MMD-1

MINI-MICRO DESIGNER

801-0082
REV. P
12/81

E&L Instruments, Incorporated
61 First Street, Derby, Connecticut 06418

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ILLUSTRATIONS

I. GENERAL DESCRIPTION

The Mini-Micro Designer® (MMD-1) is a complete educational and engineering microcomputer using an 8080-type microprocessor chip. The system has been designed to teach you about microprocessors whether you are a high school student or a digital design engineer. The MMD-1 features direct keyboard entry of data and instructions, status and data indication via LEDs, immediate access to buffered input/output busses and a convenient breadboarding socket. A portion of this socket is hardwired to the input/output bus lines and other critical control lines. This permits you to monitor what is going on, control input/output and interface to other instruments. The socket has been designed to directly accept IC's or functional plug-in modules available from E & L Instruments ("Design Modules"), to enhance your learning and to minimize your breadboarding time. In addition, the same input/output bus and control signals are available on a flex cable connector to more fully utilize the total system capability by adding supplemental hardware. The unit is also equipped with an internal power supply.

The MMD-1 is available in two formats:

- MMD-1/A: Factory assembled, inspected and ready to use. Comes with the operating manual.

- MMD-1/K: Kit form of the MMD-1/A, which requires you to assemble and solder the components into a working unit. Due to installation difficulty, the BP-25 Breadboarding Pins and the SK-10 Interface Socket are factory assembled. The unit comes with the operating manual.

Both formats are completely described in this manual.

There are many time-saving accessories available to the MMD-1 user. Complete descriptions of available options can be found in the E & L Instruments catalogue, "Teachings of the Modern Masters".

II. SPECIFICATIONS

Central Processor: Intel 8080A or equivalent

Memory: RAM - 512 words (8 bits) on board.

PROM - 256 words (8 bits) comes programmed to accommodate keyboard entry of data. Known as KEX (Keyboard Executive) and is located in prom position Ø.

256 words (8 bits) comes programmed to read data from the cassette and store it in successive memory locations on the M/I (Memory Interface) Board, starting at Ø3Ø - ØØØ. As the data is input it is displayed on the MMD-1's LED's; known as L/D (Loader/Dump) and is located in prom position 1.

Expansion capability: Up to a total of 65,536 words via cable connector - *would require additional power over 2 K RAM.

Displays: PORTS - Three groups of eight (8) LED's individually latched and addressable under software control. Note: during keyboard program entry, these LED's display Lo address, Hi address, and Memory data via the KEX PROM. Latch enables, for each port, via BP-25's, are available for external use.

HALT INDICATOR - LED, located to the left of SK-10, glows when the 8080A has executed a HALT instruction. The HALT status is cleared only through a RESET or a hardware interrupt.

Data Entry: 16 switch keyboard - numerals 0 thru 7, Hi address (H) Lo address (L) go (G) reset (RESET) examine/deposit (S) three optional keys (A, B, C).

Breadboarding Socket: SK-10/IF18 Open area on socket will take up to five (5), sixteen (16) pin ICs and discrete components (from 20 to 26 gauge diameter leads)

Bus signals hardwired to socket:

A0 thru A7	$\overline{\text{OUT}}$
GND	WAIT
+5 volts	READY
INT	D0 thru D7
INTE	RESET
$\overline{\text{I ACK}}$	M1
$\overline{\text{MEM R}}$	HALT
$\overline{\text{MEM W}}$	HLDA
$\overline{\text{IN}}$	

II. SPECIFICATIONS

Ribbon Cable Connector: Dual 20 pin, hardwired to same signals as breadboarding socket plus A8 thru A15.

Internal Power Supply: 115 or 230 VAC operation
*Use 1/2 amp fuse at 115 VAC
*Use 1/4 amp fuse at 230 VAC

D.C. Output at 105/210 VAC:	+5 V	±5%	at	1.5 amp
	+12 V	±5%	at	0.5 amp
	-12 V	±5%	at	0.5 amp
Current available for External use:	+5 V		at	0.5 amp
	+12 V		at	0.4 amp
	-12 V		at	0.4 amp

Operation Range: 105 to 125/210 to 250 VAC

NOTE: Unit can be switched from 115V to 230V by setting the switch (LS1) in back of unit with a screwdriver. The 115V plug will have to be replaced with a plug compatible with the receptacle in use.

III. ASSEMBLY INSTRUCTIONS, GENERAL

A. The material has been prepacked in plastic bags in general categories for ease of assembly. Check the contents of the bags to make certain all the correct parts are there. Inspect packing material for any loose parts before discarding.

Bring all shortages or discrepancies to the immediate attention of E & L Instruments.

1. When a wire is brought to a location, the designation "connect" is used; when it is followed by an (S), this indicates it is immediately soldered in place; if no (S) appears, do not solder at this time - other wires will be brought to that point and if solder is applied too early, the assembly will be much more difficult.

2. When soldering diodes and transistors, it is most important that the heat used is minimal - a 35W soldering iron is quite adequate for all of the assembly and a larger wattage iron should not be used.

3. The instructions are given line by line with two "Check-Off" columns. The first is for checking off as you actually do that step; the second is for rechecking if a problem is encountered.

4. Use rosin core solder only. The use of corrosive (acid core) solder or paste fluxes voids any and all warranties on the unit.

5. This manual uses the new IEEE (Institute of Electrical and Electronic Engineers) international standard term "hertz" as the basic unit of frequency. The terms are used as follows:

Hz (hertz)	=	cps	(cycles per second)
KHz (kilohertz)	=	kc	(kilocycles per second)
MHz (megahertz)	=	mc	(megacycles per second)

1. SOLDERING TIPS

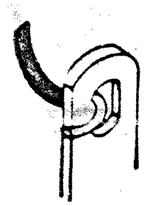
The quality of your unit is going to depend on the quality of your assembly and soldering techniques. We have outlined, below, some standard practices that you should adhere to.

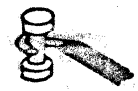
1.1 There is more to a soldered connection than two or more pieces of metal held together by a "blob" of solder. When molten solder is applied to a metal, the solder actually disolves some of the metal's surface. Thus, metals which have been soldered together are bonded by a solidified solution of solder and parts of the metals which were joined. Soldering is an easy task, but it is a task that must be done correctly. If your soldering techniques are poor you will have a great deal of trouble with the kit that you are about to assemble.

1.2 In order for molten solder to perform its function of joining metals together, the oxides on the surfaces of the metals must be removed. The oxides are removed by a FLUX. A flux is a material which, when heated, dissolves surface oxides and suspends them away from the surface of the metal. With the surface oxides removed, the molten solder can dissolve some of the surface metal and bond itself tightly to the metal.
We recommend the use of Rosin flux core solder with a mixture of 63% tin and 37% lead. This is the only mixture that goes directly from liquid state to solid state thus, bypassing the plastic state which causes cold solder joints.

1.3 A good solder connection is made in two steps: The first step is to make the mechanical connection. Then the molten solder is applied to the connection. After you have stripped a wire, always check to see that the wire is clean and free from heavy oxidation, grease or oil. Oxidation can be scraped off, and oil or grease can be removed with a rag. Steel wool or sandpaper is excellent for cleaning badly oxidized wires. Stranded wire should be tinned (covered with solder) to prevent the bare ends from fraying and possibly causing a short circuit.

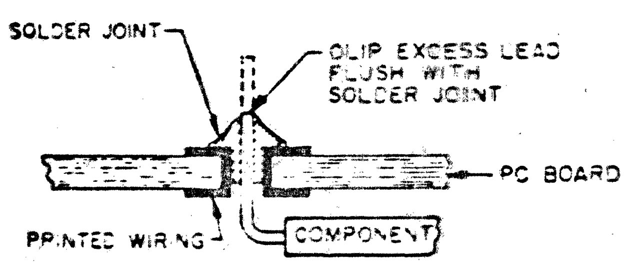
The next step in making a solder connection is to secure the wire or wires to the terminal or lug. The wire should make sufficient contact with the terminal or lug, but should not be tightly fastened. The solder will provide both mechanical strength and a low resistance junction.





After the mechanical connections are complete, the next step is to apply the solder. First heat the mechanical connection, with the iron, to allow the solder to flow on the hot metal. Apply the solder to the point where the iron meets the contact to be soldered. The flux should melt and flow freely over the contact, dissolving all oxides, and aiding heat transfer from tip to connection. The solder should then melt and flow freely, covering the area to be soldered. Make sure you apply enough solder to cover the contact.

1.4 To prepare p.c. boards for soldering, clean the area to be soldered on the printed wiring by rubbing with a pencil eraser, and clean the component leads with a piece of steel wool. Place the component on the board, on the side with the nomenclature printed on it, with the leads extending through the holes indicated for the component. Flip the board over and solder the leads. The same general rule for soldering conventional circuitry should be adhered to.

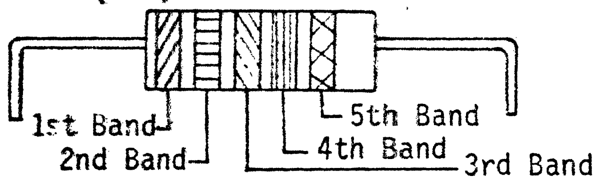


Resistor Identification

Resistor Color Code Chart #1

3 significant figures (1%)

Bend to .45"
(1.2) for E&L Boards



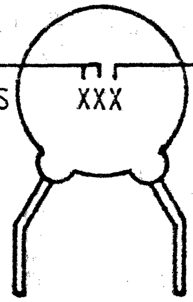
Color	BANDS				
	1st	2nd	3rd	4th	5th
Black	0	0	0	X 1.0	
Brown	1	1	1	X 10	1%
Red	2	2	2	X 100	.1%
Orange	3	3	3	X 1000	.01%
Yellow	4	4	4	X 10000	.001%
Green	5	5	5	X 100000	
Blue	6	6	6	X 1000000	
Purple	7	7	7	--	
Grey	8	8	8	--	
White	9	9	9	--	
Gold	-	-	-	÷ 10	
Silver	-	-	-	÷ 100	
-----	-	-	-		

Resistor Color Code Chart #2

Color	BANDS				
	1st	2nd	3rd	4th	5th
Black	0	0	X 1.0	-	
Brown	1	1	X 10	-	
Red	2	2	X 100	-	
Orange	3	3	X 1000	-	
Yellow	4	4	X 10000	-	
Green	5	5	X 100,000	-	
Blue	6	6	X 1000,000	-	
Purple	7	7	--	-	RC=MIL-R-39008
Grey	8	8	--	-	
White	9	9	--	-	
Gold	-	-	÷ 10	-+ 5%	
Silver	-	-	÷ 100	-+ 10%	
-----	-	-	-	-+ 20%	RC=MIL-R-11

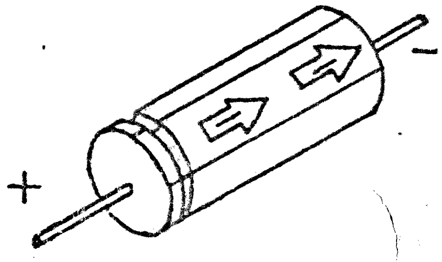
Capacitor Identification

CERAMIC CAPACITOR



EXAMPLES: 103 = 10,000 pF OR .01 µF
302 = 3000 pF OR .003 µF
676 = 67,000,000 pF OR 67 µF

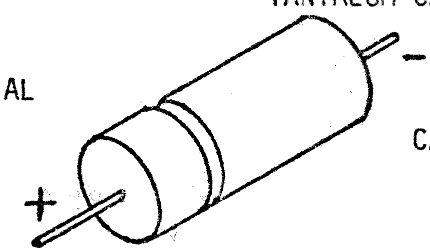
ELECTROLYTIC CAPACITOR



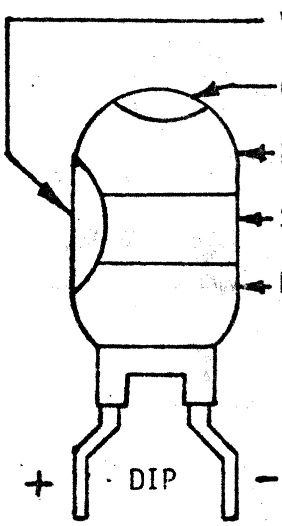
CAPACITANCE IS INDICATED ON CAPACITOR IN MICROFARADS (µF)

TANTALUM CAPACITOR

AXIAL



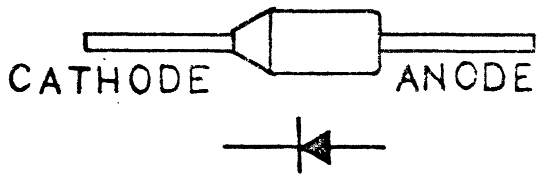
CAPACITANCE IS INDICATED ON CAPACITOR IN MICROFARADS (µF)

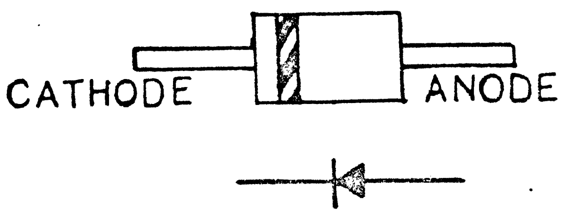


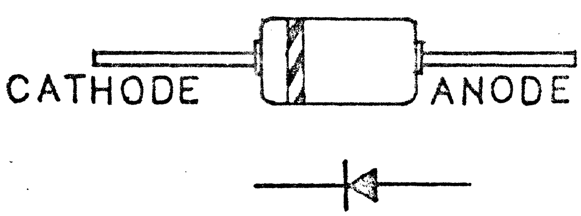
COLOR	VOLTAGE	VALUE	MULTIPLIER
BLACK	4	0	———
BROWN	6	1	———
RED	10	2	———
ORANGE	15	3	———
YELLOW	20	4	10000
GREEN	25	5	100000
BLUE	35	6	1000000
VIOLET	50	7	10000000
GRAY	———	8	———
WHITE	———	9	———

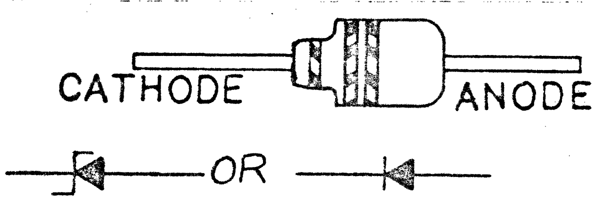
CAPACITANCE MAY BE MARKED ON CAPACITOR IN MICROFARADS (µF) OR BY COLOR CODE IN PICOFARADS (pF)

