

OA-2

OP-AMP DESIGNER

801-0009
REV-O
11/80

OPERATING MANUAL



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

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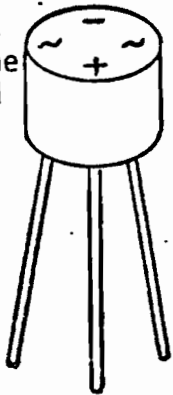
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Due to Manufacturers differences in packaging, you may find that the Bridge Rectifier called out in your manual is different than the actual part. The diagrams below will assist you in defining the leads.

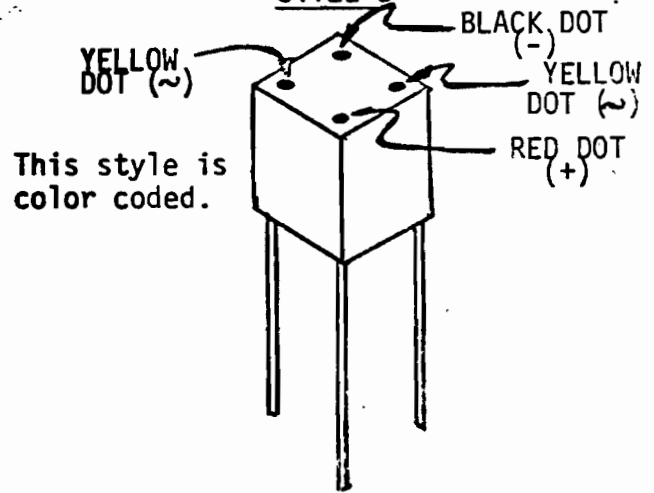
PF-05 Bridge Rectifier (1.5A 50PIV) E & L P/N: 502-0002

STYLE A

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



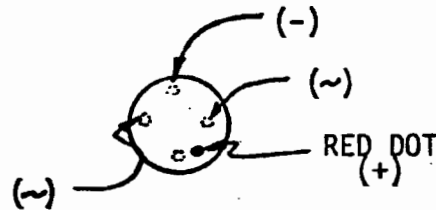
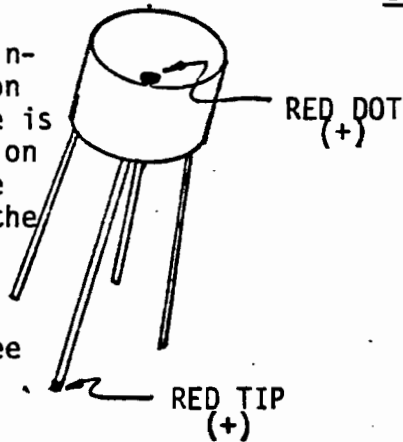
STYLE B



This style is color coded.

STYLE C

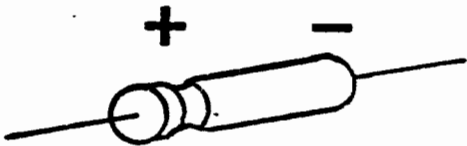
The only indication on this style is a red dot on top of the case and the plus leg has a red tip. The other three legs are assumed.



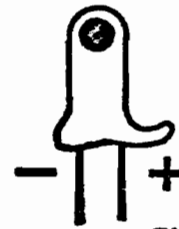
Due to manufacturers availability, the following capacitors may have been substituted in your kit:

<u>Part Number:</u> 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



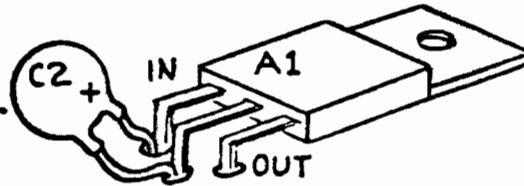
PLUS IS ALWAYS TO THE RIGHT OF THE DOT.

806-0026
4/78

ADDENDUM

Engineering Change Notice C2 has been changed from .1 mfd #520-0016, to 10 mfd tant. #524-0033.

Also, placement of C2 on the P.C. Board Assembly has been changed per the illustration shown below:



806-0039
10-29-80

Install C2 in the same holes as A1--C2 + lead into A1 IN, the remaining C2 lead into the center hole of A1.

I. INTRODUCTION

The OA-2 Op Amp Designer is an easy to use, virtually foolproof designer that gives the experimenter, engineer, and technician a powerful tool to build up circuitry requiring $\pm 15V$ supplies such as operational amplifiers and, at the same time, the +5V supply can power logic circuitry. CMOS IC's will also work with these voltages.

By using the SK-10 Universal Component Socket and the BP-22 Breadboarding Pins, soldering is eliminated. All connections can be made with any solid 22 gage wire - both on the SK-10 Socket for constructing the actual circuit or to connect to the external power supplies, switches, or potentiometers. There are 5-Way Binding Posts connected to BP-22 Pins to enable the outputs from the built-up circuit to be taken off for external use.

The SK-10 Socket is basically a matrix of 64 pairs of common contacts (5 per strip) arranged symmetrically; combined with 8 buss strips running along the length of the socket (25 contacts per strip). On the last page of this manual there is a print of the SK-10 Socket for your reference and/or preliminary sketching. The socket allows the user to insert all electronic components with lead diameters up to 20 gage wire. For very large components, we recommend the use of E&L's BP-24 Adapter Pins, which will accept leads up to 16 gage wire. When inserting DIP IC's, be certain to preset the leads at correct spacing. Insert one side partially in, then roll the second set of leads into the other side, then press squarely down, seating the IC properly.

In addition to the built-in supplies, the OA-2 comes with a self-contained function generator that simultaneously generates sine, square, and triangular waves at 500 Hz. The frequency of the generator is user adjustable by the use of external capacitors when "frequency" switch is in the "ext" position.

To aid the user who will be working with circuitry that requires null adjustments, the OA-2 has a variable sensitivity null detector that uses solid state L.E.D. readouts.

The OA-2 also includes two uncommitted slide switches and two uncommitted potentiometers.

II. SPECIFICATIONS:

- | | <u>Supply A</u> | <u>Supply B</u> |
|--------------------------|-----------------|------------------|
| A. <u>Power Supplies</u> | <u>+15V</u> | <u>+5V</u> |
| Type | Fixed, Tracking | Fixed, regulated |
| Volt. tol. | 14.25/15.75 | 4.75/5.25 |
| Output current | 200 ma each | 500 ma |
| Current limiting | Yes | Yes |
| Noise/Ripple | Less than 20 mv | Less than 10 mv |
- B. Function Generator:
Waveforms - Sine, square and triangle
Frequency - Internal 500Hz or externally adjustable from 1Hz to 100KHz
Distortion - < 1%
Amplitude - Better than 5V peak to peak - all waveforms
- C. Null Indicator: 2 L.E.D.'s
Input amplitude without overload - 15V maximum
Sensitivity - detects less than 10/100 mv difference (switchable)
Indicator - low, null, high (both off at null).
- D. Controls:
Off/On switch with integral light
Null Sensitivity Switch
Internal/External frequency selector on function generator
(2) uncommitted SPDT slide switches
(2) Slide Pots - 10K and 100K
- E. Connectors:
(1) SK10-PL Solderless Breadboarding Socket
(4) 5-way binding posts
(29) BP-22 Breadboarding Pin
(2) BNC Connectors
- F. Physical:
3.5"h (8.9cm) x 7.6"w (19.3cm) x 9" l (22.9cm)
Sloped approximately - 17°
Weight - 7 lbs. (3.18kg)

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.

