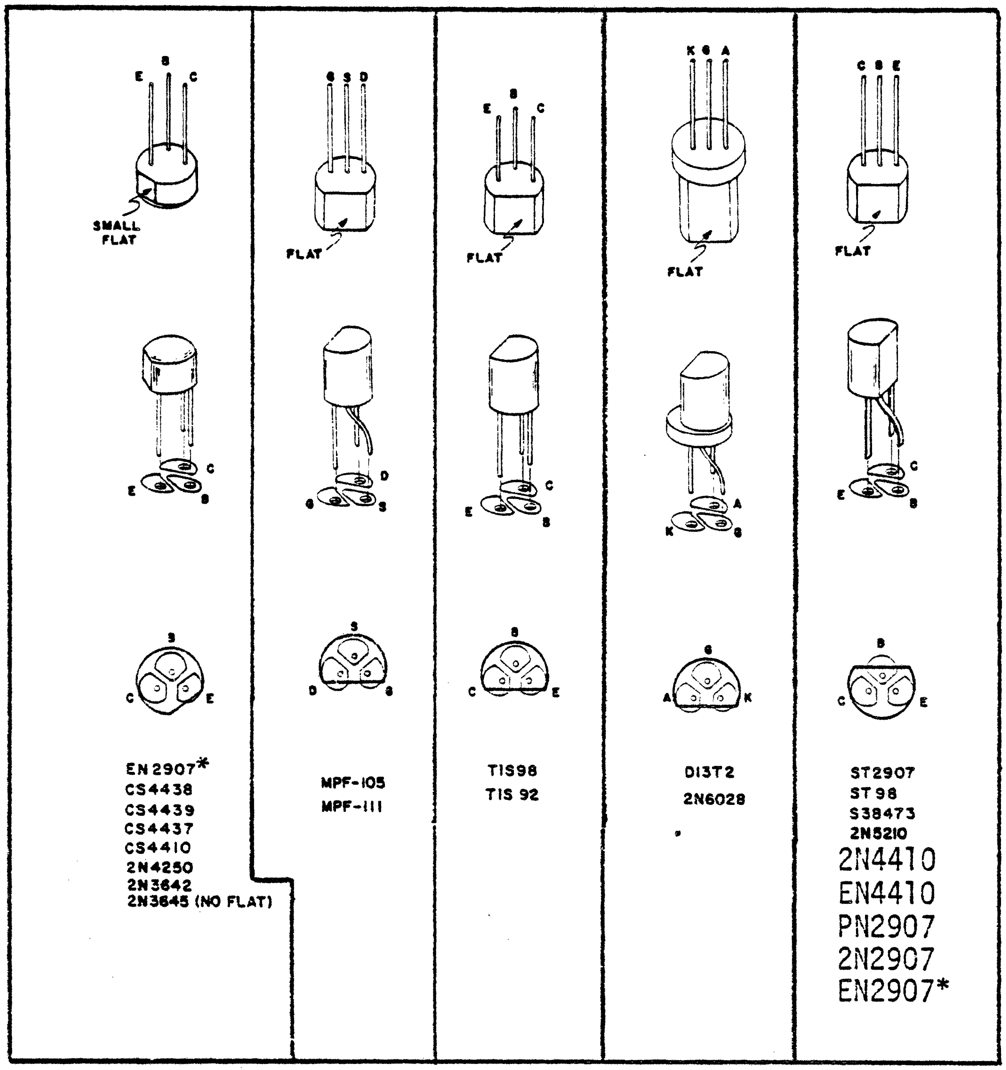
Transistor Installation

( ) Q1, Q3, Q5 & Q7 are EN2907 or PN2907 (PNP)

( ) Q2, Q4, Q6 & Q8 are 2N4410 (NPN)



TRANSISTOR IDENTIFICATION CHART



IN THE ILLUSTRATION ABOVE THE OUTLINE OF EACH TYPE OF TRANSISTOR IS SHOWN OVER 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.

VOLTAGE REGULATOR INSTALLATION

There is one 7805 regulator and one 79M08 regulator to be installed on the 8800 Board.

( ) Set the 7805 (VR5) in place on the board and align the mounting holes.

( ) 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.