Diode & LED Identification

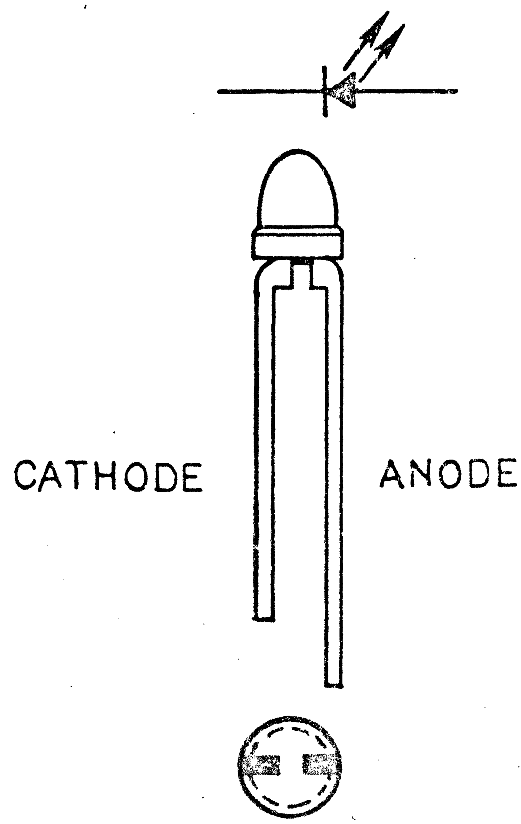


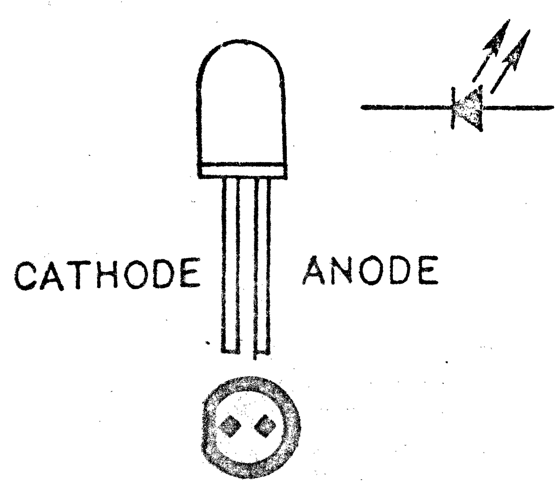






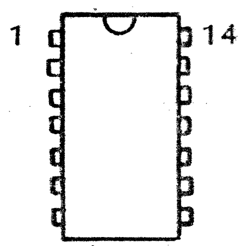
Color	BANDS		
	1st	2nd	3rd
Black	0	0	0
Brown	1	1	1
Red	2	2	2
Orange	3	3	3
Yellow	4	4	4
Green	5	5	5
Blue	6	6	6
Purple	7	7	7
Grey	8	8	8
White	9	9	9



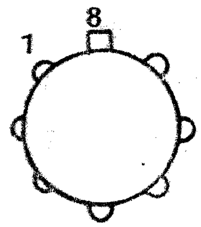


IC Identification

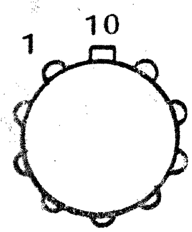
TOP VIEW



14 PIN DIP



8 PIN CAN

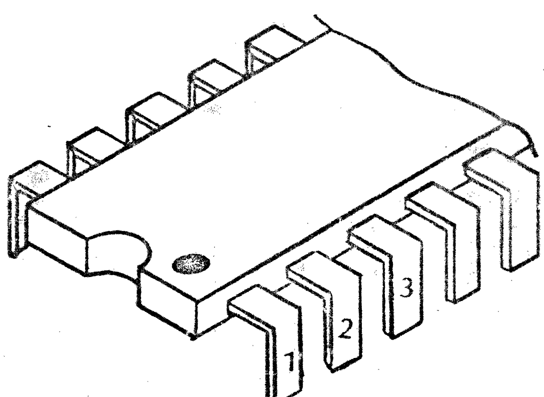


10 PIN CAN

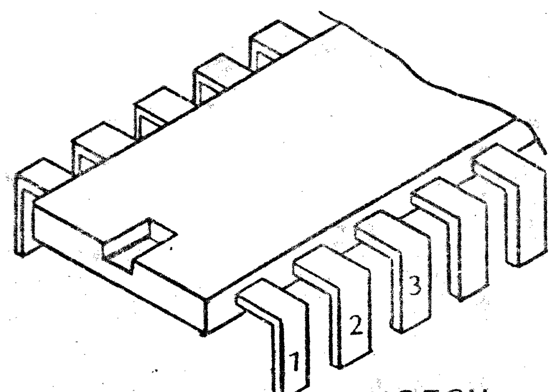
PIN COUNT IS SEQUENTIAL IN A COUNTERCLOCKWISE FASHION

PIN 1 LOCATION

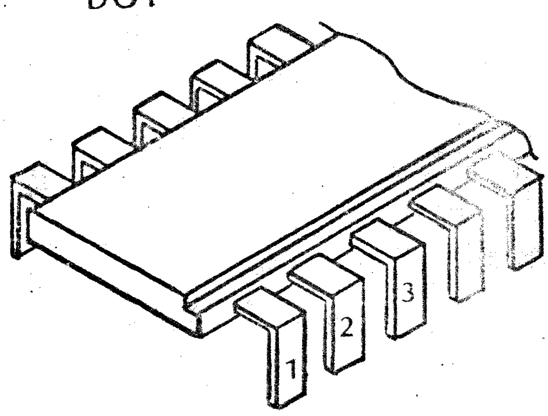
CAN STYLE TAB IS ALWAYS PLACED ON HIGHEST PIN NUMBER WITH PIN 1 TO THE LEFT SIDE



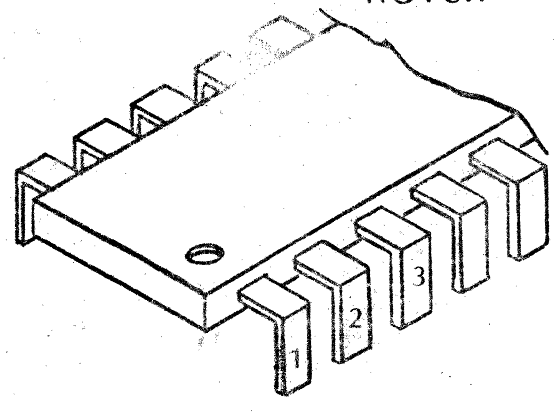
DOT



NOTCH



RIDGE



SMALL INDENTATION

IV. REPLACEMENT PARTS LIST

PACKING BAG	MANUAL DESIG.	DESCRIPTION	QTY.	P/N	CHECK
POWER SUPPLY PACKAGE	-	Power Supply P.C. Board, Mach.	1	711-0125	
	Q1	Transistor, TIP3055	1	500-0026	
	VR1, VR2	Voltage Reg., 7812UC (LM340-12T)	2	504-0009	
	D1	Bridge Rect., (6 amp-200V) Power Components Inc. BR-62	1	502-0007	
	D2, D3	Bridge Rect., (1 amp-100V) Electronic Devices Inc. PF-05	2	502-0002	
	C1	Elec. Cap. 2200 mfd - 16V	1	523-0044	
	C2, C3	Elec. Cap. 1000 mfd-35V	2	523-0041	
	C4, C5	Tant. Cap. 1.0 mfd-35V	2	524-0009	
	C6	Cer. Cap. 0.1 mfd-50V	1	520-0016	
	R1	Trimpot 2.5Ω Thumbwheel	1	515-0023	
	R2	CCRES 1/4W - 1KΩ - 5%	1	511-0039	
	R3	CCRES 1/4W - 2.2KΩ - 5%	1	511-0046	
	R4	WWRES 2W - .25Ω - 3%	1	519-0023	
	F1	Fuseholder, Littlefuse #348-657	1	563-0019	
	S1	Switch, SPST, w/integral light, Carling Co. LTA-110-PBWR	1	570-0019	
	- *	Fuse, 1/2 amp. Bussman AGC-Slo-Blo	1	563-0013	
	-	Rubber Feet, self-stick, 3M Co. S15112	4	611-0001	
	VR1, VR2	Sil-Pad for Regulator	2	616-0012	
	LS1	AC line voltage select switch	1	579-0003	
	Q1	Sil-Pad for transistor	1	616-0013	
	VR1,VR2, Q1	Nylon Bushing	3	617-0010	

MAIN BOARD PACKAGE	R35,R42	CCRES 1/4W - 10KΩ - 5%	8	511-0062	
	C1	Elec. Cap. 33 mfd - 6.3V	1	523-0019	
	C2	Tant. Cap. 5 mfd - 15V	1	524-0032	
	C3,C5-C15	Cer. Cap. .01 mfd - 50V	12	520-0008	
	C4	Elec. Cap. 3.3 mfd - 50V	1	523-0003	
	C16,C17	Mica Cap. 47 pfd - 5%	2	521-0003	
	R1, R2 R4-R6	CCRES 1/4W - 1KΩ - 5%	5	511-0039	
	R3	CCRES 1/4W - 2.2KΩ - 5%	1	511-0046	
	R7-R30	CCRES 1/4W - 470Ω - 5%	24	511-0031	
	R31-R33	CCRES 1/4W - 4.7KΩ - 5%	3	511-0054	
	R34	CCRES 1/4W - 220Ω - 5%	1	511-0022	
	D1-D24	Red LED,Hewlett Packard 5082-4484	24	551-0005	
	D25	Zener Diode, 5.1V - 5%, IN751A	1	501-0003	
	D26	Zener Diode, 3.3V - 5%, IN746	1	501-0002	
	D27	Red LED,Hewlett Packard 5082-4850	1	551-0003	
	XTAL	Crystal, 5.76 MHz - 0 to 50 degree Cent. series resonance 0.1% Bliley Elec. HC18/U	1	509-0006	

IV. REPLACEMENT PARTS LIST (contd.)

PACKING BAG	MANUAL DESIG.	DESCRIPTION	QTY	P/N	CHECK
MAIN BOARD PACKAGE	-	Binding Post, Red, E.F. Johnson 111-0102-001	1	543-0007	
	-	Binding Post, Black, E.F. Johnson 111-0103-001	1	543-0008	
	-	Binding Post, Blue, E.F. Johnson 111-0110-001	1	543-0009	
	-	Binding Post, White, E.F. Johnson 111-0101-001	1	543-0011	
	-	Capacitor Mount, white nylon	13	616-0006	
	-	Keyboard	1	575-0002	
	-	Connector, Rt. Angle, 40 Pin P.C. mount	1	540-0010	
	-				
	-	Label - Interface Socket	1	633-0038	

INTEGRATED CIRCUITS	A1, A22, A23	SN7404	3	503-0041	
	A2, A3, A30	SN7400	3	503-0014	
	A4	SN74LS174	1	503-0123	
	A5	Intel 8224	1	503-0116	
	A6, A7	Intel 8216	2	503-0117	
	A8	Intel 8080A Microprocessor	1	503-0078	
	A9-A12	Intel 8111-2**	4	503-0118	
	A13, A17	SN74LS05	2	503-0122	
	A14	SN74LS155	1	503-0121	
	A15	Intel 1702-A (Pre-Programmed) (Kex)	1	660-0008	
	A16	Intel 1702-A (Pre-Programmed) (L/D)	1	660-0024	
	A18	SN74L42	1	503-0081	
	A19	SN7402	1	503-0042	
	A20, A21	SN74L04	2	503-0120	
	A24-A29	SN74LS75	6	503-0187	
	A31	SN74365	1	503-0086	
	A32, A33	SN74148	2	503-0119	
	U1	Voltage Reg., LM723 (DIP) +5 volt (Power Supply)	1	504-0014	

SOCKET	J1-J3 J13, J17 J19-J23 J30, J34	Socket, DIP, 14 Pin	12	542-0005	
	J4-J7 J14, J18 J24-J29 J31-J33	Socket, DIP, 16 Pin	15	542-0008	
	J9-J12	Socket, DIP, 18 Pin	4	542-0021	
	J15, J16	Socket, DIP, 24 Pin	2	542-0017	
	J8	Socket, DIP, 40 Pin	1	542-0016	

IV. REPLACEMENT PARTS LIST (contd.)

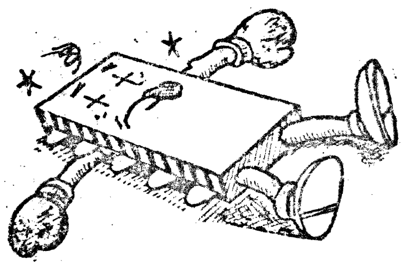
PACKING BAG	MANUAL DESIG.	DESCRIPTION	QTY	P/N	CHECK
HARDWARE	-	6-32 x 1/2" Pan Hd. Screw	4	605-0002	
	-	6-32 Hex Nut	4	606-0012	
	-	#6 Lockwasher	2	607-0008	
	-	#6 Ground Lug	1	545-0020	
	-	4-40 M/F Standoff	3	615-0019	
	-	4-40 x 1/4" Pan Hd. Screw	3	605-0025	
	-	4-40 Hex Nut	6	606-0006	
	-	#4 Lockwasher	8	607-0001	
	-	#4-40 x 3/8" Pan Hd. Screw	2	605-0037	
		#4-40 NUT, Small	2	606-0009	
	-	#4-40 x 7/8" Pan Hd. Screw	3	605-0056	
	-	#4 Nylon Spacer	3	615-0016	
WIRE (581-0005)	-	1-1/2" (3,81 cm) 18 ga. White	1		
	-	1-1/2" (3,81 cm) 18 ga., Black	1		
	-	2" (5, 1 cm) 18 ga., Black	1		
	-	5-1/2" (13,97 cm) 18 ga. White	1		
	-	5-1/2" (13, 97 cm) 18 ga. Black	1		
	-	6" (15, 24 cm) 18 ga. White	1		
	-	6" (15,24 cm) 18 ga. Black	1		
	-	6-1/2" (16,51 cm) 18 ga. White	1		
	-	3 1/2" (8,9cm) 22 ga., Green	9		
	-	5" (12,7cm) 22 ga., Orange	6		
	-	12" (30,5cm) 22 ga., White	1		
	-	12" (30,5cm) 22 ga., Red	1		
	-	12" (30,5cm) 22 ga., Blue	1		
	-	12" (30,5cm) 22 ga., Black	1		
		12" (30,5cm) 22 ga. Buss Wire	1		
FACTORY INSTALLED MAIN BOARD ASSEMBLY	-	P.C. Board, Machined	1	711-0099	
	BP	BP-25 Breadboarding Pin	36	544-0004	
	SK-10	SK-10/IF-18 Interface Socket	1	415-0003	
	-	4-40 x 5/8" Flat Hd. Screw	6	605-0033	
	-	#4 Lockwasher	6	607-0001	
	-	4-40 Hex Nut	6	606-0006	
	-	6-32 x 1/2" Pan Hd. Screw, used to mount Main Board to Housing installed for shipping	4	605-0002	
MISCELLANEOUS	-	Housing (E&L Instr.)	1	620-1011	
	T1	Transformer, (E&L Instr.)	1	531-0017	
	-	Line Cord w/Molded Plug (115V)	1	567-0002	
	-	Strain Relief, Heyco Inc. SR6P4	1	617-0002	
	-	Operating Manual	1	801-0082	
	-				
	-				
	-	8080A Inst. Reference Card	1	803-0147	
	-	Yellow Warranty Card	1	801-0137	

* *For 230V operation use:*

-	*1/4 amp Fuse-Bussman-AGC Slo-Blo*	*1*	*563-0020*	

** Faster RAMs (8111A-4) (2111-2) may be substituted.

CAUTION!