- B. Certain features of construction instruction are followed throughout the building of this kit as outlined below.

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)

6. Terminal #1 on an IC is either a dot or an indentation. The dark band on a diode denotes the cathode end. On an L.E.D. the cathode (negative) lead is indicated by a flat or a notch on the flange.

IV. REPLACEMENT PARTS LIST

ITEM NO.	PACKING BAG	MAN. DES.	DESCRIPTION	QTY.	P/N	CHECK
1	HARD-WARE	SC-1	4-40 x 1/4" Pan Hd. Screw	10	605-0025	
2		SC-2	4-40 x 5/8" Flat Hd. Screw	4	605-0033	
3		SC-3	4-40 x 1/4" Flat Hd. Screw	1	605-0003	
4		SC-4	4-40 x 1 1/2" Pan Hd. Screw	2	605-0049	
5		SC-5	4-40 x 2" Flat Hd. Screw	2	605-0010	
6		SC-6	4-40 x 1/2" Pan Hd. Screw	3	605-0019	
7		SC-7	6-32 x 5/16" Pan Hd. Screw	4	605-0038	
8		N1	4-40 Hex Nut	26	606-0006	
9		N2	6-32 Hex Nut	1	606-0012	
10		LW1	#4 Lockwasher	14	607-0001	
11		LW2	#5 Lockwasher	1	607-0002	
11a.		SC-8	6-32 x 1/2" Pan Hd. Screw	1	605-0002	
12	SWITCH	S1	SPST Rocker Switch w/integral light	1	570-0019	
13		S2-S5	SPDT Slide Switch	4	571-0005	
14	CONNECTOR	*J1-J29	BP-22 Breadboarding Pin	29	544-0001	
15		J30	Blue Binding Post w/hex nut	1	543-0009	
16		J31	Red Binding Post w/hex nut	1	543-0007	
17		J32	Black Binding Post w/hex nut	1	543-0008	
18		J33	White Binding Post w/hex nut	1	543-0011	
19		J34, J35	BNC Connector w/hex nut	2	549-0001	
20		J36	SK10-PL Solderless Breadboarding Soc.	1	545-0001	
21		J37	Ground Lug	1	545-0022	
22		** J38	I.C. Socket - 14 Pin	1	542-0005	
23		*** TP1, TP2	BP-25 Breadboarding Pin	2	544-0004	
24	J39, J40	BNC Ground Lug	2	545-0017		
25	RESISTOR	R1, R2	Resistor - 75Ω - 1/4w - ±5% (Pur., Grn., Blk, Gold)	2	511-0014	
26		R3, R4	Resistor - 2Ω - 1/2w - ±5% (Red, Blk, Gold, Gold)	2	512-0015	
27		R5, R6	Resistor - 56KΩ - 1/4w - ±1%	2	511-0099	
28		R7, R21	Resistor - 402KΩ - 1/4w - ±1%	2	511-0113	
29		R8	Heli Trimpot - 10KΩ	1	515-0016	
30		R9, R25, R29	Resistor - 20KΩ - 1/4w - ±1%	3	511-0108	
31		R10	Resistor - 2KΩ - 1/4w - ±1%	1	511-0106	
32		R11	Thumbwheel Pot. - 10KΩ	1	515-0021	
33		R12, R15, R17	Resistor - 4.7KΩ - 1/4w - ±5% (Yel, Pur, Red, Gold)	3	511-0054	

ITEM NO.	PACKING BAG	MAN. DES.	DESCRIPTION	Qty.	P/N	CHECK
34						
35						
36		R16	Thumbwheel Pot. - 1K Ω	1	515-0024	
37		R18 R13	Resistor - 15K Ω - 1/4w - \pm 5% (Brn, Grn, Org, Gold)	2	511-0065	
38		R19,R20 R23	Thumbwheel Pot. - 100K Ω	3	515-0020	
39		R22	Resistor - 220K Ω - 1/4w - \pm 5% (Red, Red, Yel, Gold)	1	511-0084	
40		R24, R30	Resistor - 30.1K Ω - 1/4w - \pm 1%	2	511-0130	
41		R26, R31	Resistor - 1.5M Ω - 1/4w - \pm 5% (Brn, Grn, Grn, Gold)	2	511-0090	
42		R27, R32	Resistor - 5.1K Ω - 1/4w - \pm 5% (Grn, Brn, Red, Gold)	2	511-0055	
43		R28, R33	Resistor - 750 Ω - 1/4w - \pm 5% (Pur, Grn, Brn, Gold)	2	511-0036	
44		R34	Potentiometer - 10K Ω	1	515-0002	
45		R35	Potentiometer - 100K Ω	1	515-0001	
45a						
45b						
46	CAPACITOR	C1	Capacitor - 2200 mfd - Elec.	1	523-0044	
47		C12	Capacitor - .1 mfd - Cer.	1	520-0016	
48		C3,C7 C8	Capacitor - .01 mfd - Cer.	3	520-0008	
49		C4,C9 C10,2	Capacitor - 10 mfd - Tant.	4	524-0005	
50		C5,C6	Capacitor - 1000 mfd - Elec.	2	523-0041	
51		C13,C14 C16	Capacitor - .05 mfd - Cer.	3	520-0019	
52		C15	Capacitor - .33 mfd - Mylar	1	522-0007	
53	WIRE	-	Wire - Insul. - Str. - 22 gage	20'	580-0001	
54		-	Wire - Bare - Solid - 22 gage	3'	582-0001	
55		-	Wire - Insul. - Str. - 18 gage	2'	580-0002	
55A	SLEEVING	-	Sleeving	3'	583-0002	
56	SEMI- CONDUCTOR	Q1	Transistor - TIP 30 w/insul. & bush.	1	500-0025	
57		Q2	Transistor - TIP 29 w/insul. & bush.	1	500-0024	
58		Q3	Transistor - 2N4121	1	500-0013	
59		Q4	Transistor - 2N5134	1	500-0018	
60		A1	Regulator - 7805C	1	504-0005	
61		A2	Regulator - Dual - SG4501	1	504-0004	

ITEM NO.	PACKING BAG	MAN. DES.	DESCRIPTION	QTY.	P/N	CHECK
62		A3,A4, A6,A7	I.C. - 741CH	4	503-0009	
63		A5	I.C. - 8038	1	503-0003	
64		CR1, CR2,CR3	Bridge Rectifier - 1.5A - 50 Piv (PF05)	3	502-0002	
65		CR4, 8 CR5, 9	Diode - IN914	4	501-0006	
66		CR6, CR7	Diode - IN5221	2	501-0030	
67		CR 10 CR 11	L.E.D. w/snapping & bushing	2	551-0003	
68	MISCEL- LANEOUS	K	Knob	2	613-0003	
69		AB	Adapter Bushing	4	608-0001	
70		HS1	Heatsink (TO-5)	1	619-0002	
71		HS2	Heatsink	1	619-0006	
72		F	Fuse - 1/2A - Slo-Blo	1	563-0013	
73		FH	Fuseholder	1	563-0019	
74		SPC	Spacer - 1"	4	615-0020	
75		RF	Rubber Foot	4	611-0001	
76		SR	Strain Relief - Straight	1	617-0002	
77			Heatsink Grease	1	619-0033	
78	FINAL	P	*Panel, Finished	1	621-1021	
79		P.C.	P.C. Board	1	711-0023	
80		H	Housing	1	620-0001	
81		LC	***Line Cord w/Molded Plug	1	567-0002	
82		T1	Transformer	1	531-0017	
83		M	Operating Manual	1	801-0009	

* BP-22 Pins are premounted on panel.