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

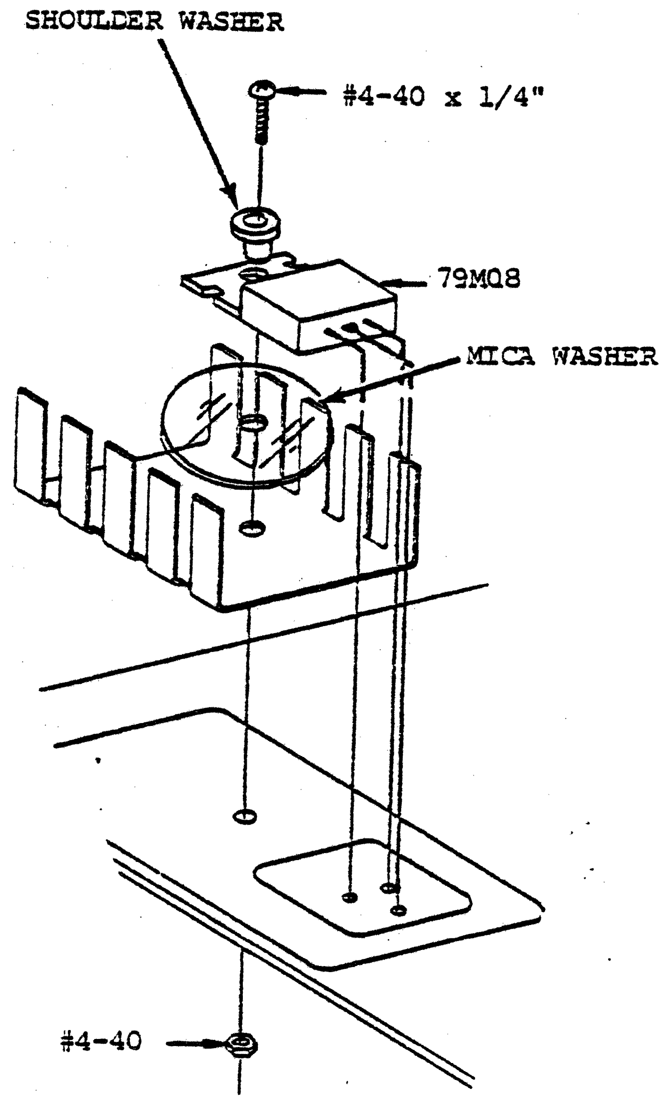
( ) Referring to the drawing, set the regulator and heat sink in place on the silk-screened side of the board. Secure them as shown, holding the regulator in place as you tighten the nut to keep from twisting the leads.

( ) 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.

( ) Install the VR-2 in the same manner; except, there is a mica insulating washer and shoulder washer to be installed. Different hardware is also used. (see drawing on right)

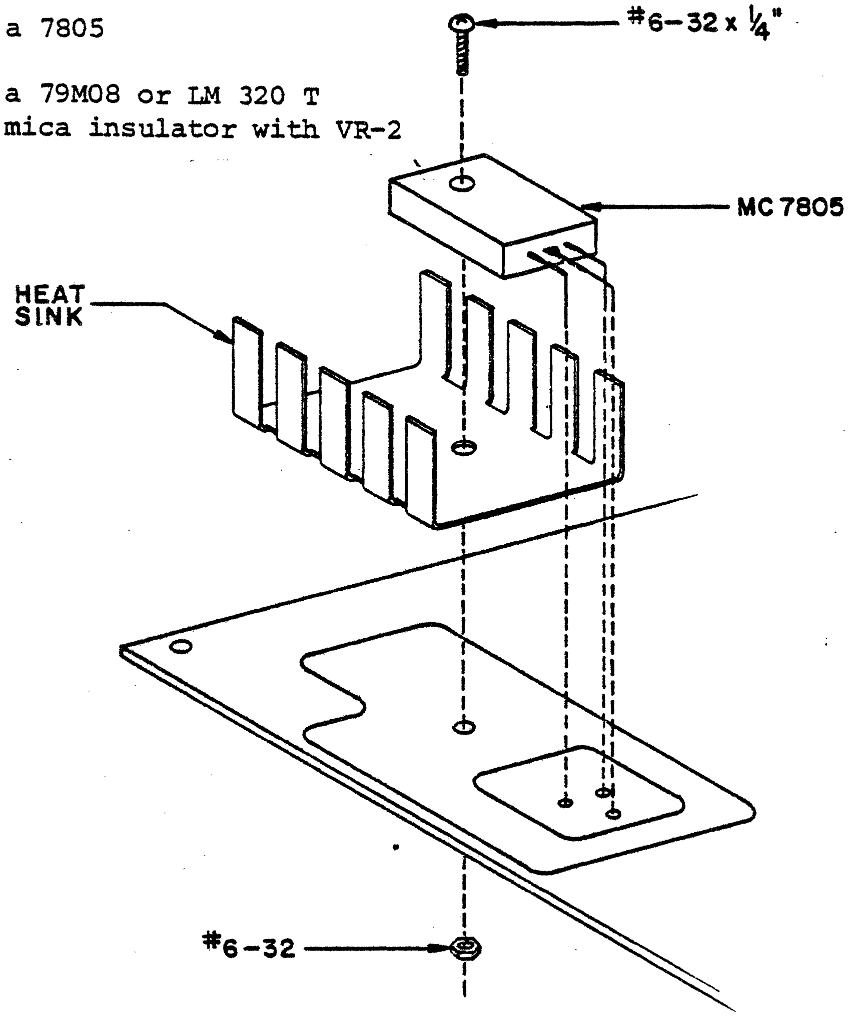
NOTE: This regulator must be entirely insulated from the board. If an ohmmeter is available, use it to be sure there is no short.