STATIC ELECTRICITY

KILLS

the following devices:

INTEL 8080 Microproccessor chip

INTEL 1702A-2 PROM

INTEL 8212 IN/OUT Port chip

INTEL 8102A-2 RAM

INTEL 8111-2 RAM

INTEL 8216

INTEL 2102A-6 RAM

Although protection against electrostatic effects is provided by built-in circuitry, the following handling precautions should be taken:

1. Soldering iron tips and test equipment should be grounded.
2. Devices should not be inserted in non-conductive containers such as conventional plastic snow or trays.
3. Assembly work surfaces should be grounded.
4. Avoid carpeting or other furnishings that encourage electrostatic charging of assembly personnel.

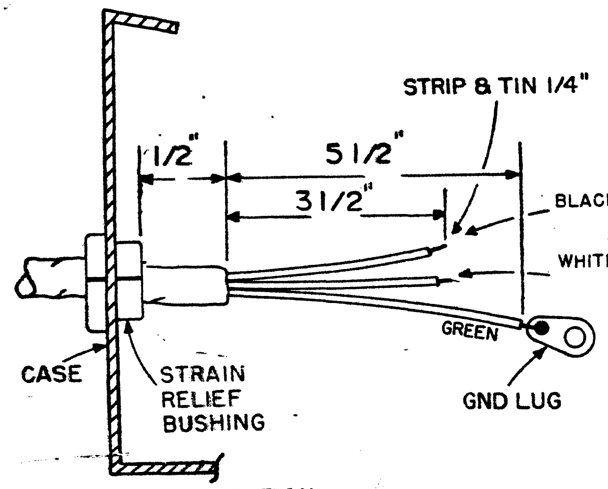
V. POWER SUPPLY ASSEMBLY AND CHECKOUT
(See Illustrations 1, 1A and 2)

A. Line Cord Preparation

CONST. CHECK

If your unit is for 230V operation, the line cord will have no plug attached. A plug must be obtained that is suitable for the receptable available.

1. Prepare Line Cord as shown below. Slide strain relief onto Line Cord with large end towards plug end of cord. _____ _____



POWER CORD PREPARATION

2. Insert Line Cord through hole in rear of housing. Compress Strain Relief and snap into hole. Connect the Ground Lug to the Green wire as shown. _____ _____

B. Transformer Installation (See Illustration 1)

1. Scrape paint from around frontmost transformer mounting hole to bare metal for good grounding contact. _____ _____

2. Fasten Transformer into the housing with (2) 6-32 x 1/2" Pan Head Screws, #6 Lockwashers and 6-32 Hex Nuts. Place Ground Lug under Transformer at frontmost hole when fastening. Terminals 1 through 4 with wires attached should be closest to the Line Cord (See Illustration 1). _____ _____

C. Mounting Voltage Regulators VR1, VR2 and Power Transistor Q1

1. Install with Sil-Pads shown in Illustration 1 using a 4-40x7/8" Pan Hd.Screw, #4 Nylon Spacer and 4-40 Hex Nut. _____ _____

2. Repeat the above step for VR1 and Q1. _____ _____

D. Completion of Case Assembly

1. Install (3) standoffs in the 3 remaining holes in the bottom of the housing using the 4-40 x 1/4" Pan Head Screws and

CONST. CHECK

#4 lockwashers.

2. Install line switch LS1 with (2) 4-40 x 3/8" screws, (2) 4-40 hex nuts (small), and (2) #4 washers. Make sure 230V shows toward the top of case. (See Illus. #1). ____ ____

3. Install fuseholder (F1) into hole at extreme right of housing with word "TOP" printed on fuseholder in the up position. Push until it snaps into place. ____ ____

4. Install ON/OFF power switch (S1) in center hold between F1 and LS1 on rear of housing, with terminal 3 towards the top. Push in until it snaps into place. (See Illustration #1.) ____ ____

STEPS 5 Through 10 See Illustration #1A

5. Connect 5-1/2" (13,97 cm) white wire from terminal 4 of T1 and white wire from Line Cord to top lug on switch (S1-3). Connect 1-1/2" (3,81 cm) white wire from (LS1-5) to (S1-3) (S). ____ ____

6. Connect 6-1/2" (16,51 cm) white wire from (LS1-4) (S) to terminal 2 of T1. Connect 6" (15,24 cm) white wire from terminal 2 of T1 (S) to (LS1-3) (S).

7. Connect 5-1/2" (13, 97 cm) black wire from terminal 1 of T1 (S) to lower lug on Switch (S1-1). Connect 1-1/2" (3,81 cm) black wire from (S1-1) (S) to (LS1-1) (S). ____ ____

8. Connect 2" (5,1 cm) black wire from middle lug on Switch (S1-2) to the top lug on fuseholder (F1) (S). ____ ____

9. Connect 6" (15,24 cm) black wire from (LS1-2) to terminal 3 of T1 (S). ____ ____

10. Connect black wire from Line Cord to lower lug on fuseholder (F1) (S). ____ ____

PUT HOUSING ASIDE AT THIS POINT.

E. Power Supply P.C. Board Assembly (See Illustration 2)

NOTE: All solder connections are made on lower side of board.

1. The (2) jumper wires using the 22 ga. bus wire supplied. Note the jumpers should be flat against the board before soldering. ____ ____

2. The 14-Pin IC Socket (J34). Note the notch on socket is adjacent to white doe on P.C. Board. ____ ____

3. The 2.5K Trimpot (R1). ____ ____

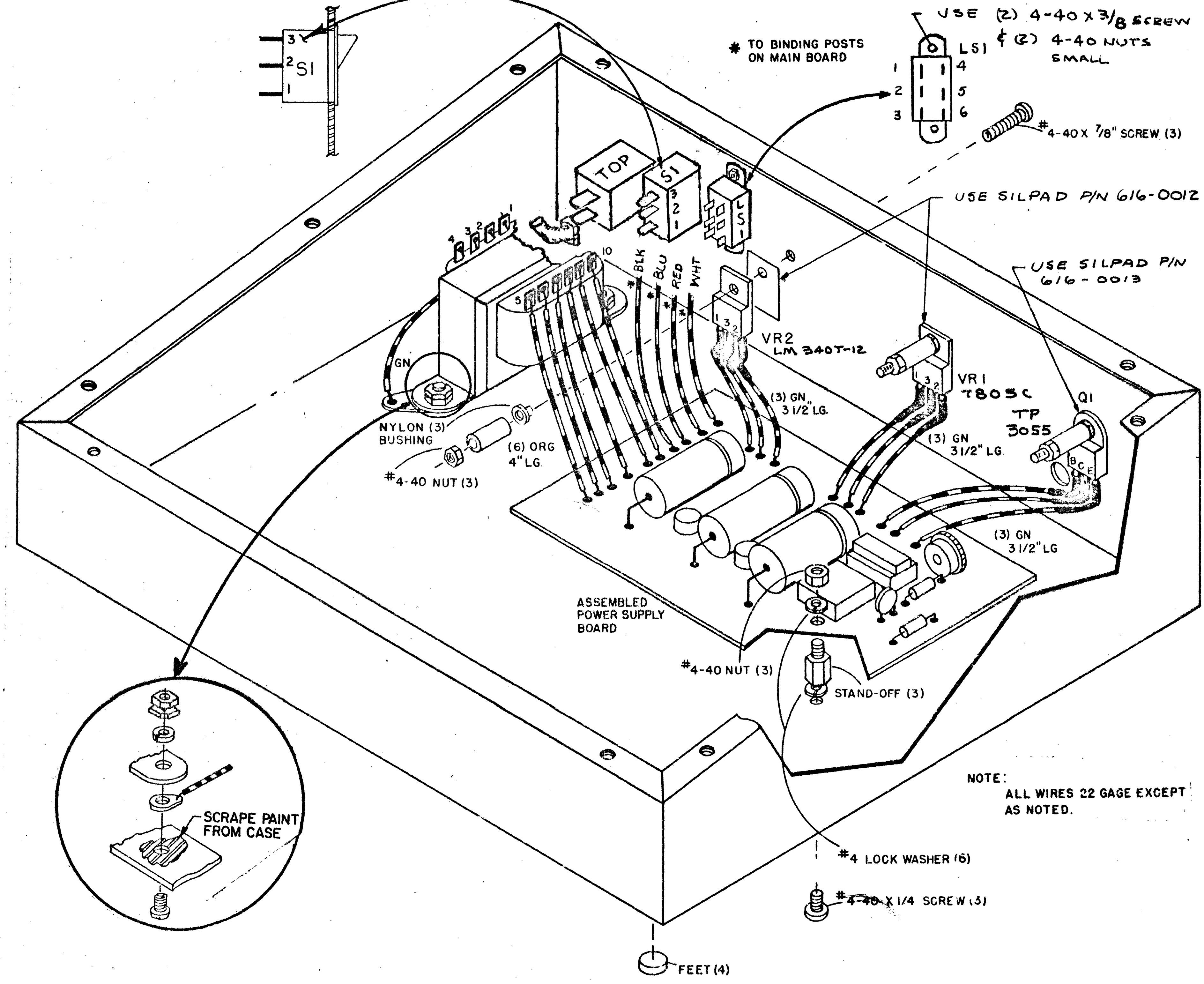
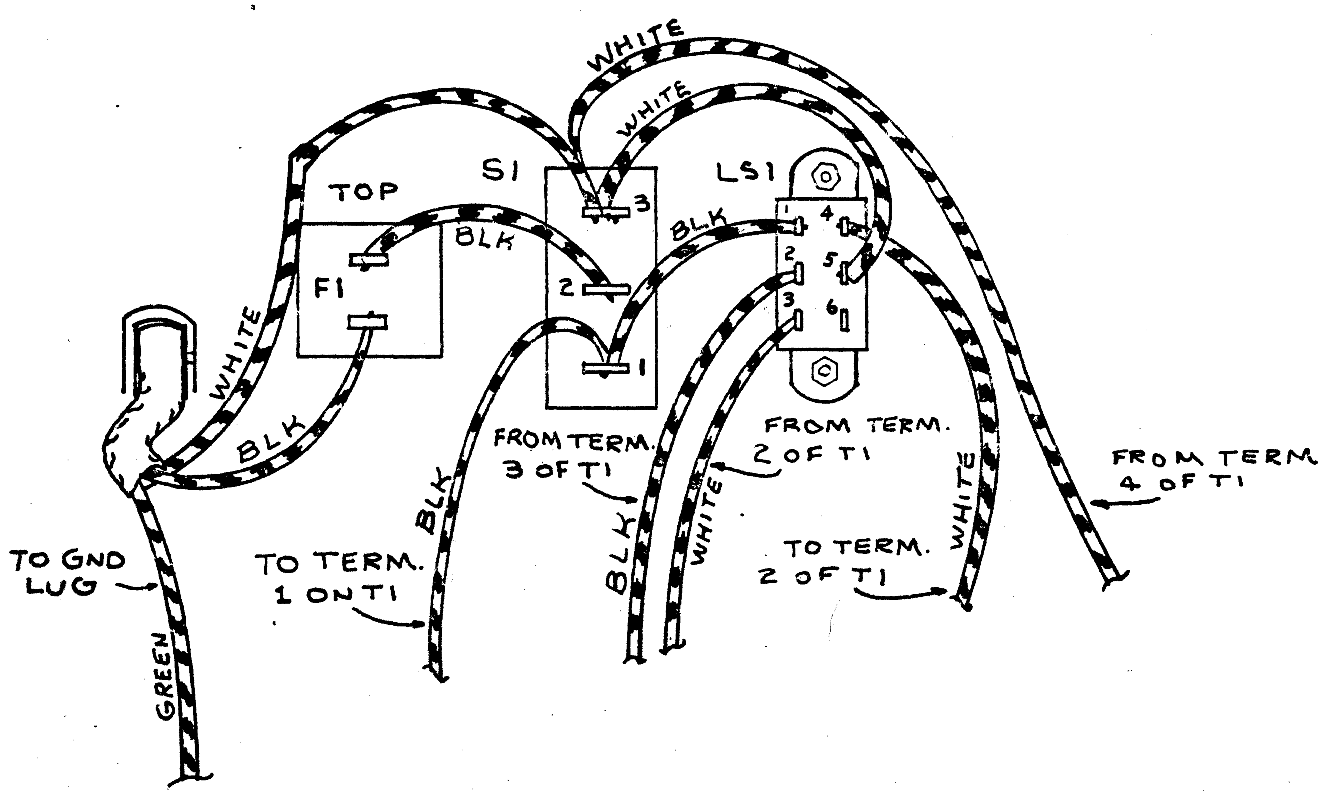


ILLUSTRATION #1

		CONST.	CHECK
4.	The 2.2K Resistor (R3).	_____	_____
5.	The 1K Resistor (R2).	_____	_____
6.	The .25 ohm wirewound resistor (R4).	_____	_____
7.	The (2) 1 mfd tant. capacitors (C4, C5), making certain that polarity agrees with marking on P.C. Board.	_____	_____
8.	The .1 mfd capacitor (C6).	_____	_____
9.	The (2) bridge receifiers (D2, D3), making certain that polarity agrees with markings on P.C. Board.	_____	_____
10.	The bridge receifier (D1) making certain that polarity agrees with marking on P.C. Board. This Device should stand approx. 3/8" above P.C. Board.	_____	_____

(Instructions continued on Page 16.)