** Included in Kit version only.

*** Use P/N 567-0004 for 230V Wiring.

**** BP-25 Pins are premounted on P.C. Board.

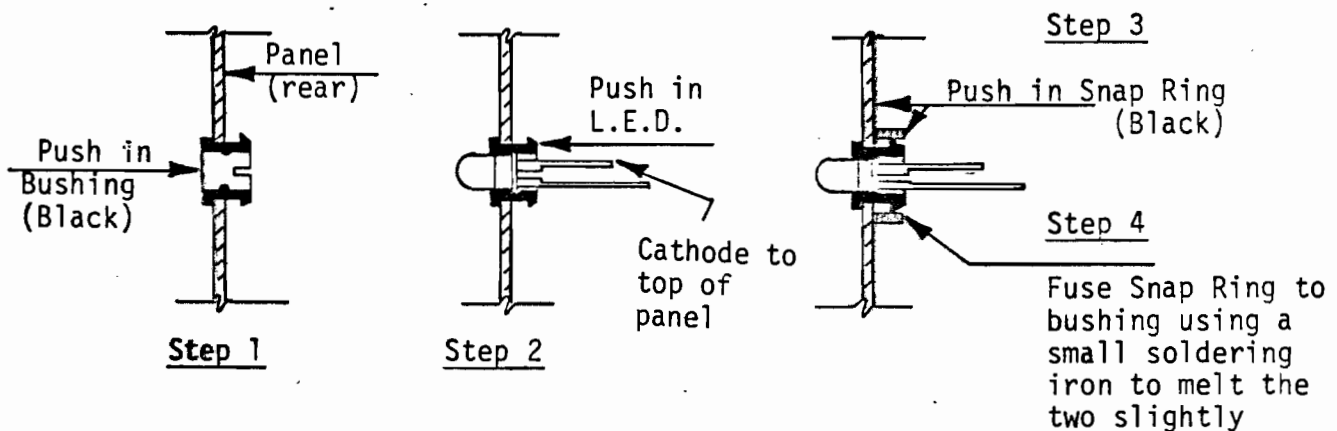
V. MECHANICAL ASSEMBLY - PANEL

- A. Due to the possibility of component breakage during installation, the factory has premounted the twenty nine BP-22 Breadboarding Pins (J1-J29).

Follow sequence exactly or difficulties may be encountered. Pay special attention to orientation instructions and insertion diagrams - *instructions printed in italics are for 230 VAC operation.*

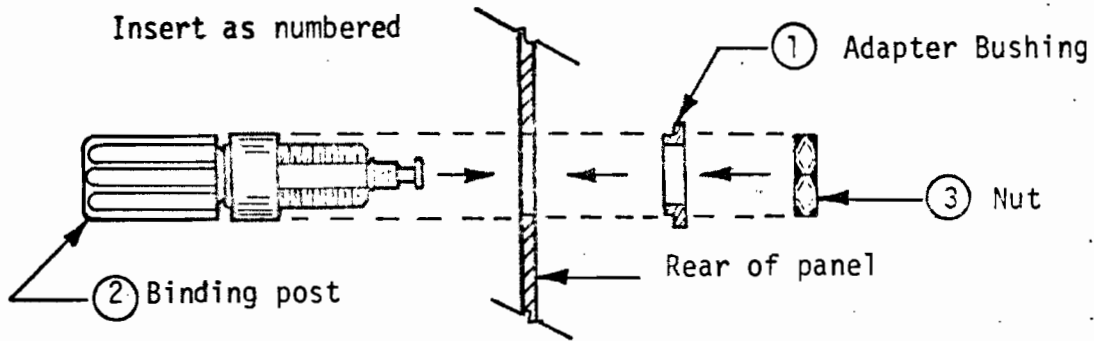
Refer to Illustrations 5 and 10.

- | B. Mount in Order: | <u>CONST</u> | <u>CHECK</u> |
|--|--------------|--------------|
| 1. The SPST ROCKER SWITCH (S1). TAB Number 3 should be toward the top of the panel; the switch will snap into place. The "ON" position is <u>UP</u> . | _____ | _____ |
| 2. The Fuse Holder (FH). It will snap into place, the side that reads TOP should be towards the top of the panel. | _____ | _____ |
| 3. The L.E.D.'s (CR 10, CR11) with bushing and snap ring supplied. Take note of the polarity. The cathode is the lead nearest the flat. After you insert the L.E.D. into the bushing you cannot see the flat, so take note of the cathode before inserting it. | _____ | _____ |



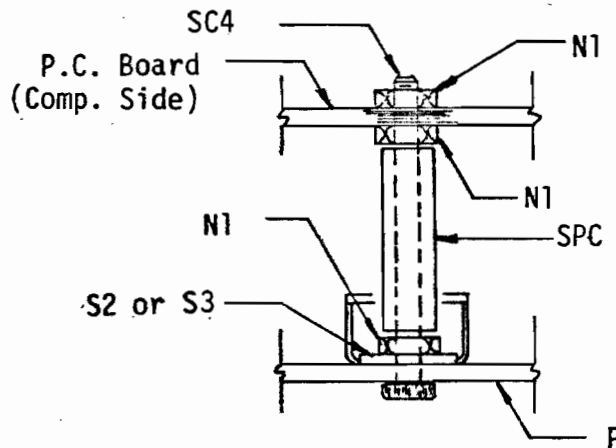
1) MOUNTING OF L.E.D.'s

- | | | |
|---|-------|-------|
| 4. The four Binding Posts (J30 - J33) with hex nuts (supplied with each Binding Post) and the Adapter Bushings (AB) as shown in illustration 2. | _____ | _____ |
|---|-------|-------|