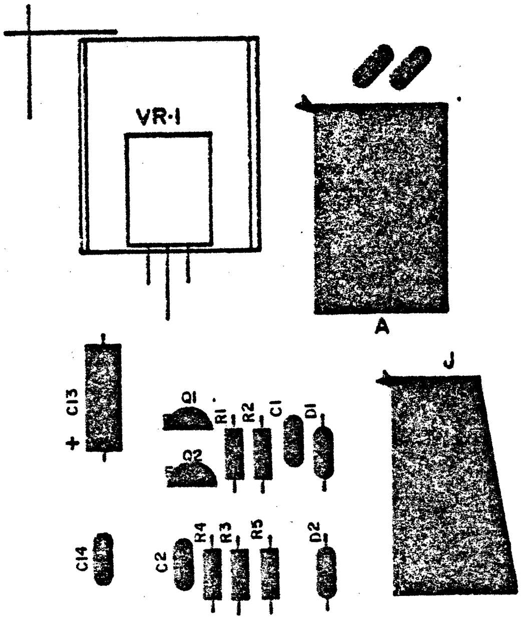


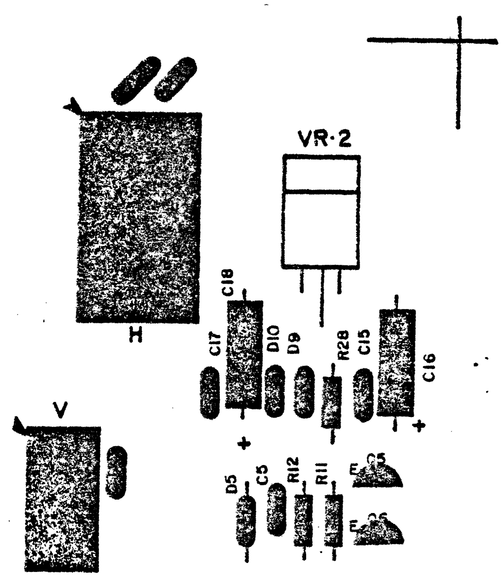
Voltage Regulator Installation

( ) VR-1 is a 7805

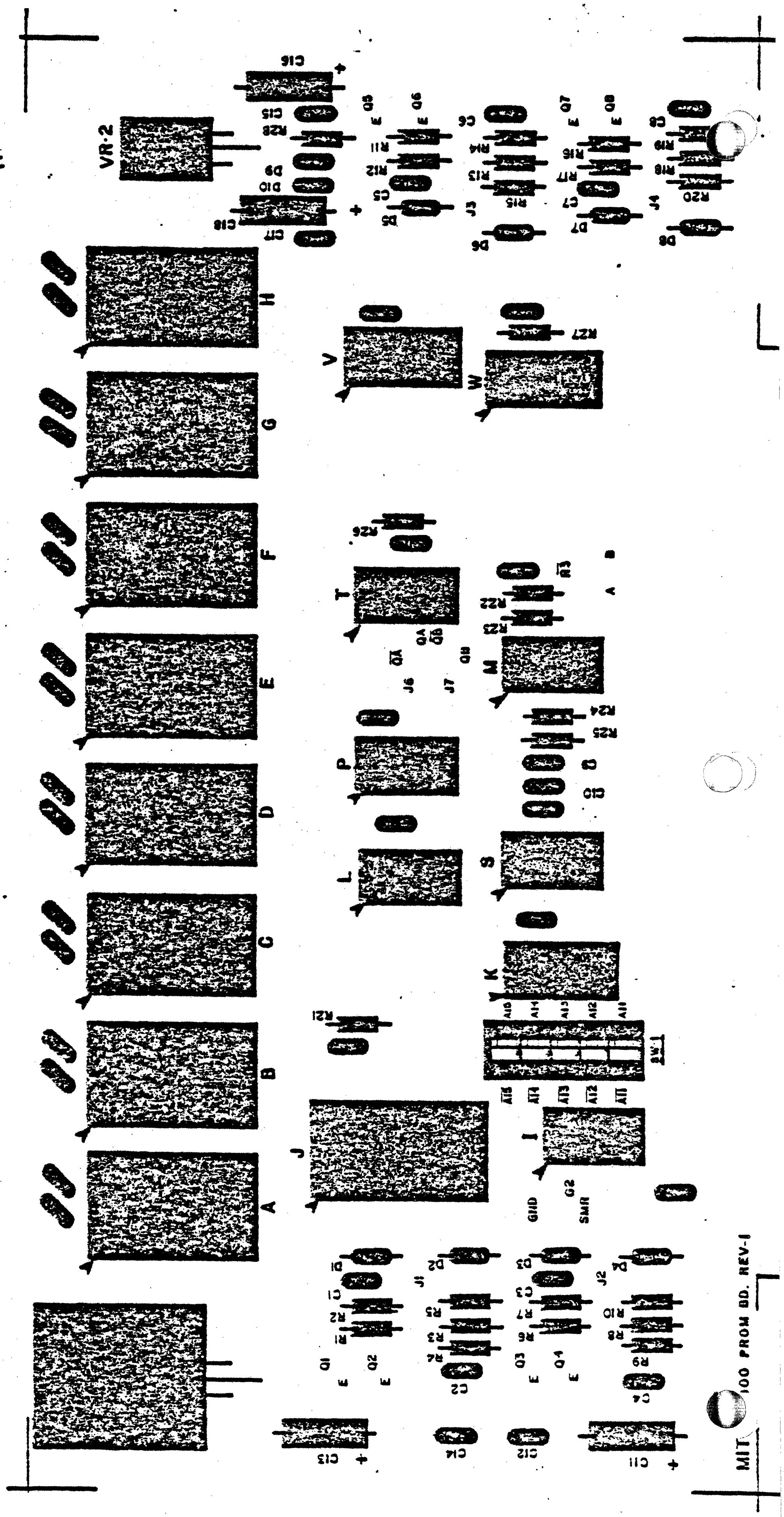
( ) VR-2 is a 79M08 or LM 320 T
install mica insulator with VR-2







NOTE: There are several component pads, both silkscreened and unsilkscreened, on this board which are not to be used. Do not do anything with these. Ignore any pads not referred to specifically in the instructions.



DIP SWITCH INSTALLATION

Install SW1 according to the following instructions:

1. Start the pins on one side of the switch into their respective holes on the silkscreened side of the board. Do not push the pins in all the way. If you have difficulty inserting the pins into the holes, guide them with the tip of a small screwdriver.

2. Start the pins on the other side of the switch into their holes in the same manner. When all of the pins have been started, push the switch into place by gently rocking it back and forth until it rests as close as possible to the board. Secure in place with a piece of masking tape.

3. Solder each pin to the foil pattern on the back of the board. Be careful not to leave any solder bridges. Clip off any excess lead lengths and remove the tape.