PRIMARY WIRING

ILLUSTRATION 1A

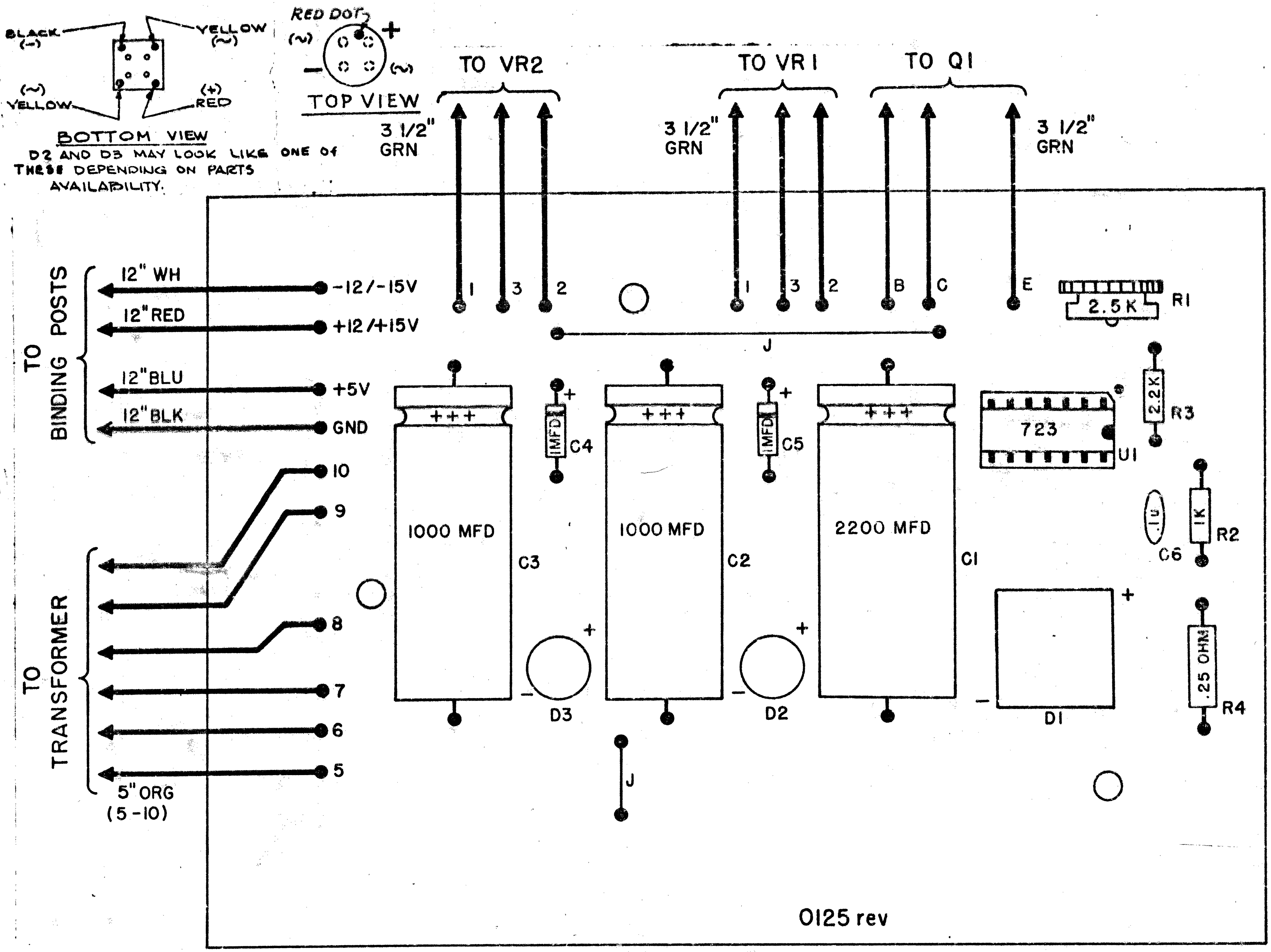


ILLUSTRATION #2

E. Power Supply P.C. Board Assembly (contd.) CONST. CHECK

11. The (2) 1000 mfd capacitors (C2 & C3), and 2200 mfd capacitor (C1) making certain that polarity on capacitors agree with markings on P.C. board. ____ ____

12. The (9) 3 1/2" (8,9cm) long green wires at hole locations marked 1,2,3,B,C, & E along the top edge of the P.C. board. ____ ____

13. The (6) 5" (12,7cm) long orange wires at hole locations marked 5,6,7,8,9, & 10 on the left side of the P.C. board. ____ ____

14. The 12" (30,5cm) long black wire at hole marked "GND" on P.C. board. ____ ____

15. The 12" (30,5cm) long blue wire at hole marked "+5" on P.C. board. ____ ____

16. The 12" (30,5cm) long red wire at hole marked "+12" on P.C. board. ____ ____

17. The 12" (30,5cm) long white wire at hole marked "-12" on P.C. board. ____ ____

DO NOT install the I.C. at this time.

This completesthe Power Supply Board Wiring.
Refer to Illustration 1 for the following steps:

18. Position the Power Supply Board over the Stand-Offs in the Housing and fasten with (3) 4-40 Hex Nuts and #4 Lockwashers. ____ ____

19. Slip a 1" (2,5cm) piece of Heatshrink Tubing over each green wire then solder the (3) sets of 3 green wires to the corresponding semiconductors at the rear inside of the Housing as shown. Slide the Tubing up over the entire lead and heat to secure. ____ ____

20. Solder the (6) orange wires to the terminals on the Transformer (T1): ____ ____
    Hole #5 to term. 5.
    Hole #6 to term. 6.
    Hole #7 to term. 7.
    Hole #8 to term. 8.
    Hole #9 to term. 9.
    Hole #10 to term. 10.

	CONST.	CHECK

The remaining 4 wires, black, blue, red, and white still go to the four Binding Posts on the Main Board at the Final Assembly.

F. Testing the Power Supply

1. Insert I.C. (U1) LM723 into socket. Be certain that pin 1 is located next to the dot on the P.C. board. _____ _____

2. Install the Fuse into the Fuseholder (F1). _____ _____
   1/2 amp for 115V.
   1/4 amp for 230V.

3. Check that the 4 unconnected wires are not touching each other or touching the Housing. _____ _____

4. Plug Line Cord into an Outlet and turn on Switch (S1). Red light on switch should glow. If this does not happen, unplug cord from power and re-check all wiring. _____ _____

5. Connect appropriate lead of D.C. voltmeter to black wire "GND." _____ _____

6. Touch the other lead of voltmeter to blue, red & white wires to read the following voltages: _____ _____
   Blue*................+5V ±5%
   Red..................+12V ±5%
   White................-12V ±5%

*Adjust the Thumbwheel on the Trimpot (R1) to obtain this value. If any voltages are missing or incorrect, unplug the power cord and recheck all wiring.

7. Install (4) Rubber Feet at the corners of the bottom of the Housing. _____ _____

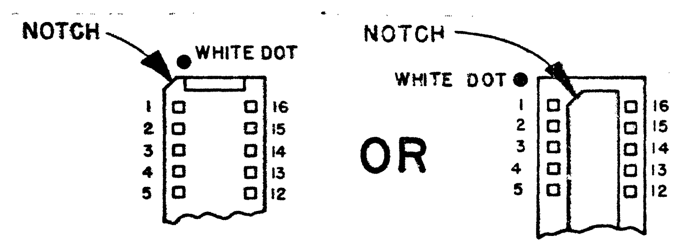
This completes Housing and Power Supply Assembly. Set aside and proceed to the Main Board Assembly.

VI. MAIN BOARD ASSEMBLY AND CHECKOUT (See Illustration 3)

CONST. CHECK

All solder connections are made on bottom (solder side of this board.

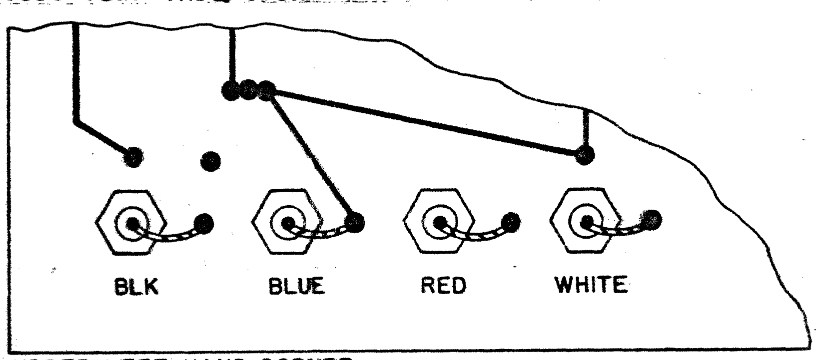
1. Insert and solder all I.C. sockets in their proper locations. Be extremely careful to avoid solder bridges between pins or adjacent clad. Pin 1 of the sockets is indicated by a notch or cut-off corner which is placed nearest to the white dot on the Main Board. Be certain that all leads protrude thru board and socket is flush with top of board before soldering. ____ ____



SOCKET INSTALLATION

2. Insert and solder the 40 pin ribbon connector. The connector supplied may be numbered 1 thru 40 or A thru VV. This is not important, just be sure that the horizontal pins for mating plug are on the right side of the board. ____ ____

3. Attach Binding Posts to Main Board as shown with colors in positions as indicated below. When tightening Binding Posts turn so that test lead holes are parallel with sides of board to allow test lead insertion. ____ ____



UPPER LEFT HAND CORNER
BOTTOM SIDE OF MAIN BOARD

4. Cut (4) 1" (5,1cm) pieces of 22 ga. buss wire; Insert each wire into the corresponding hole as shown and solder. Trim the excess wire from the top of the board.

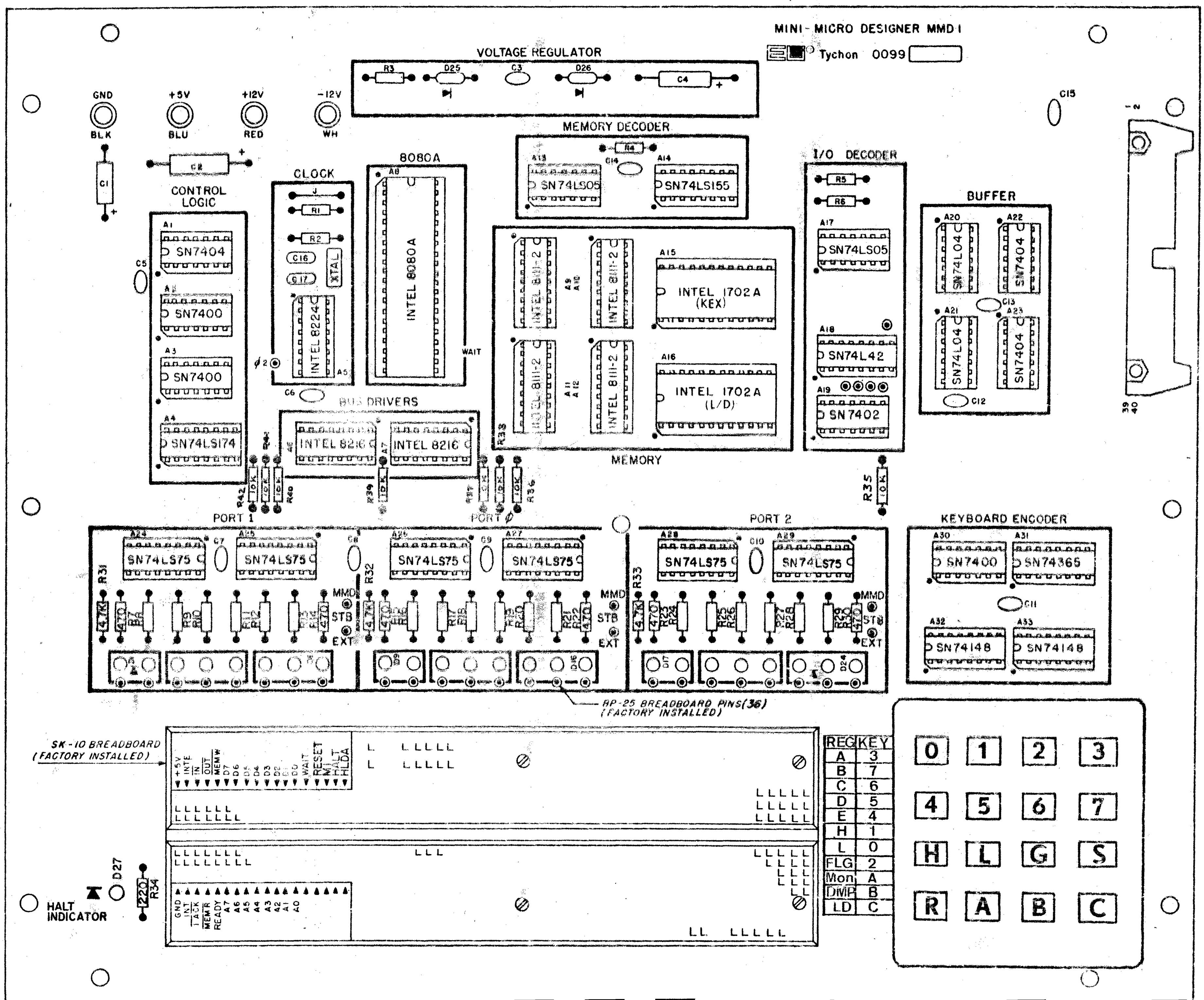
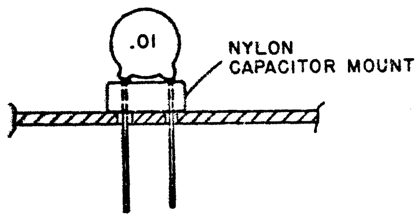


ILLUSTRATION #3

5. Insert nylon capacitor mounts over leads on (12) .01 mfd disc capacitors (C3, C5 thru C15) and insert and solder in the proper locations. ____ ____



6. Insert and solder the 33 mfd electrolytic capacitor (C1) and 5 mfd tant. capacitor (C2) at the top left hand corner of the board with (+) lead at the (+) silkscreened on the P.C. board. ____ ____