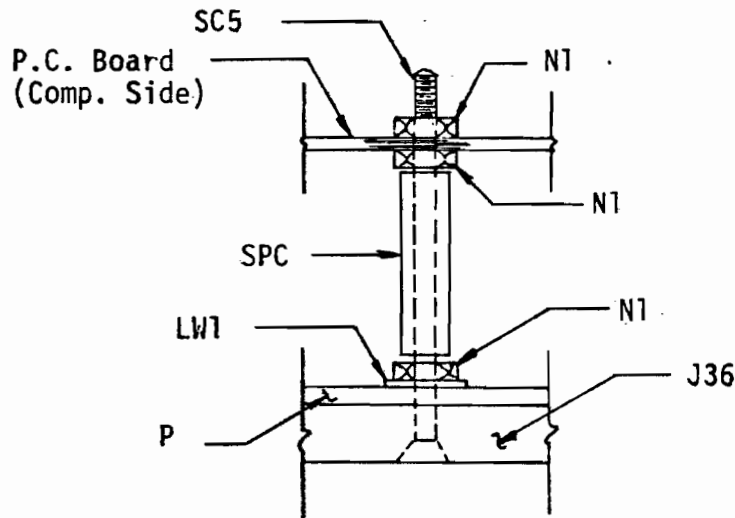
2) BINDING POST INSTALLATION

5. The BNC Connectors (J34, J35) with the hex nut supplied with each connector and a BNC Ground Lug (J39, J40). Insert through front of Panel and tighten hex nut over Ground Lug to back. _____
6. The Slide Potentiometers (R34, R35). Secure each to panel with two 4-40 x 1/4" Pan Hd. Screws (SC1). Terminals 1 and 2 will be towards the left (from rear) side of panel. Place Knobs (K) on after mounting. _____
7. The two Slide Switches (S4, S5). Mount these using four 4-40 x 1/4" Pan Hd. Screws (SC1), four #4 Lockwashers (LW1) and four 4-40 Hex Nuts (N1). _____
8. The two remaining Slide Switches (S2, S3). Mount each switch with one 4-40 x 1/4" Pan Hd. Screw (SC1) one #4 Lockwasher, and one 4-40 Hex Nut (N1) in the right (from rear of panel) mounting hole. In the left mounting hole use one 4-40 x 1 1/2" Pan Hd. Screw (SC4), one Spacer (SPC), and two 4-40 Hex Nuts (N1) as shown in Illustration 3 - the P.C. Board and top nut will be added later. _____

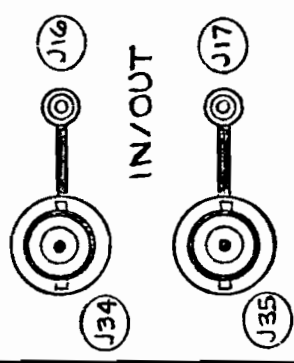
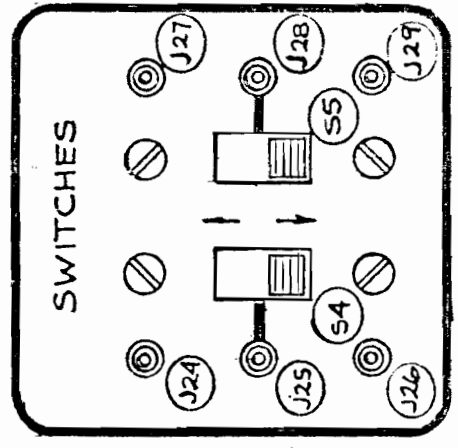
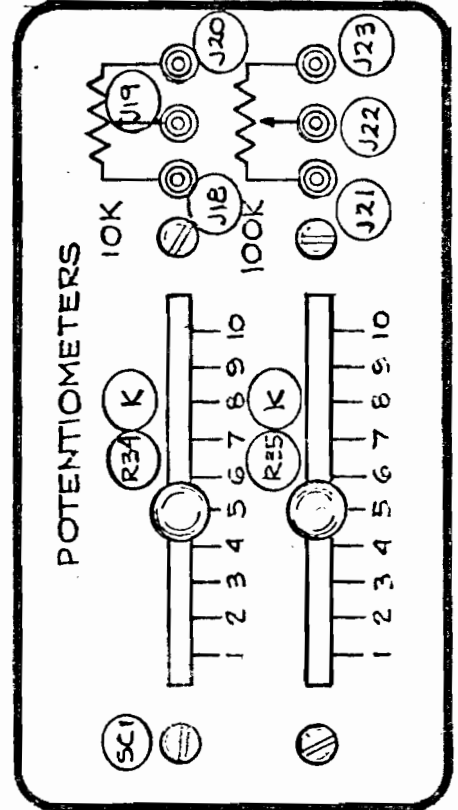
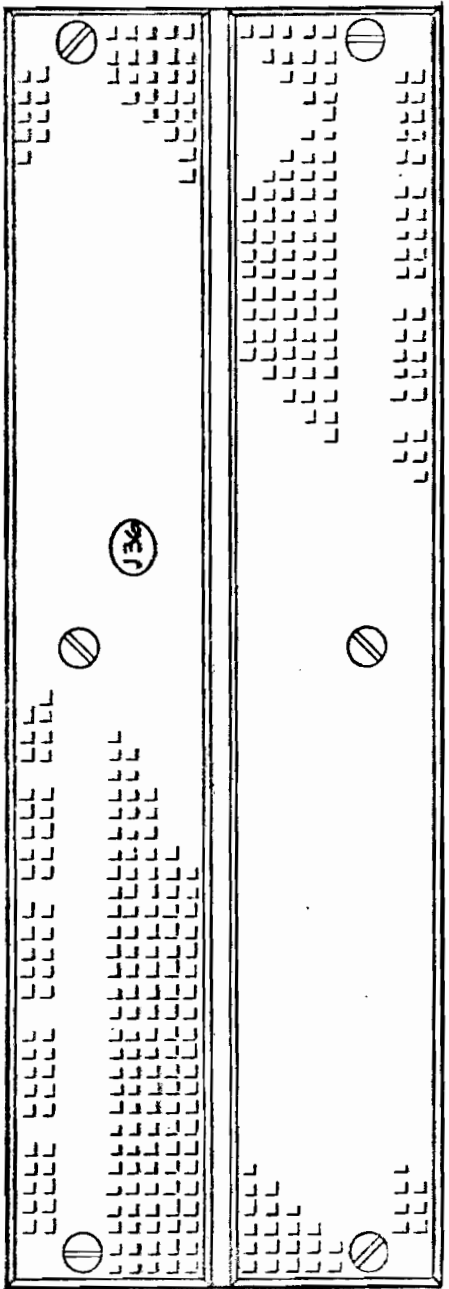
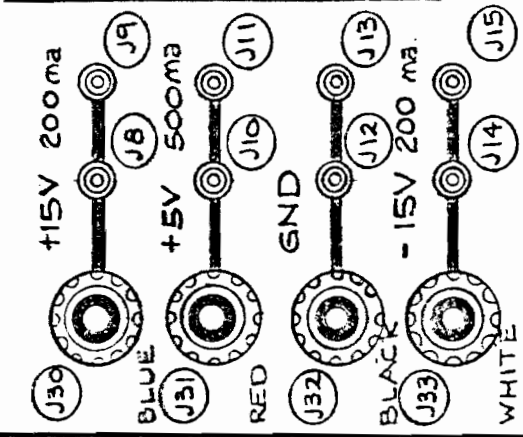
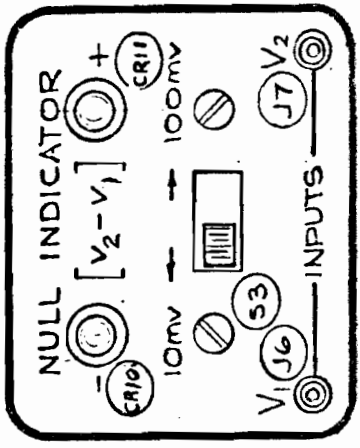
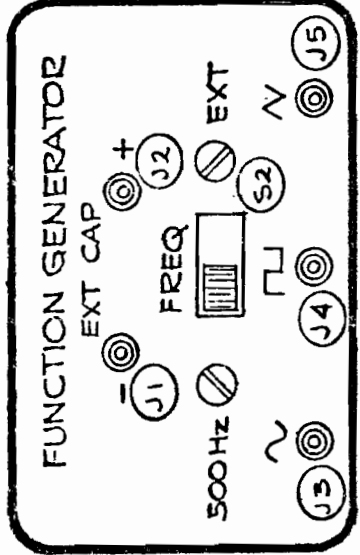
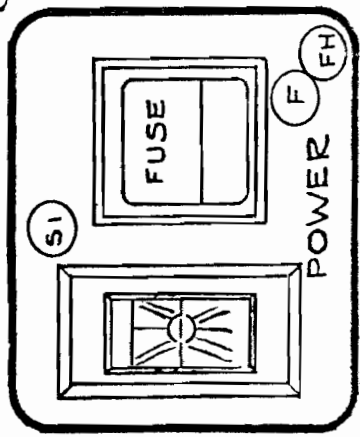