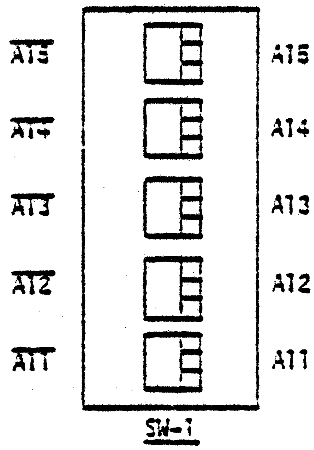
MEMORY ADDRESS SELECTION

There are several switch settings to be made on the 8800 memory boards for selecting the starting address for each board.

The starting address for each individual board is entirely optional within a few limitations. With only a single memory board in your system there is no problem, as long as the starting address selected in noted and taken into account when programming.

When more than one memory board is in the system, the sequence of starting addresses becomes critical. This is especially true when combining 1K and 4K boards in the same system. The important aspect in this case is to be sure that the individual blocks of memory on each board follow each other sequentially. There should be no gaps between the last address of one board and the starting address of the next.

The starting address of the 88-PMC board is selected by setting the five address switches according to the following chart. Each switch has two positions allowing selection of either the true address (A11-A15) or the complement address ($\overline{A11}$-$\overline{A15}$) for each of the five upper address lines. See Figure 1. By selecting the appropriate combination of switch settings, the starting address of the board may be selected in 2K (byte) increments as shown in the chart.



STARTING ADDRESS

Decimal	Octal					
0	0	$\overline{A14}$	$\overline{A14}$	$\overline{A13}$	$\overline{A12}$	$\overline{A11}$
2048	4000	$\overline{A15}$	$\overline{A14}$	$\overline{A13}$	$\overline{A12}$	A11
4096	10000	$\overline{A15}$	$\overline{A14}$	$\overline{A13}$	A12	$\overline{A11}$
6144	14000	$\overline{A15}$	$\overline{A14}$	$\overline{A13}$	A12	A11
8192	20000	$\overline{A15}$	$\overline{A14}$	A13	$\overline{A12}$	$\overline{A11}$
10240	24000	$\overline{A15}$	$\overline{A14}$	A13	$\overline{A12}$	A11
12288	30000	$\overline{A15}$	$\overline{A14}$	A13	A12	$\overline{A11}$
14336	34000	$\overline{A15}$	$\overline{A14}$	A13	A12	A11
16384	40000	$\overline{A15}$	A14	$\overline{A13}$	$\overline{A12}$	$\overline{A11}$
18432	44000	$\overline{A15}$	A14	$\overline{A13}$	$\overline{A12}$	A11
20480	50000	$\overline{A15}$	A14	$\overline{A13}$	A12	$\overline{A11}$
22428	54000	$\overline{A15}$	A14	$\overline{A13}$	A12	A11
24576	60000	$\overline{A15}$	A14	A13	$\overline{A12}$	$\overline{A11}$
26624	64000	$\overline{A15}$	A14	A13	$\overline{A12}$	A11

Decimal	Octal					
28672	70000	$\overline{A15}$	A14	A13	A12	$\overline{A11}$
30720	74000	$\overline{A15}$	A14	A13	A12	A11
32768	100000	A15	$\overline{A14}$	$\overline{A13}$	$\overline{A12}$	$\overline{A11}$
34816	104000	A15	$\overline{A14}$	$\overline{A13}$	$\overline{A12}$	A11
36864	110000	A15	$\overline{A14}$	$\overline{A13}$	A12	$\overline{A11}$
38912	114000	A15	$\overline{A14}$	$\overline{A13}$	A12	A11
40960	120000	A15	$\overline{A14}$	A13	$\overline{A12}$	$\overline{A11}$
43008	124000	A15	$\overline{A14}$	A13	$\overline{A12}$	A11
45056	130000	A15	$\overline{A14}$	A13	A12	$\overline{A11}$
47104	134000	A15	$\overline{A14}$	A13	A12	A11
49152	140000	A15	A14	$\overline{A13}$	$\overline{A12}$	$\overline{A11}$
51200	144000	A15	A14	$\overline{A13}$	$\overline{A12}$	A11
53248	150000	A15	A14	$\overline{A13}$	A12	$\overline{A11}$
55296	154000	A15	A14	$\overline{A13}$	A12	A11
57344	160000	A15	A14	A13	$\overline{A12}$	$\overline{A11}$
59392	164000	A15	A14	A13	$\overline{A12}$	A11
61440	170000	A15	A14	A13	A12	$\overline{A11}$
63488	174000	A15	A14	A13	A12	A11