The following 4 steps Refer to Voltage Regulator Section

7. Insert and solder the following:
   a. The 2.2K resistor (R3). ____ ____
   b. The 1N751 5.1V Zener diode (D25). Observe Polarity. ____ ____
   c. The 1N746 3.3V Zener diode (D26). Observe Polarity. ____ ____
   d. The 3.3 mfd Electrolytic capacitor (C4). Observe Polarity. ____ ____

The following 4 steps Refer to Clock Section

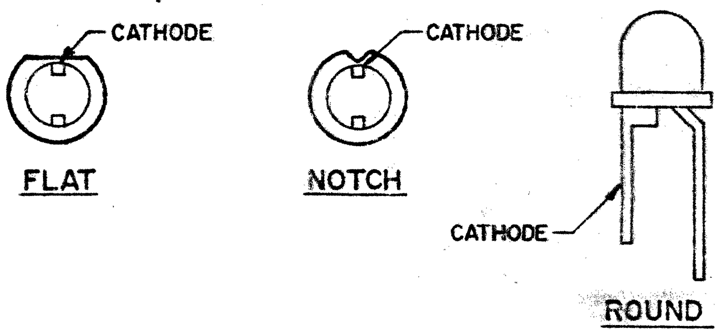
8. Insert and solder the following:
   a. The 22 ga. black wire jumper. ____ ____
   b. The (2) 1K resistors (R1 & R2). ____ ____
   c. The (2) 47 pf Mica capacitors (C16 & C17). ____ ____
   d. The 6.75 MHz crystal, (XTAL), using 1 capacitor mount. ____ ____

9. Insert and solder (1) 1K resistor (R4) in the Memory Decoder Section. ____ ____

10. Insert and solder (2) 1K resistors (R5 & R6) in the I/O Decoder Section. ____ ____

11. Insert and solder (24) 470Ω resistors (R7 thru R30) at the 3 ports, Ø, 1 & 2. ____ ____

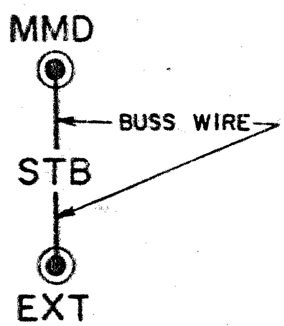
12. Insert and solder (24) Red L.E.D.'s (D1 thru D24). Be sure to note polarity.
Please be advised of the three types of L.E.D.'s E&L carries, as shown, on next page. One of these types is contained in this kit. ____ ____



CAUTION!!! The (24) L.E.D.'s are easily damaged by excessive heat during soldering. Install the L.E.D.'s such that they stand up 1/8" from the top of the P.C. Board Solder them in from the bottom side of the board, only. Do not solder them in from the top side of the board as this is unnecessary and risks damaging them from excessive heat.

13. Insert and solder the (3) 4.7KΩ resistors (R31 thru R33). _____ _____

14. Insert (3) 3/4" (19,1mm) pieces of buss wire into the (6) BP-25 pins marked "MMD," "STB," "EXT," as shown below. _____ _____



15. Insert and solder the large Red L.E.D. (D27) in the Halt Indicator spot next to the SK-10 socket on the P.C. Board Be sure that this L.E.D. is put in FLUSH with the top of the board and then soldered. Note polarity. _____ _____

16. Insert and solder the 220Ω resistor (R34) in P.C. Board next to large Red L.E.D. labeled Halt Indicator. _____ _____

VI. MAIN BOARD ASSEMBLY AND CHECKOUT (Continued)

	CONST.	CHECK
17. Insert and solder (8) 10KΩ Resistors R35 through R42.	_____	_____
18. Insert and solder the keyboard, making sure that the keyboard is mounted FLUSH with the top of the P.C. Board. Solder and clip the leads once it is mounted.	_____	_____
19. Peel Labels from backing for the SK-10 Bread-boarding socket and affix as shown in Illustration 3.	_____	_____
20. Place completed Main Board above the Housing, face down (solder side up), with the Binding Posts at the lower left.	_____	_____
21. Solder the (4) remaining wires, black, blue, red and white from power supply board to corresponding Binding Post terminals on Main Board.	_____	_____
22. Place Main Board on top of Housing Assembly and fasten with (6) 6-32 x 1/2" long screws.	_____	_____

You will now make some initial tests before inserting the integrated Circuit Chips.

A. Main Board Checkout

1. Plug unit into an outlet. Place switch (S1), in the UP position. The red light should come on. ______ ______

2. Connect common lead of D.C. Voltmeter to black binding post (GND). Check voltages at the following points. ______ ______

D.C. Volts	+5V	-5V	+12V	-9V
I.C. Number	Pin Numbers			
A8	20	11	28	--
A5	16	--	9	--
A6, A7	16	--	--	--
A9-A12	18	--	--	--
A15, A16	12,13,15 22,23	--	--	16,24*
A24-A29	5	--	--	--
A1-A3, A13, A17 A20-A23, A30	14	--	--	--
A4,A14,A18-A19, A31-A33	16	--	--	--

*Prom must be in place for -9V to be present.
Remember to reverse D.C. Voltmeter leads for Negative Voltage Checks.

3. Remove power from the MMD-1, and insert the SN74LS75 latches (A24 thru A29). Be sure to note how the I.C.'s go into their sockets. There is a small mark near pin 1 for all the I.C.'s. This is part of the white screening. With the latches installed, apply power to the system. All of the L.E.D.'s should be on. If any are not on, check the associated SN74LS75 latch. With power still applied, ground the data bus lines D0 thru D7 at the SK-10 socket one at a time. One of the L.E.D.'s in each group of eight should go out, one at a time. If this doesn't happen, again check the SN74LS75's. This will prevent accidental short circuits at the I.C.'s which could cause damage. ______ ______

4. The keyboard section consists of 16 keyswitches, 15 of which are used to input data and one of which is hardwired to the 8224 chip for the Reset function. The keyswitch closures are encoded in two SN74148 octal encoder chips and the encoded binary data is gated onto the bus through a three state DM8095 or SN74365 chip. Remove Power from the MMD-1, then insert the four integrated circuits,

A. Main Board Checkout

A30 thru A33. The keyboard is tested by monitoring the data on the L.E.D.'s. CAREFULLY ground pin 1 on A31 being very sure pin 2 is not also shorted. Also ground the $\overline{IN}$ line on the SK-10 socket. This will cause data from the keyswitch encoders to constantly be output to the bus. With these two points grounded, apply power and depress the keys, one at a time. The binary data for each keyswitch will be observed on the L.E.D.'s at all of the output ports, simultaneously. You will also note that the most significant bit, D7, will be on whenever one of the keys is depressed. This is often called a 'flag' since it is used to flag down the computer and tell it that one of the switches is ready with data. The second, third, and fourth most significant digit may be on, as they are not directly connected to the keyboard encoder. The lower left key will not output any data since it is hardwired to the 8224 clock chip. You can check this key's operation by testing the voltage at pin 1 of A5, the 8224 clock chip. When A5 is installed, it should normally be at about zero volts and will go to about 3 volts when the reset key is depressed.

5. After I.C. voltages, L.E.D. display and keyboard sections have been tested, install the remaining I.C.'s Remember to be sure that the I.C.'s are properly oriented as shown on the screened legends on the P.C. Board. Be sure that the R/W Section is installed correctly w/all four 18 pin sockets and all four 8111's going in sections 2 and 3, the KEX PROM (1702A) going in position 0, and the L/D PROM (1702A) going in position 1. (Refer to Illustration 3). If you have not already done so, obtain one of the 1702A PROMs with the Keyboard Executive (KEX) software, and one 1702A PROM with the Load/Dump (L/D) software in it. Preprogrammed PROMs are available (see Parts List) and if you already have a 1702A PROM, it may be programmed from the listing provided. There are currently a number of 1702A type PROMs available. These are 4702A and 8702A. These are pin-for-pin equivalents of the 1702A, but their access times are slower. The 1702A PROMs or equivalents should have a maximum access time of about 1300 nanoseconds to work with the Mini-Micro. If you purchase a 'surplus' PROM, be sure that these conditions are met. The PROM containing the KEX software must be placed in the PROM position 0. It will not work correctly if placed in position 1 since the addresses will be incorrect. The PROM containing L/D software must be placed in the PROM position 1. It will not work correctly if placed in position 0 since the addresses will be incorrect.

A. Main Board Checkout

6. Turn on the power with all the I.C.'s in place and check the power supply voltages at the Binding Posts. They should be at their preset levels of +5 and ±12 volts. If these are correct, your Mini-Micro system should be operational. ______ ______

7. Depress the Reset key, R. The L.E.D. displays should now indicate 003 or 00000011 at the HI and 000 or 00000000 at the LO. The Output Port 2 L.E.D.'s may have some random data present. If this doesn't happen, remove the power and carefully check your system. Things to check for are solder bridges, cold joints, unsoldered I.C. pins and incorrect I.C. orientation. Plated through holes don't have to be soldered unless there is a component or other lead going through them. Also check for +5 volts and ground at all the I.C.'s. Refer to Step 2 of Main Board Checkout. ______ ______

8. If the L.E.D.'s are on in the correct pattern, depress and release the S key. Each time that this key is pressed, the LO address information should be incremented by 1. If this doesn't happen, check the keyboard encoder section and the Input/Output sections of the Mini-Micro. ______ ______

9. If the L.E.D's are operating correctly, try and enter some data, 0 through 7 from the keyboard. The binary codes for these switches should enter the Data Register display (Port 2) in the three least significant bits. You will note that as new data is entered the old data is shifted to the left where it finally disappears as more new data is entered. The actual operation of the KEX software to input and output data is discussed later in the KEX software section. ______ ______