3) SWITCH/SPACER ASSEMBLY

9. The transformer (T1). Position T1 so that terminals 1 through 4 are towards the right (from rear) side of the panel. Insert a 6-32 x 1/2" Pan Hd. Screw (SC8) through the panel into the top mounting hole on the transformer, secure with a #6 Lockwasher (LW2) and a 6-32 Hex Nut (N2). In the remaining hole, insert a 4-40 x 1/4" Flat Hd. Screw (SC3) through the panel and secure with a #4 Lockwasher (LW1) and a 4-40 Hex Nut (N1).
10. The SK-10-PL Solderless Breadboarding Socket. Mount with three 4-40 x 5/8" Flat Hd. Screws (SC2), two #4 Lockwashers (LW1) on the upper row end screws, one 5 prong Terminal Strip (J41) on the center screw of the top row (See Illustration 10 for Terminal Strip (J41) placement), and three 4-40 Hex Nuts (N1) in the upper three holes. In the lower right (from rear) hole use a 4-40 x 5/8" Flat Hd. Screw (SC2), a #4 Ground Lug (J37), and a 4-40 Hex Nut (N1). In the remaining two holes use two 4-40 x 2" Flat Hd. Screws (SC5), two #4 Lockwashers (LW1), two Spacers (SPC) and four 4-40 Hex Nuts (N1) as shown in Illustration #4. P.C. Board and top nuts will be added later.



4) SOCKET/SPACER ASSEMBLY



5) PANEL ASSEMBLY - FRONT VIEW

VI. PRINTED CIRCUIT BOARD ASSEMBLY
(See Illustration 6 & 7)

A. Components:

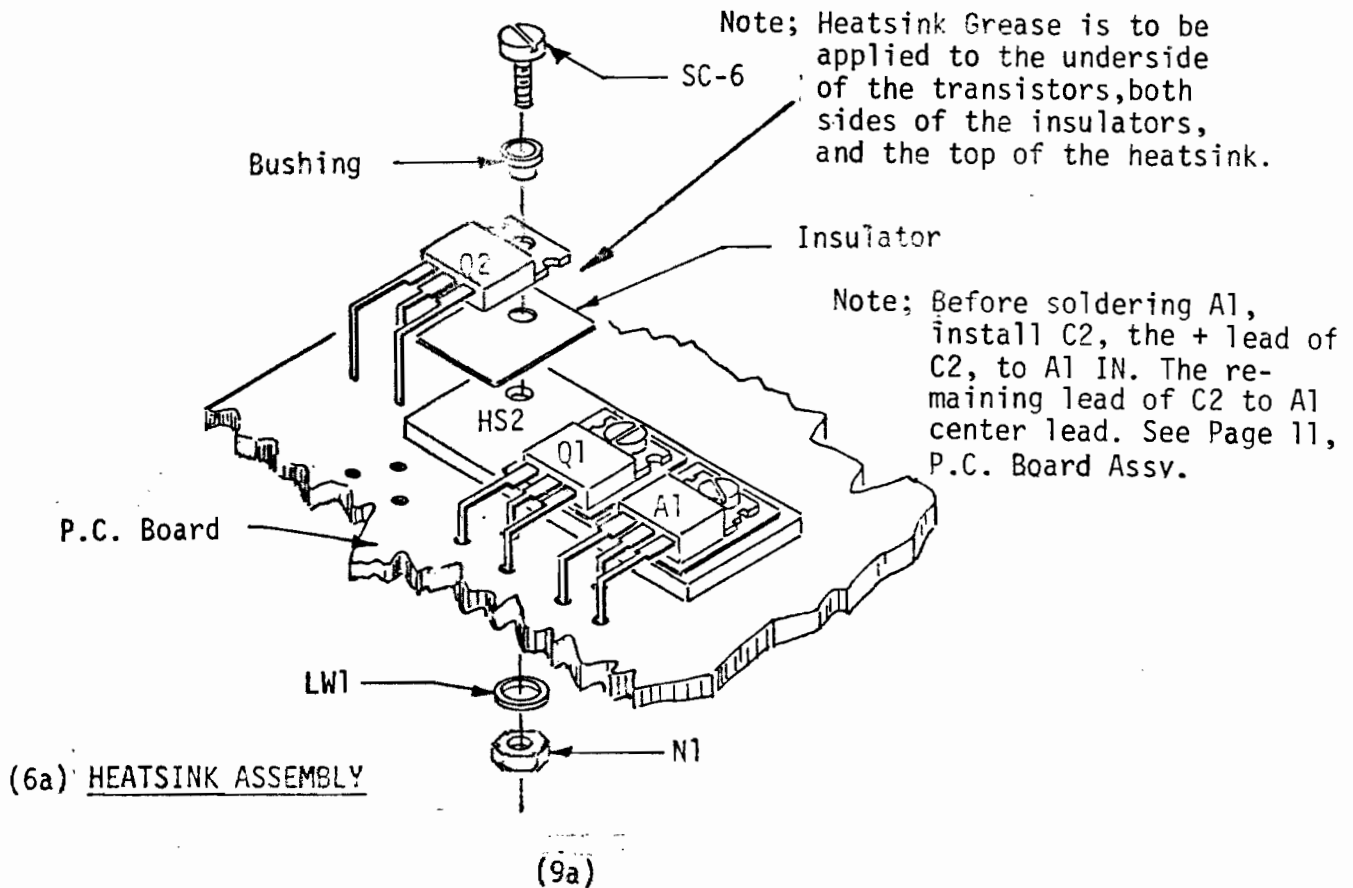
CONST CHECK

For your convenience, the component side of the P.C. Board has been painted to indicate where each component is to be mounted. The BP-25 Breadboarding Pins (TP-1, TP-2) have been pre-mounted, and have to be soldered and the rear protrusions cut off after soldering. Mount the components in the following sequence:

1. All Jumper Wires using the insulated wire provided. A Jumper is indicated by a single line between two holes. _____
2. All Resistors (R1 - R33) (S). Refer to Illustration 7 - "Component Value Chart" for aid in identification. _____

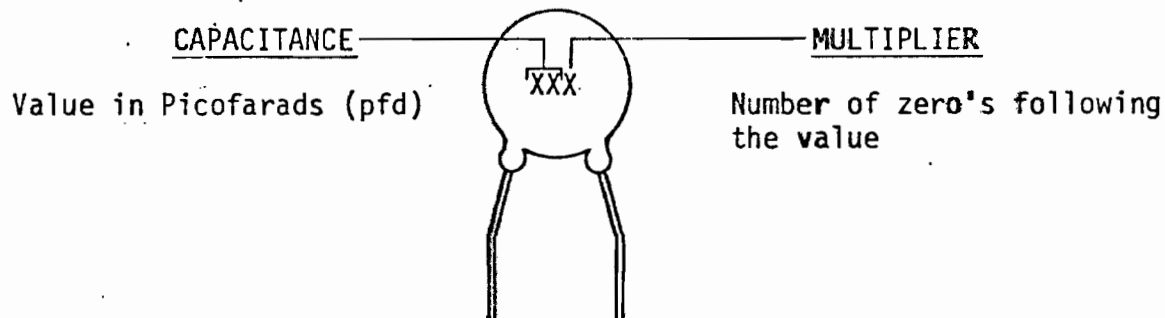
PRINTED CIRCUIT BOARD ASSEMBLY CONT.

3. All Capacitors (C1 - C16) (S). Note polarity where marked (+). _____
4. All Diodes and Bridge Rectifiers (CR1-CR9) (S). Note polarity. _____
5. The I.C. Socket (J38) (S). Insert the 8038 I.C. (A5) in socket taking note of notch position. _____
6. The three components (Q1, Q2, A1) on HS2 with insulators and three 4-40 x 1/2" Pan Hd. Screws (SC6), three #4 Lockwashers (LW1), and three 4-40 Hex Nuts(N1) (S) See Illustration 6a. _____



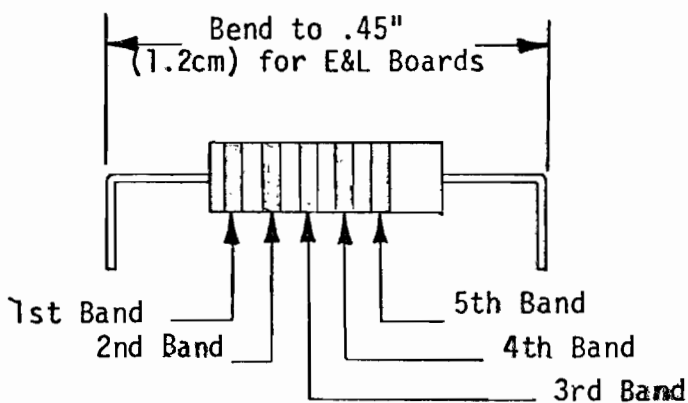
7) COMPONENT VALUE CHART

General Ceramic Capacitor Identification



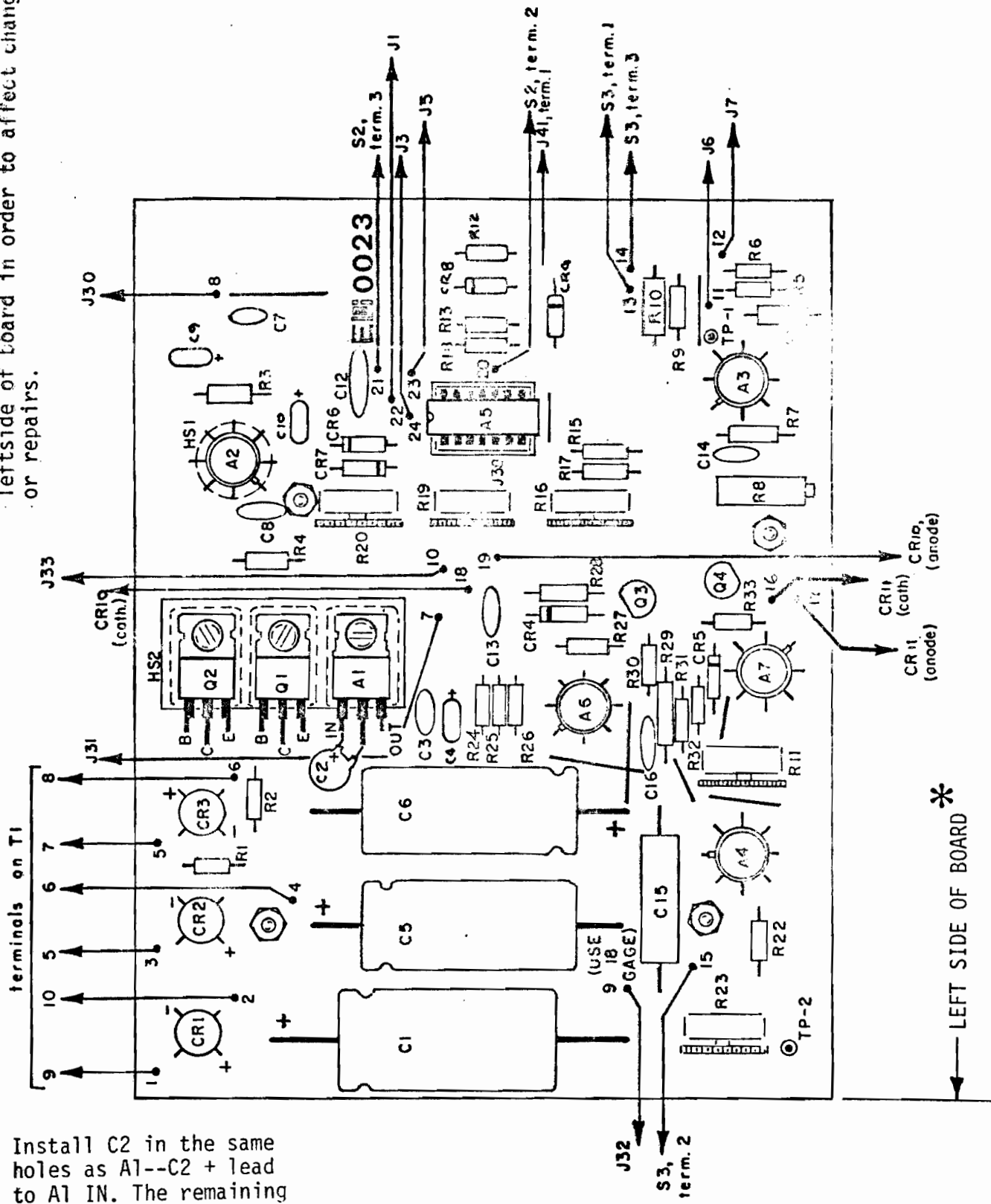
EXAMPLES: 103 = 10,000 pfd or .01 mfd
 302 = 3,000 pfd or .003 mfd
 676 = 67,000,000 pfd or 67 mfd

Resistor Color Code Chart



COLOR	BANDS				
	1st	2nd	3rd	4th	5th
Black	0	0	x1.0	-	↑
Brown	1	1	x10	-	
Red	2	2	x100	-	
Orange	3	3	x1000	-	
Yellow	4	4	x10000	-	
Green	5	5	x100,000	-	
Blue	6	6	x1000,000	-	
Purple	7	7	-	-	↓
Grey	8	8	-	-	
White	9	9	-	-	
Gold	-	-	±10	±5%	
Silver	-	-	±100	±10%	
-----	-	-	-	±20%	RC=MIL-R-11

* Wires are shown in these directions for point to point clarity only - after all wires are soldered in place they should be brought out from the left side of board in order to affect changes and/or repairs.