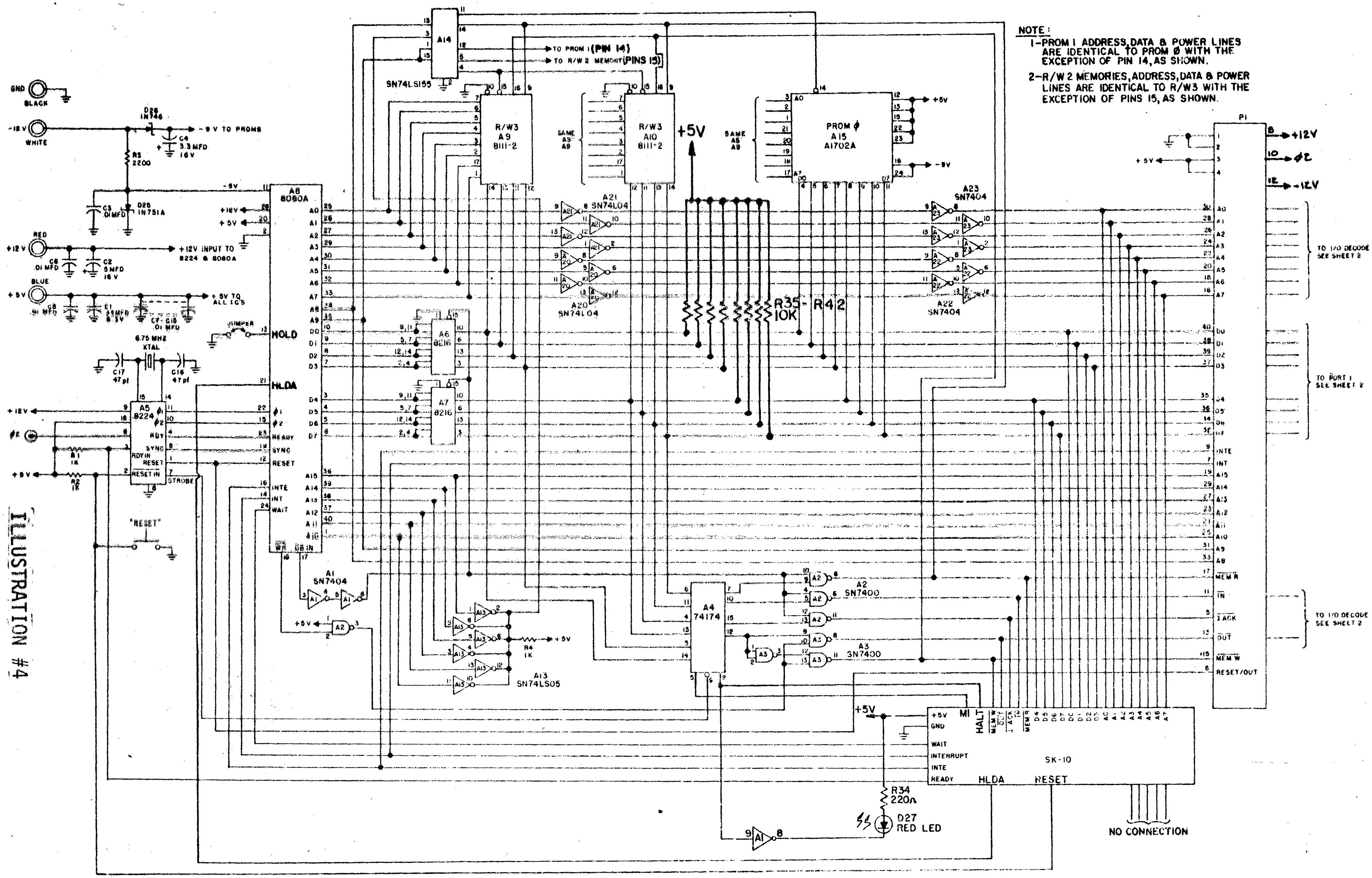


ILLUSTRATION #4

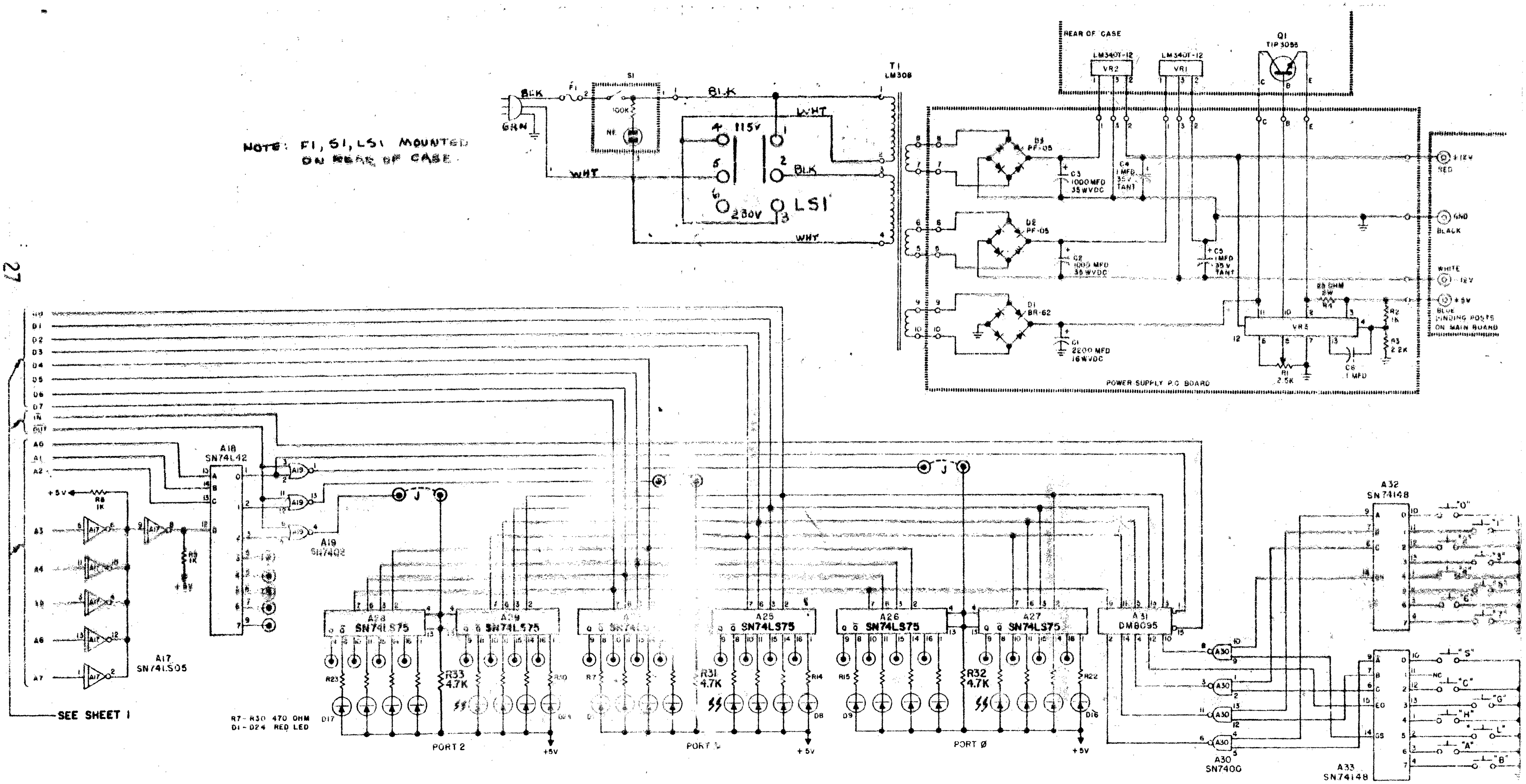


ILLUSTRATION #5

VII. Operation-How to Use the Mini-Micro

The Keyboard Executive software is the 'heart' of the system. It allows you to examine data or program steps and it allows you to change data or program steps stored in the R/W portion of the memory. We can also specify any address and start the program there. The keyswitches are labeled 0-7 for octal data, H for HI Address, L for LO Address, G for Go and S for See and Store. Three keys are not used by the KEX, A, B and C. The Reset key, R, will always reset the computer and restart the KEX if its PROM is in place. All manual data entry is through the keyboard in the basic Mini-Micro system and there are no binary toggle switches to worry about.

Whenever you want to start the system, depress R. This will reset the KEX and it will always output the first address in the R/W block of memory in section 3. This is HI=003 and LO=000. If you will only be using one block of R/W memory to get started, it MUST be in block 3. The KEX will not function without R/W memory in section 3.

To enter data, whether it will be used for new data or addresses, simply depress the numbered keys as you would on a calculator. Data will be entered into the three least significant (right-most) LEDs and it will shift to the left as more data is entered. If a mistake is made, simply reenter the data. Mistakes are shifted out the left side and lost. The Data Register LEDs will display the data just entered from the keyboard and this may be used as HI Address data by depressing H, or it may be used as LO Address data by depressing L. These keys will transfer the data to the proper LED display register and it will be used by the 8080A to address a new memory location.

Whenever a new H or L is specified by actuating one of these two keys, the KEX will always output the contents of the specified location on the Data Register LEDs. To examine the next location, depress the S key for its See function. By depressing S again and again, we can examine data in sequential memory locations. It should be noted that this See function follows increasing memory locations, not the sequential flow of a program.

To change the data in a R/W memory location, simply load the address using the data input key and the H and L keys. The old data presently in the location will immediately appear on the Data Register LEDs. Enter the new data into the Data register using the numeric keys and then enter it into the R/W location by depressing the S key for the Store function. After S is actuated, the new data is stored and the address is automatically incremented by one to go to the next location. The data from the next location is now displayed on the Data Register LEDs. The S key has two functions, both See and Store. How can we tell the difference? If the data has changed we will store it and see the next location. If the data hasn't changed, we will store it back where it came from and then see the next location. When we store old data back to the location from which we got it,we can't really see any change, but this is exactly what the KEX does. It inputs data from the specified location, allows us to make changes and then puts it back. If no changes are made, the old data is restored to its memory location.

Once a program is entered into the computer through the keyboard, we can start it by loading our starting address and actuating the G or Go key. This will transfer control from the KEX software to the software that we want to try. Starting addresses are loaded in the same way that we use them to examine and alter locations. Starting addresses don't have to be in R/W memory, but can just as easily be in PROM.

If your program starts at the first location in R/W memory, 003 000, you can simply depress R followed by G. We can do this because KEX always resets the address back to this first R/W location.

Keys labeled A, B and C are not used by KEX. It should be remembered that the three LED output ports and the keyboard input port are not hardwired for KEX alone. They are available for you to use in your programs. All fifteen keys may be used in any way you like, using software.

Keyboard Executive Software

The Keyboard Executive software is in a single 1702A type PROM which goes in PROM socket 0. This contains all the necessary software to operate the keyboard and the LED displays. This is our software controlled 'front panel',since the keys and LEDs perform functions determined by the KEX software.

How KEX Operates

Whenever the R key is depressed, the 8080A CPU chip will start to execute the program that starts at location 0. Looking at the software listing for KEX you will see that immediately after starting at location 0, the software instructions cause the computer to jump to location HI=000, LO=070 (HI=000 throughout KEX) where we START the program by pointing to the first R/W memory address in our minimum system, 003 000. The address and the data in that location are displayed on the three output ports. This is done between POINTA and POINTC. The software between POINTC and POINTD will do the necessary tasks to input new data from the keyboard and shift the data onto the LEDs. The shifting is done inside the 8080A with software instructions. Doing this in hardware would take many more chips, but it takes relatively few software steps. The software routines at POINTD, POINTE, POINTF and POINTG make up what is called a command decoder. The software decodes the key codes into real actions. Depressing H or L causes the data temporarily stored in the 8080A as numeric key inputs to be output to either the HI or LO set of LEDs. The S key code causes the current or new data to be put back into the memory location that we are looking at. Depressing G causes the computer to use the HI and LO address as the starting point for a new program.

The TIMOUT and KBRD software subroutines have specific tasks. TIMOUT will count its way through various loops for about 10 milliseconds, while the KBRD subroutine will input code from the keyboard. The KBRD subroutine has some unique features which illustrate an interesting hardware-software tradeoff. The keyswitches used in the Mini-Micro are not bounce free, so that when contacts are opened or closed, they can often re-make or re-break the contacts. This can be confusing to the computer since it can't distinguish between a real switch closure and a bounce. We don't want the computer to sense each bounce as a key closure so we would like some way to filter them out. Additional circuitry including latches, clocks and monostables could do this for us, but it complicates the system. We can also do the debouncing in software. The KBRD subroutine will recognize any key closure, but it will only input the key codes after being sure that the key is closed and not bouncing. It does this by waiting after sensing closure and then rechecking the switch to be sure it is still closed. It also checks when we release a key to be sure that it has stopped bouncing before it tries to sense another key being depressed by the user. We have traded some additional software steps for a great deal of hardware. Since we had plenty of PROM left, it was easy to include.

Since the TIMOUT and KBRD software segments have been set up as subroutines, you can use them in your software and in the experiments. Each of these subroutines may be started with a CALL instruction, 315.

The TIMOUT subroutine does not affect any of the registers or flags and it only serves to delay the software flow by 10 msec. The KBRD subroutine will return with the key code for the depressed key in the A register in the 8080A CPU chip. Flags and, of course, the A register have been used and modified.

An important distinction between the 8008 and the 8080 processors is in the use of subroutines. In the 8008, return pointer addresses were stored in the 8008 chip itself. In the 8080, these return pointer addresses are stored in a portion of the R/W memory. This is called a "stack" area, Whenever a subroutine is used we want to do the subroutine's task and then return back to the normal program flow. These return addresses are very important to the computer since they provide the only link between the subroutine and the main program. If we are to store them in a portion of R/W memory, the computer must know where this storage area is if it is to be able to use the addresses properly. In the KEX software this is set to be the top of the R/W memory with instructions at locations 070, 071 and 072. The LXISP instruction loads an internal 8080 stack Pointer Register to HI=004, LO=000. Since the Stack Pointer Register is decremented to point to a new location before anything is stored, the first stack location will be HI=003, LO=377. Check your sixteen bit binary numbers if this looks a little confusing.

You can use the stack as set up by the KEX (generally a good idea) or you can put your own stack anywhere you want, just by using the LXISP instruction. Remember to avoid the stack area when writing your programs. Remember, too, that you can't put the stack in an area of non-existent memory or in PROM.

You will use the stack area and you'll see how it can also be used to temporarily store data. This will be covered in the software modules. Let's see how the TIMOUT and KBRD subroutines can be used in our own software. We will use the software stack already set up in KEX.

Let's input a keyboard character, add a constant to it and display the result. We would first CALL the KBRD subroutine to input a binary key code, then add the constant and display the result.

The following software will do this:

HI	LO	INSTR	MNEMONIC	
003	000	315	CALL	/Input keyboard character
003	001	315	KBRD	/Subroutine's LO address
003	002	000	0	/Subroutine's HI address
003	003	306	ADI	/Add the following DATA to
003	004	???	DATA	/the contents of register A
003	005	323	OUT	/Output data from register A to
003	006	000	000	/device 000 (LEDs)
003	007	303	JMP	/Jump back to program at
003	010	000	000	/LO address =000
003	011	003	003	/HI address =003

You can enter this with KEX, just restart, specify HI=003 and LO=000 and start entering data. Enter 000 at location 003 004 so we'll first add zero to the codes. This will let us check what values are assigned to each key. Write down the codes. Go back and restart KEX and change the value in 003 004 to, say, 005. This will add 5 to each code. Restart your software and see if this is the case. Congratulations, you have just done your first software experiment! The instructions at 003 003 and 003 004 could be changed to do other things to the data. Can you suggest one?

The 10 msec delay routine, TIMOUT, can be useful when we want a software delay that is in multiples of 10 msec. The following software routine will delay an output of all 1's on Output Port 0 by about 2.5 seconds after the program is started. Try it. Can you see how the time delay might be shortened? Can you see any use for programs like this?

Assume HI=003 throughout this program:

LO	INSTR	MNEMONIC	
000	006	MVIB	/Load register B with the following data
001	370	370	/Data: time constant
002	315	CALL	/Call TIMOUT subroutine at
003	277	277	/LO address =277
004	000	000	/HI address =000
005	005	DECB	/Decrement B by 1
006	302	JNZ	/Jump if result is not zero to
007	002	002	/LO address =002
010	003	003	/HI address =003
011	076	MVIA	/Load register A with the following data
012	377	377	/Data; all 1's
013	323	OUT	/Output to device,
014	000	000	/device 000 (LEDs)
015	166	HLT	/Stop once you reach here

The keyboard input subroutine, KBRD, is called at address 000 315 and the time delay subroutine, TIMOUT, is called at address 000 277.

The 8080A Microprocessor

The 8080A type microprocessor chip is an eight bit paralled central processing unit (CPU) in which data is operated upon and decisions made. Unlike the earlier 8008 and 8008-1, the 8080A is a more powerful, easy to use device. The 8008 was an 18 pin device and many things were multiplexed on the same bus. The 8080A is a 40 pin package which offers many advantages over the earlier devices:
- simplified bus, separate address (16 bits) and data (8 bits) buses
- three state and TTL compatible buses
- simplified control
- improved interrupt and stack
- more instructions

While the power and clock requirements for the 8080A are a bit more complex than for the 8008, they are easily met.

How the Mini-Micro Works

The Mini-Micro uses the same basic computer functions found in most other computers, large or small. These are:

- Central processing unit (CPU)
- Memory (R/W and PROM)
- Control Logic
- Input/Output Control
- Clock and power supplies

The 8080A has 24 data output lines, sixteen of which are used for address information and eight of which are a bidirectional data bus taking data to and from the CPU. The data flow on the data bus is controlled by the DBIN or Data Bus IN signal output by the 8080A chip on pin 17. Two bus buffers, Intel type 8216, are used to boost or buffer the data bus outputs and to protect the 8080A's imputs. The DBIN signal switches the 8216 buffer chips for either input or output of data on the bus.

The system's operation is controlled by signals output by the 8080A at various times as synchronized by the clock frequency. An Intel 8224 clock chip with a 6.75 MH_z crystal is used to provide the 750 KH_z MOS clock levels to the 8080A. These clocks are slightly out of phase and are nonoverlapping. While the 8080A chip can operate at frequencies up to 2 MH_z, the Mini-Micro's clock has been set to 750 KH_z so that it will work with the relatively slow 1702A type PROMs. You can increase the speed of the Mini-Micro by using a higher frequency crystal. The 8224 chip divides the crystal's frequency by nine, so an 18 MH_z crystal will give the 2 MH_z output needed for the highest operating speed.

The clock chip also synchronizes the Ready input with the clock so that system can slow down for slow memories and I/O devices. The Reset input from the R key is also input to the 8224 chip where it, too, is synchronized to the clock, and output to reset the 8080A.*

The 8080A's data bus will also contain some STATUS information which is used by the Control Logic section to synchronize its control operations. The STATUS information is output and is available when the SYNC signal is output from the 8080A. The 8224 clock chip gates the SYNC pulse from the 8080A with the main system clock to provide a very short $\overline{STSTB}$ signal or Status Strobe which 'catches' the status information in the SN74174 latch. The status information indicated data output,data input, halt condition, memory read, memory write and a special condition which signals the start of the next instruction, M1. Four of these status signals are gated with other system signals to provide the $\overline{IN}$, $\overline{OUT}$, $\overline{MW}$ and $\overline{MR}$ signals used throughout the Mini-Micro. These signals are used as indicated on the next page.

* For more information about these signals and chips, see Intel's 8080 Microcomputer System User's Manual, Sept. 1975 and Bugbooks V and VI , for further information.

$\overline{IN}$ and $\overline{OUT}$ - used to synchronize data flow to ($\overline{IN}$) and from ($\overline{OUT}$) the 8080A CPU. They are used with external devices for data transfer.

$\overline{MR}$ and $\overline{MW}$ - used to indicate to the memory that the computer is executing a Memory Read or a Memory Write.

$\overline{INTA}$ - indicates that the computer has acknowledged an interrupt.

HALT and M1 - latched and provided for the user. These are not used in the Mini-Micro, but are described in the experiment modules and are available for your use.

When the 8080A addresses memory, one and only one address must be specified on the 16 bit address lines. Since the 1702A and the 8111-2 memories only have eight input address lines to address their 256 locations, the remaining eight address lines must be used to select one and only one of the memory blocks. We can select from two blocks of PROM, two blocks of R/W or possibly no blocks on the Mini-Micro if we have expanded the memory off the card.

Address lines A0 through A7 are applied directly to the memory chips on the Mini-Micro card. Address lines A10 through A15 are gated in a six input NOR gate made from an SN74LS05 open collector inverter, IC13. When this gate's output is a logic 1, it indicates that we are selecting one memory location within the first 1024 locations. Address lines A10 - A15 are equal to logic 0. This would be one of the locations in either R/W or PROM, since these are located within the first 1024 locations. If the NOR gate indicates a logic 0, at least one of the address inputs, A10 -A15, must be at a logic 1, indicating that we are now addressing memory outside the blocks on the Mini-Micro. Address bits A8 and A9 and the memory read signal $\overline{MR}$ are gated together in an SN74LS155 decoder to select the proper block of the four possible on the Mini-Micro card. The 8111-2 memories input the memory read and memory write signals to control the flow of data from and to the CPU. The 1702A PROM has only a chip select input, so the memory read synchronizing signal is used in the SN74LS155 to gate data from the 1702A onto the bus at the correct time. Table 1 shows the memory selection.

Table 1. MEMORY SELECTION

NOR Gate Output	A9	A8	$\overline{MR}$	Memory Selected
0	X	X	X	NONE
1	0	0	0	PROM 0
1	0	1	0	PROM 1
1	0	0	1	NONE
1	0	1	1	NONE
1	1	0	X	R/W 2 *
1	1	1	X	R/W 3 *

* MR and MW applied independently to the 8111-2 chips
X = Don't care condition, logic 0 or logic 1

Data flows to and from the memory on the bidirectional data bus and the sixteen bit address bus specifies each location. This address bus is also used to help control the flow of data to and from external devices. The eight least significant or LO address bits can specify one of 256 possible peripheral devices. The address bits are decoded in the Mini-Micro to select one of four possible on-board devices. These are the three groups of LEDs and the keyboard. Address bits A3 - A7 are all ORed together in IC17, an OR gate made from a series of open-collector inverters in an SN74LS05 chip. If the eight bit LO address outputs a value greater than seven, the OR gate's output becomes a logic 1. Address bits A0 - A2 are used in IC 18, an SN74L42 decoder chip to provide a one-out-of-eight code for devices 0 to 7. The OR gate's output is used to enable the decoder for device coded 0 - 7, but to disable it for other codes. The decoding scheme is shown in Table 2.

Table 2. On-Board I/Q DEVICE DECODER

OR Gate Output	A2	A1	A0	Mini-Micro Device
1	X	X	X	NONE
0	0	0	0	LED Port 0, Keyboard
0	0	0	1	LED Port 1
0	0	1	0	LED Port 2
0	0	1	1	Available for user
0	1	0	0	Available for user
0	1	0	1	Available for user
0	1	1	0	Available for user
0	1	1	1	Available for user

X = Don't care condition, logic 1 or logic 0.

You will notice that device code 0 selects both the LED Port 0 and Input Port 0, the keyboard. How can the computer output and input data at the same time. It can't, and some means must be used to distinguish between them. The Control Logic section outputs two control signals, $\overline{IN}$ and $\overline{OUT}$ which indicate whether data will be input to the CPU or output to an external device. Both signals are exclusive, never taking place at the same time. The pulses are generated by the 8080A and the Control Logic section under control of our software. Only when we execute an I/O type instruction will either of these signals be generated. The device codes for theSN74LS75latches are gated with $\overline{OUT}$ in IC19, a NOR gate package, and the $\overline{IN}$ is gated with the keyboard device doce in the DM8095 buffer chip associated with the keyboard, IC31. Data is input or output only when we have a valid device code and either $\overline{IN}$ or $\overline{OUT}$.

A software-hardware user's group has been formed for the Mini-Micro. People interested should contact:

Digital Directions, Editor
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61 First St.
Derby, CT 06418

VIII. KEX PROM PROGRAM LISTING (OCTAL)

```
ADDRESS       DATA
HI  LOW       B7...B0

                                 *000 000
000 000        303               JMP
000 001        070               START
000 002        000               0


                                 / JUMP UP 10 R/W MEMORY TO BE USED BY
                                 / RESTARTS & VECTORED INTERRUPTS

                                 *000 010
000 010        303               JMP
000 011        010               010
000 012        003               003
                                 *000 020
000 020        303               JMP
000 021        020               020
000 022        003               003
                                 *000 030
000 030        303               JMP
000 031        030               030
000 032        003               003
                                 *000 040
000 040        303               JMP
000 041        040               040
000 042        003               003
                                 *000 050
000 050        303               JMP
000 051        050               050
000 052        003               003
                                 *000 060
000 060        303               JMP
000 061        060               060
000 062        003               003


                                 / BEGINNING OF MAIN PROGRAM

                                 *000 070
000 070        061    START,     LXISP    /SET STACK POINTER TO TOP OF R/W MEM.
000 071        000               000
000 072        004               004
000 073        041               LXIH     /INITIAL VALUE OF H & L
000 074        000               000
000 075        003               003
000 076        116    POINTA,    MOVCM    /LOAD MEM DATA INTO TEMP DATA BUFFER
000 077        174               MOVAH    /OUTPUT HI TO LED'S
000 100        323               OUT
000 101        001               001
000 102        175               MOVAL    /OUTPUT LOW TO LED'S
```

VIII. KEX PROM PROGRAM LISTING (OCTAL)

```
ADDRESS      DATA
HI  LOW      B7...B0

000 103      323               OUT
000 104      000               000
000 105      171    POINTB,    MOVAC    / OUTPUT TEMP. DATA BUFFER DATA TO LED'S
000 106      323               OUT
000 107      002               002
000 110      315    POINTC,    CALL     / WAIT & INPUT NEXT KEY CLOSURE
000 111      315               KBRD
000 112      000               0
000 113      376               CPI
000 114      010               010
000 115      322               JNC      / JUMP IF KEY WAS < 010
000 116      134               POINTD   /    (0-7 , OCTAL DIGIT )
000 117      000               0
000 120      107               MOVBA    / SAVE KEY CODE
000 121      171               MOVAC    / GET OLD VALUE
000 122      027               RAL      / ROTATE 3 TIMES
000 123      027               RAL
000 124      027               RAL
000 125      346               ANI      / MAK OUT LEAST SIG. OCTAL DIGIT
000 126      370               370
000 127      260               ORAB     / OR IN NEW OCTAL DIGIT
000 130      117               MOVCA    / PUT NEW DATA BACK INTO BUFFER
000 131      303               JMP
000 132      105               POINTB
000 133      000               0
000 134      376    POINTD,    CPI
000 135      011               011      / "L" KEY
000 136      302               JNZ      / JUMP IF NOT AN "L"
000 137      145               POINTE
000 140      000               0
000 141      151               MOVLC    / PUT BUFFER DATA IN L
000 142      303               JMP
000 143      076               POINTA
000 144      000               0
000 145      376    POINTE,    CPI
000 146      010               010      / "H" KEY
000 147      302               JNZ      / JUMP IF NOT AN "H"
000 150      156               POINTF
000 151      000               0
000 152      141               MOVHC    / PUT BUFFER DATA IN H
000 153      303               JMP
000 154      076               POINTA
000 155      000               0
000 156      376    POINTF,    CPI
000 157      013               013      / "S" KEY
000 160      302               JNZ      / JUMP IF NOT "S"
000 161      170               POINTG
000 162      000               0
000 163      161               MOVMC    / PUT TEMP. DATA INTO MEMORY
000 164      043               INXH     / INCERMENT H & L
000 165      303               JMP
000 166      076               POINTA
000 167      000               0
000 170      376    POINTG,    CPI
```

VIII. KEX PROM PROGRAM LISTING (OCTAL)

```
ADDRESS      DATA
HI  LOW      B7...B0

000 171      012                012      / "G" KEY
000 172      302                JNZ      / JUMP IF NOT "G"
000 173      110                POINTC
000 174      000                0
000 175      351                PCHL     / GO EXECUTE PGM POINTED TO BY H & L

                                / THIS 10 MSEC DELAY DISTURBS NO REGISTERS OR FLAG

                                *000 277
000 277      365      TIMEOUT,PUSHPSW / SAVE REGISTERS
000 300      325                PUSHD
000 301      021                LXID     / LOAD D & E WITH VALUE TO BE DECREMENTED
000 302      046                046
000 303      001                001
000 304      033      MORE,     DCXD     / JUMP IN THIS LOOP UNTIL
000 305      172                MOVAD    /     D & E ARE BOTH ZERO
000 306      263                ORAE
000 307      302                JNZ
000 310      304                MORE
000 311      000                0
000 312      321                POPD
000 313      361                POPPSW   / RESTORE REGISTERS
000 314      311                RET

                                / THE KBRD ROUTINE DEBOUNCES KEY CLOSURES
                                /     AND TRANSLATES KEY CODES

                                / FLAGS AND REG A ARE CHANGED
                                / A0-A3= CODE  ; A4-A7= 0000

000 315      333      KBRD,     IN       / INPUT FROM KEYBOARD ENCODERS
000 316      000                000
000 317      267                ORAA     / SET FLAGS
000 320      372                JM       / JUMP BACK IF LAST KEY NOT RELEASED
000 321      315                KBRD
000 322      000                0
000 323      315                CALL     / WAIT 10 MSEC
000 324      277                TIMOUT
000 325      000                0
000 326      333      FLAGCK,   IN
000 327      000                000
000 330      267                ORAA
000 331      362                JP       / JUMP BACK TO WAIT FOR A NEW
000 332      326                FLAGCK   /   KEY TO BE PRESSED
000 333      000                0
000 334      315                CALL     / WAIT 10 MSEC FOR BOUNCING
000 335      277                TIMOUT
000 336      000                0
000 337      333                IN
000 340      000                000
000 341      267                ORAA
000 342      362                JP       / JUMP BACK IF NEW KEY NOT STILL
```

VIII. KEX PROM PROGRAM LISTING (OCTAL)

```
ADDRESS      DATA
HI  LOW      B7...B0

000 343       326            FLAGCK  / PRESSED (FALSE ALARM)
000 344       000            0
000 345       346            ANI     / MASK OUT ALL BUT KEY CODE
000 346       017            017
000 347       345            PUSHH   / SAVE H&L
000 350       046            MVIH    / ZERO H REG
000 351       000            000
000 352       306            ADI     /ADD THE ADDRESS OF THE BEGINNING OF
000 353       360            360     / THE TABLE TO THE KEY CODE
000 354       157            MOVLA   /
000 355       176            MOVAM   / FETCH NEW VALUE FROM TABLE
000 356       341            POPH    / RESTORE H & L
000 357       311            RET

                             / THIS TRANSLATION TABLE CONVERTS THE CODE
                             / GENERATED BY KEY CLOSURES TO THE CODE
                             / USED BY THE MAIN KEX PROGRAM

000 360       000   TABLE,   000
000 361       001            001
000 362       002            002
000 363       003            003
000 364       004            004
000 365       005            005
000 366       006            006
000 367       007            007
000 370       013            013     / S
000 371       000            000     / THIS CODE CAN'T BE GENERATED
000 372       017            017     / C
000 373       012            012     / G
000 374       010            010     / H
000 375       011            011     / L
000 376       015            015     / A
000 377       016            016     / B
```

IX. LOAD/DUMP PROM PROGRAM LISTING (OCTAL)

This is a listing of the Loader/Dump program when resident in the main board PROM (PROM "1").

```
                                / 7-13-76  MMD-1 M-I Routines
                                / THE FOLLOWING ROUTINES ARE USED WITH THE
                                / MMD-1 MEMORY-INTERFACE BOARD


                                / THE READ FROM CASSETTE ROUTINE, RCAS, READS
                                / DATA FROM THE CASSETTE AND STORES IT IN
                                / SUCESSIVE MEMORY LOCATIONS ON THE M-I
                                / BOARD, STARTING AT 030 000.  AS THE DATA IS INPUT
                                / IT IS DISPLAYED ON THE MMD-1'S LEDS.

                                001  000

001 000  041   RCAS,            LXIH    / INITIALIZE THE MEMORY POINTER
001 001  000                    000
001 002  030                    030
001 003  333                    IN      / CLEAR FLAGS IF NECESSARY
001 004  022                    022
001 005  315   NEXTIN,          CALL    / INPUT A BYTE OF DATA
001 006  103                    CASIN
001 007  003                    0
001 010  167                    MOVMA   / STORE THE DATA
001 011  323                    OUT     / OUTPUT DATA AND ADDRESS
001 012  002                    002
001 013  175                    MOVAL
001 014  323                    OUT
001 015  000                    000
001 016  174                    MOVAH
001 017  323                    OUT
001 020  001                    001
001 021  043                    INXH    / INCREMENT THE MEMORY POINTER
001 022  303                    JMP     / JUMP BACK FOR MORE DATA
001 023  005                    NEXTIN
001 024  001                    0


                                / THE WRITE ONTO CASSETTE ROUTINE, WCAS, IS USED
                                / TO STORE ON CASSETTE FROM 1 TO 8 256 BYTE BLOCKS
                                / OF MEMORY STARTING AT 030 000.  ONCE THE ROUTINE
                                / HAS BEEN STARTED, A KEY ON THE MMD-1 KEYBOARD IS
                                / PRESSED TO INDICATE HOW MANY 256 BYTE BLOCKS ARE
                                / TO BE TRANSFERED. (KEY "0" INDICATES 8 BLOCKS.)
                                / THEN AFTER A 5 SECOND DELAY THE DATA IS WRITTEN
                                / ONTO THE CASSETTE; AFTER ANOTHER 5 SECOND DELAY
                                / CONTROL IS RETURNED TO KEX.

001 025  041   WCAS,            LXIH    / INITIALIZE THE MEMORY POINTER
001 026  000                    000
001 027  030                    030
001 030  315   KEY,             CALL
```