Note: Install C2 in the same holes as A1--C2 + lead to A1 IN. The remaining lead of C2 to center lead of A1.

8) P.C. BOARD ASSEMBLY

7. The remaining Transistors and I.C.'s (A2, A3, A4, A6, A7 and Q3, Q4) (S). _____
8. Place the remaining Heatsink (HS1) on the SG4501 Reg. I.C. (A2). _____

B. Wiring the P.C. Board (See Illustration #8):

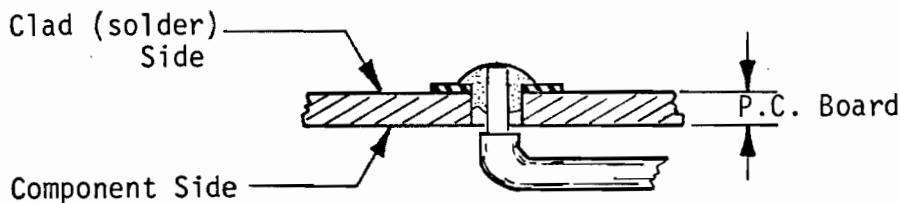
The most convenient way to start wiring the unit is to solder all the wires on the board before mounting it to the panel.

All wires should be put through the component side and soldered on the clad side (See Illustration 9). Use the 22 gage insulated, stranded wire for this step, except where otherwise indicated. The wire lengths are calculated to permit the builder to bring the completed wiring to the left side of the board (towards the top of the panel) to enable the builder, after completion of unit, to flip the board up on one side to expose the panel.

Solder in place the following wire lengths:

Hole #1	} 4" (10,16 cm)	#10 - 8" (20,32 cm)	} 8" (20,32 cm)
#2		#11 > 11" (28 cm)	
#3		#12 > 11" (28 cm)	
#4		#13 > 11" (28 cm)	
#5		#14	
#6		#15 - 9" (22,86 cm)	
#7 > 8" (20,32 cm)	#16 > 11" (28 cm)	#18	
#8	#17	#19	
#9 - 11" (28cm)		#20	
(Use 18 Gage for #9 ONLY)		#21	
		#22	
		#23	
		#24	
		#25 - 8" (20,32 cm)	

The P.C. Board will be mounted to the panel after the panel has been wired.

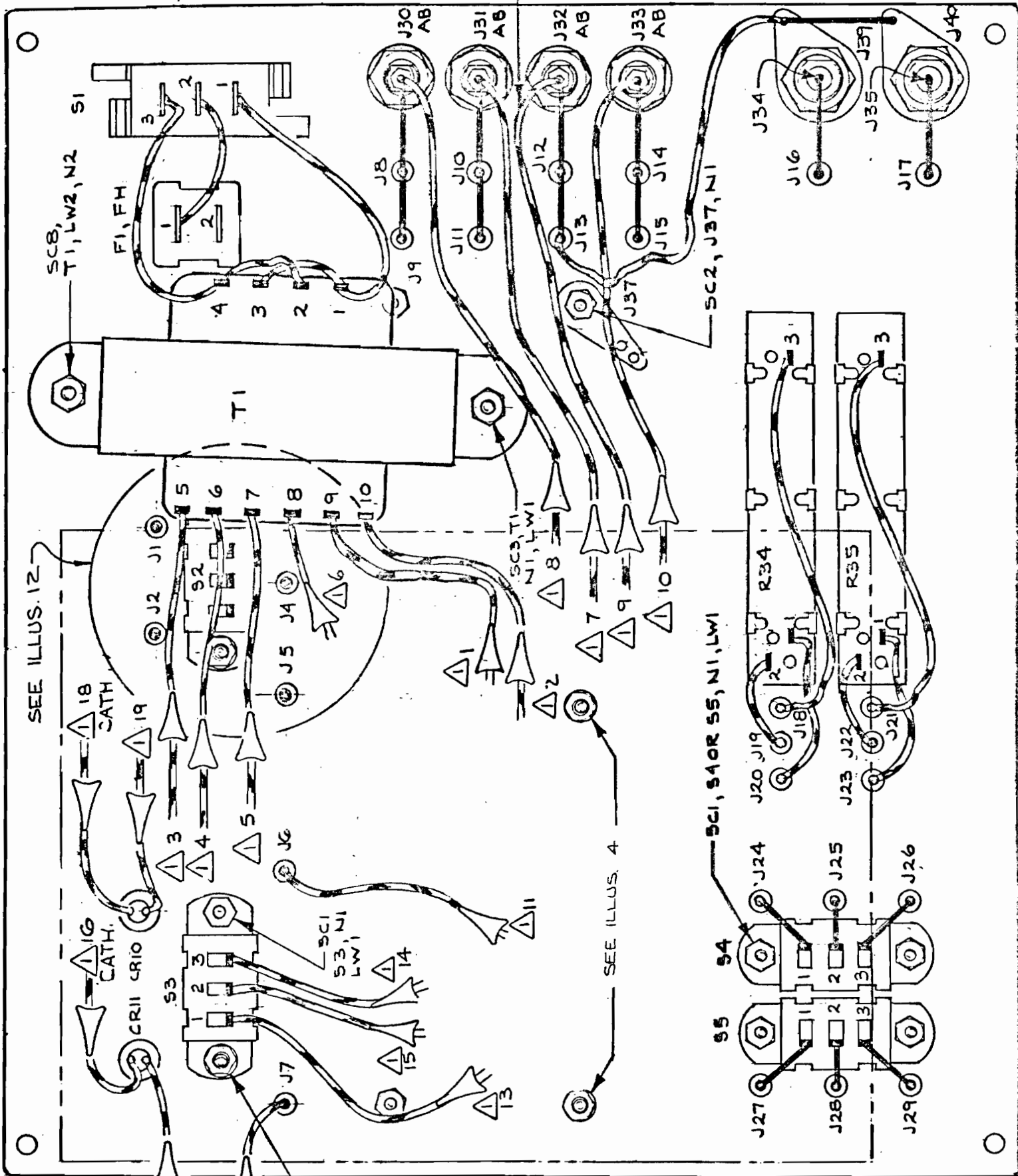


9) SOLDER DIAGRAM

VII. ASSEMBLY AND WIRING INSTRUCTIONS

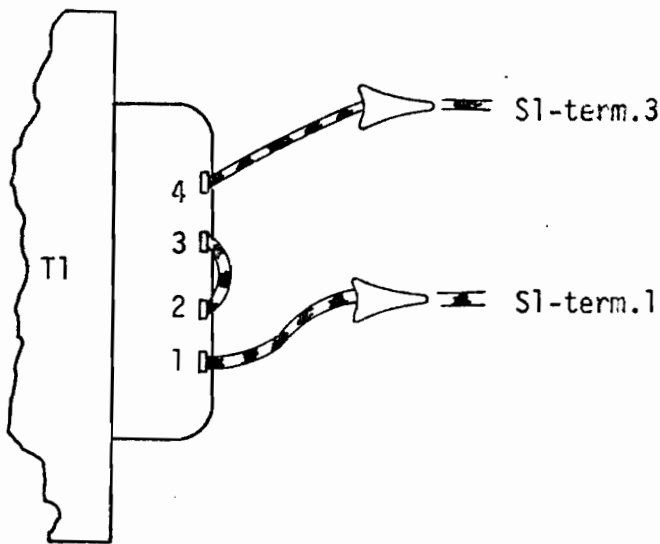
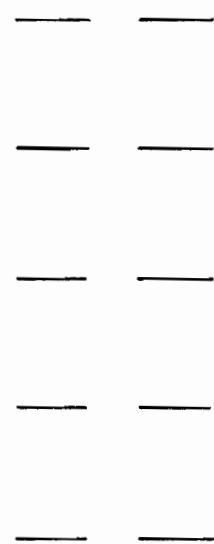
Refer to illustrations 10 and 5. Solder only when indicated.