IX. LOAD/DUMP PROM PROGRAM LISTING (OCTAL)

```
ØØ1 Ø31  315            315     / KEX KEYBOARD INPUT ROUTINE
ØØ1 Ø32  ØØØ            ØØØ
ØØ1 Ø33  376            CPI     / CHECK FOR Ø-7
ØØ1 Ø34  Ø1Ø            Ø1Ø
ØØ1 Ø35  322            JNC     / IF NOT, JUMP BACK
ØØ1 Ø36  Ø3Ø            KEY
ØØ1 Ø37  ØØ1            Ø
ØØ1 Ø4Ø  267            ORAA    / S SET FLAGS
ØØ1 Ø41  3Ø2            JNZ
ØØ1 Ø42  Ø46            NOTØ
ØØ1 Ø43  ØØ1            Ø
ØØ1 Ø44  3Ø6            ADI     / ADD 8 IF ZERO KEY
ØØ1 Ø45  Ø1Ø            Ø1Ø
ØØ1 Ø46  2Ø4   NOTØ,    ADDH    / COMPUTE STOPPING ADDRESS
ØØ1 Ø47  127            MOVDA   / SAVE IT IN REG D
ØØ1 Ø5Ø  315            CALL    / DELAY FOR 5 SECONDS
ØØ1 Ø51  13Ø            FIVSEC
ØØ1 Ø52  ØØ1            Ø
ØØ1 Ø53  176   MORE,    MOVAM   / GET DATA FROM MEMORY
ØØ1 Ø54  315            CALL    / OUTPUT TO CASSETTE
ØØ1 Ø55  114            CASOUT
ØØ1 Ø56  ØØ1            Ø
ØØ1 Ø57  323            OUT     / DISPLAY DATA AND ADRESS
ØØ1 Ø6Ø  ØØ2            ØØ2
ØØ1 Ø61  175            MOVAL
ØØ1 Ø62  323            OUT
ØØ1 Ø63  ØØØ            ØØØ
ØØ1 Ø64  174            MOVAH
ØØ1 Ø65  323            OUT
ØØ1 Ø66  ØØ1            ØØ1
ØØ1 Ø67  Ø43            INXH    / INCREMENT THE MEMORY POINTER
ØØ1 Ø7Ø  174            MOVAH
ØØ1 Ø71  272            CMPD    / CHECK FOR END OF LOOP
ØØ1 Ø72  3Ø2            JNZ     / JUMP BACK IF MORE DATA TO BE OUTPUT
ØØ1 Ø73  Ø53            MORE
ØØ1 Ø74  ØØ1            Ø
ØØ1 Ø75  315            CALL    / DELAY 5 SECONDS
ØØ1 Ø76  13Ø            FIVSEC
ØØ1 Ø77  ØØ1            Ø
ØØ1 1ØØ  3Ø3            JMP     / RETURN TO KEX
ØØ1 1Ø1  Ø7Ø            Ø7Ø
ØØ1 1Ø2  ØØØ            ØØØ

                        / THE CASSETTE INPUT SUBROUTINE, CASIN, WAITS
                        / FOR DATA TO BE RECEIVED BY THE CASSETTE
                        / UART, AND INPUTS THE DATA.

ØØ1 1Ø3  333   CASIN,   IN      / INPUT STATUS BITS
ØØ1 1Ø4  Ø23            Ø23
ØØ1 1Ø5  Ø37            RAR
ØØ1 1Ø6  322            JNC     / JUMP BACK IF NO DATA AVAILABLE YET
ØØ1 1Ø7  1Ø3            CASIN
```

IX. LOAD/DUMP PROM PROGRAM LISTING (OCTAL)

```
ØØ1 11Ø  ØØ1               Ø
ØØ1 111  333               IN       / INPUT DATA
ØØ1 112  Ø22               Ø22
ØØ1 113  311               RET


                           / THE CASSETTE OUTPUT SUBROUTINE, CASOUT, WAITS
                           / IF THE TRANSMITTER HOLDING REGISTER IS FULL,
                           / AND THEN OUTPUTS THE DATA

ØØ1 114  365  CASOUT,      PUSHPSW / SAVE DATA
ØØ1 115  333               IN      / INPUT STATUS BITS
ØØ1 116  Ø23               Ø23
ØØ1 117  346               ANI
ØØ1 12Ø  ØØ4               ØØ4
ØØ1 121  312               JZ      / JUMP IF TRANSMISSION REG. NOT EMPTY
ØØ1 122  115               CASOUT+1
ØØ1 123  ØØ1               Ø
ØØ1 124  361               POPPSW  / RESTORE DATA
ØØ1 125  323               OUT     / OUTPUT DATA
ØØ1 126  Ø22               Ø22
ØØ1 127  311               RET


                           / THE FIVE SECOND DELAY SUBROUTINE, FIVSEC, DELAYS
                           / FOR FIVE SECONDS BY REPEATEDLY CALLING THE
                           / 1Ø MSEC DELAY IN KEX.

ØØ1 13Ø  365  FIVSEC,      PUSHPSW / SAVE REGISTERS
ØØ1 131  3Ø5               PUSHB
ØØ1 132  ØØ1               LXIB    / LOAD COUNT
ØØ1 133  364               364
ØØ1 134  ØØ1               ØØ1
ØØ1 135  315               CALL    / KEX TIMOUT SUBROUTINE
ØØ1 136  277               277
ØØ1 137  ØØØ               ØØØ
ØØ1 14Ø  Ø13               DCXB    / DECREMENT COUNT
ØØ1 141  17Ø               MOVAB
ØØ1 142  261               ORAC
ØØ1 143  3Ø2               JNZ     / JUMP IF COUNT IS NOT ZERO
ØØ1 144  135               FIVSEC+5
ØØ1 145  ØØ1               Ø
ØØ1 146  3Ø1               POPB    / RESTORE REGISTERS
ØØ1 147  361               POPPSW
ØØ1 15Ø  311               RET


                           / THE TELETYPE INPUT SUBROUTINE, TTYIN, WAITS FOR
                           / A CHARACTER TO BE RECEIVED BY THE TTY UART,
                           / INPUTS THE CHARACTER, MASKS OUT THE PARITY BIT,
                           / AND THEN ECHOS IT.
```

IX. LOAD/DUMP PROM PROGRAM LISTING (OCTAL)

```
ØØ1 151  333   TTYIN,          IN       / INPUT STATUS BITS
ØØ1 152  Ø21                   Ø21
ØØ1 153  Ø37                   RAR
ØØ1 154  322                   JNC      / JUMP BACK UNTIL A CHARACTER IS    EIVED
ØØ1 155  151                   TTYIN
ØØ1 156  ØØ1                   Ø
ØØ1 157  333                   IN       / INPUT THE CHARACTER
ØØ1 16Ø  Ø2Ø                   Ø2Ø
ØØ1 161  346                   ANI      / MASK OUT THE PARITY BIT
ØØ1 162  177                   177


                               / THE TELETYPE OUTPUT SUBROUTINE, TTYOUT, WAITS
                               / IF THE TRANSMISSION HOLDING REGISTER IS NOT
                               / EMPTY, AND OUTPUTS THE CHARACTER.

ØØ1 163  365   TTYOUT,         PUSHPSW  / SAVE THE CHARACTER
ØØ1 164  333                   IN       / INPUT STATUS BITS
ØØ1 165  Ø21                   Ø21
ØØ1 166  346                   ANI
ØØ1 167  ØØ4                   ØØ4
ØØ1 17Ø  312                   JZ       / JUMP IF TRANSMITTER REG. NOT EMPTY
ØØ1 171  164                   TTYOUT+1
ØØ1 172  ØØ1                   Ø
ØØ1 173  361                   POPPSW   / RESTORE THE CHARACTER
ØØ1 174  323                   OUT      / OUTPUT THE CHARACTER
ØØ1 175  Ø2Ø                   Ø2Ø
ØØ1 176  311                   RET


                               / THE PAPER TAPE READER INPUT SUBROUTINE, RDRIN,
                               / TURNS ON THE READER RELAY CIRCUIT, WAITS FOR
                               / DATA TO BE RECEIVED, AND INPUTS IT.

ØØ1 177  323   RDRIN,          OUT      / TURN READER RELAY ON
ØØ1 2ØØ  Ø21                   Ø21
ØØ1 2Ø1  333                   IN       / INPUT STATUS BITS
ØØ1 2Ø2  Ø21                   Ø21
ØØ1 2Ø3  Ø37                   RAR
ØØ1 2Ø4  322                   JNC      / JUMP BACK IF NO DATA AVAILABLE
ØØ1 2Ø5  2Ø1                   RDRIN+2
ØØ1 2Ø6  ØØ1                   Ø
ØØ1 2Ø7  333                   IN       / INPUT DATA
ØØ1 21Ø  Ø2Ø                   Ø2Ø
ØØ1 211  311                   RET

      RCAS   = ØØ1 ØØØ  NEXTIN = ØØ1 ØØ5  WCAS   = ØØ1 Ø25  KEY    = ØØ1 Ø3Ø
      NOTØ   = ØØ1 Ø46  MORE   = ØØ1 Ø53  CASIN  = ØØ1 1Ø3  CASOUT = ØØ1 114
      FIVSEC = ØØ1 13Ø  TTYIN  = ØØ1 151  TTYOUT = ØØ1 163  RDRIN  = ØØ1 177

      ERRORS DETECTED = ØØØ
```

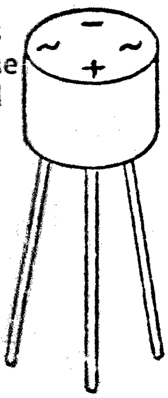
ENGINEERING NOTICE

Due to Manufacturers differences in packaging, you may find that the Bridge Rectifier called out in your manual is different than the actual part. The diagrams below will assist you in defining the leads.

PF-05 Bridge Rectifier (1.5A 50PIV) E & L P/N: 502-0002

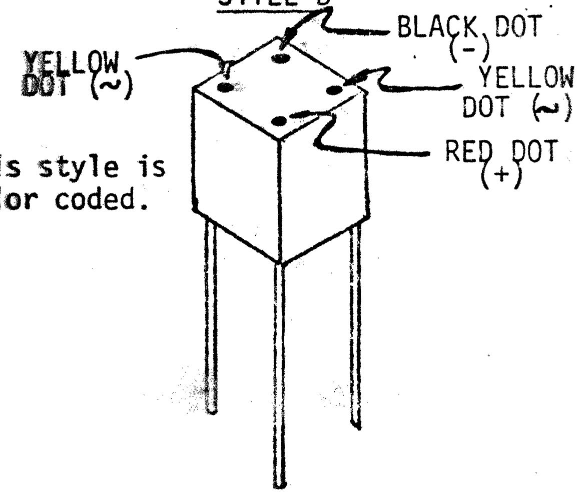
STYLE A

This style has each leg of the bridge stamped on the top of the case.



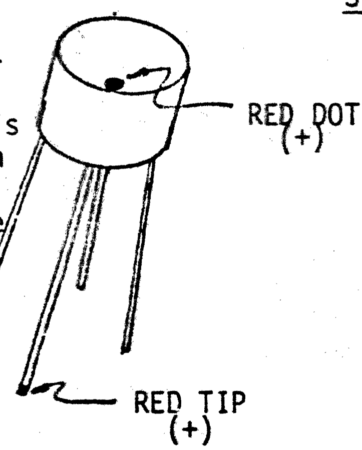
STYLE B

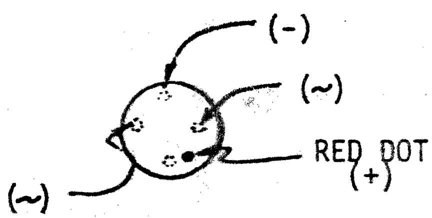
This style is color coded.



STYLE C

The only indication on this style is a red dot on top of the case and the plus leg has a red tip. The other three legs are assumed.





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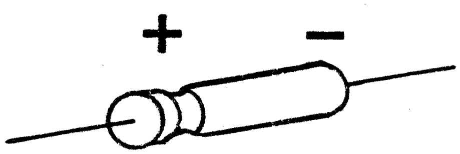
ENGINEERING NOTICE

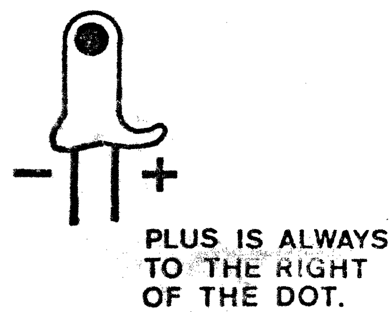
Due to manufacturers availability, the following capacitors may have been substituted in your kit:

Part Number:				
524-0005	10 mfd	@	20 V
524-0009	1 mfd	@	35 V
524-0010	22 mfd	@	15 V
524-0032	5 mfd	@	15 V

The substitution on the above parts is not a value substitution but a case style substitution.



OR



806-0026 (4-78)

ENGINEERING NOTICE

Due to manufacturers availability we are temporarily out of stock of SN74LS75's (P/N 503-0187). In order not to hold up the shipment of your unit we have elected to substitute SN7475's (P/N 503-0045). Please make the necessary changes in your manual.

806-0033
3/79

E&L Instruments, Incorporated
61 First Street, Derby, Connecticut 06418

ENGINEERING NOTICE

Due to an internal change, by the manufacturers, to the 8224 Clock Generator Chip, the 47 pf capacitors (C 16 & C 17) are no longer necessary. We are not going to eliminate them from the manual at this time or change the pc board until we have made the proper tests and are certain that these caps will no longer be needed. All you have to do is ignore the references to these caps in your manual, we have eliminated from the bag of parts.

If you wish to go through your manual and note these changes now, they appear on pages 6, 18, and 19.

5/79
806-0034

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