- | | <u>CONST</u> | <u>CHECK</u> |
|---|-------------------|------------------|
| A. Wire the buss strips first, use the bare wire provided.
Each piece is approximately 1" (2,5cm), cut 16. | <u>CONST</u> | <u>CHECK</u> |
| Connect: | | |
| 1. J34 to J16 (S) | _____ | _____ |
| 2. J35 to J17 (S) | _____ | _____ |
| 3. J30 to J8 to J9, solder only at J8 and J9. | _____ | _____ |
| 4. J31 to J10 to J11, solder at J10 and J11 only. | _____ | _____ |
| 5. J32 to J12 to 13, solder at J12 only. | _____ | _____ |
| 6. J33 to J14 to J15, solder at J14 and J15 only. | _____ | _____ |
| 7. S4 a) term. 1 to J24 (S) | _____ | _____ |
| b) term. 2 to J25 (S) | _____ | _____ |
| c) term. 3 to J26 (S) | _____ | _____ |
| 8. S5 a) term. 1 to J27 (S) | _____ | _____ |
| b) term. 2 to J28 (S) | _____ | _____ |
| c) term. 3 to J29 (S) | _____ | _____ |
| 9. J39 to J40, solder at J40 only. | _____ | _____ |
|
B. Make the following connections using the insulated wire provided. |
<u>CONST.</u> |
<u>CHECK</u> |
| Connect: | | |
| 1. R34 a) term. 1 to J20 with a 1 1/2" (4cm) length (S) | _____ | _____ |
| b) term. 2 to J19 with a 1" (3cm) length (S) | _____ | _____ |
| c) term. 3 to J18 with a 4" (10cm) length (S) | _____ | _____ |
| 2. R35 a) term. 1 to J23 with a 1 1/2" (4cm) length (S) | _____ | _____ |
| b) term. 2 to J22 with a 1" (3cm) length (S) | _____ | _____ |
| c) term. 3 to J21 with a 4" (10cm) length (S) | _____ | _____ |
| 3. S2 a) term. 1 to J2 with a 1" (3cm) length (S)
(See Illustration 12) | _____ | _____ |



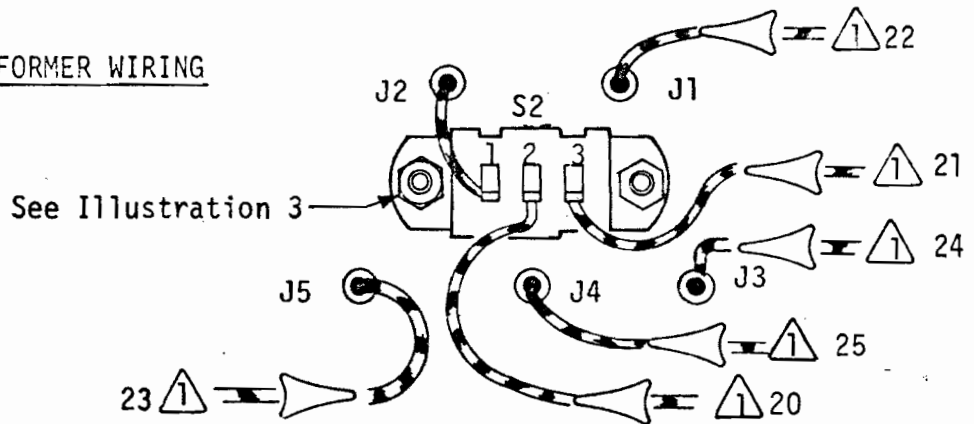
10) PANEL ASSEMBLY - REAR VIEW

4. T1
- a) term. 1 to term. 1 of S1 with a 3" (8cm) length, solder only at S1. For 230 VAC operation solder at T1 also.
 - b) term. 1 to term. 3 of T1 with a 1" (3cm) length (S). Do not do this step for 230 VAC operation.
 - c) term. 2 to term. 4 of T1 with a 1" (3cm) length, solder at term. 2 only. For 230 VAC operation, do not do this step.
 - d) For 230 VAC operation only - term. 2 to term. 3 of T1 with a 3/4" (2cm) length (S). (See Illustration 11)
 - e) term. 4 to term. 3 of S1 with a 4" (10cm) length, solder at T1 only.



△ - Symbol represents all wires going in or coming from panel to PC board.

11) 230V TRANSFORMER WIRING



12) DETAIL OF SWITCH WIRING

5. S1 a) term. 2 to term. 1 of Fuse Holder (FH)
with a 2" (5cm) length (S) _____

6. J39 to J13 with a 3" (8cm) length (S) _____

C. At this point, connect the wires from the P.C. Board to the following positions, without setting the P.C. Board on the mounting screws. CONST. CHECK

Connect the wire from Hole Number

(1) to term. 9 of T1 (S) _____

(2) to term. 10 of T1 (S) _____

(3) to term. 5 of T1 (S) _____

(4) to term. 6 of T1 (S) _____

(5) to term. 7 of T1 (S) _____

(6) to term. 8 of T1 (S) _____

(7) to J31 (S) _____

(8) to J30 (S) _____

(9) to J32 (S) _____

(10) to J33 (S) _____

(11) to J6 (S) _____

(12) to J7 (S) _____

(13) to term. 1 of S3 (S) _____

(14) to term. 3 of S3 (S) _____

(15) to term. 2 of S3 (S) _____

(16) to the cathode of CR11(S) _____

(17) to the anode of CR11(S) _____

(18) to the cathode of CR10(S) _____

(19) to the anode of CR10(S) _____

- | | | |
|---|-------|-------|
| (20) to term. 2 of S2 (S) (See Illustration 12) | _____ | _____ |
| (21) to term. 3 of S2 (S) | _____ | _____ |
| (22) to J1 (S) | _____ | _____ |
| (23) to J5 (S) | _____ | _____ |
| (24) to J3 (S) | _____ | _____ |
| (25) to J4 (S) | _____ | _____ |

D. Position P.C. Board over the four long screws with spacers so that the left side of the board is towards the top of the panel. Tighten a 4-40 Hex Nut (N1) over each of the four screws. Arrange wires so that they go over the left side of the board, this will allow greater ease in checking and troubleshooting during use of unit as the board can be rotated on its left edge and placed face down beside the panel without unsoldering any connections.

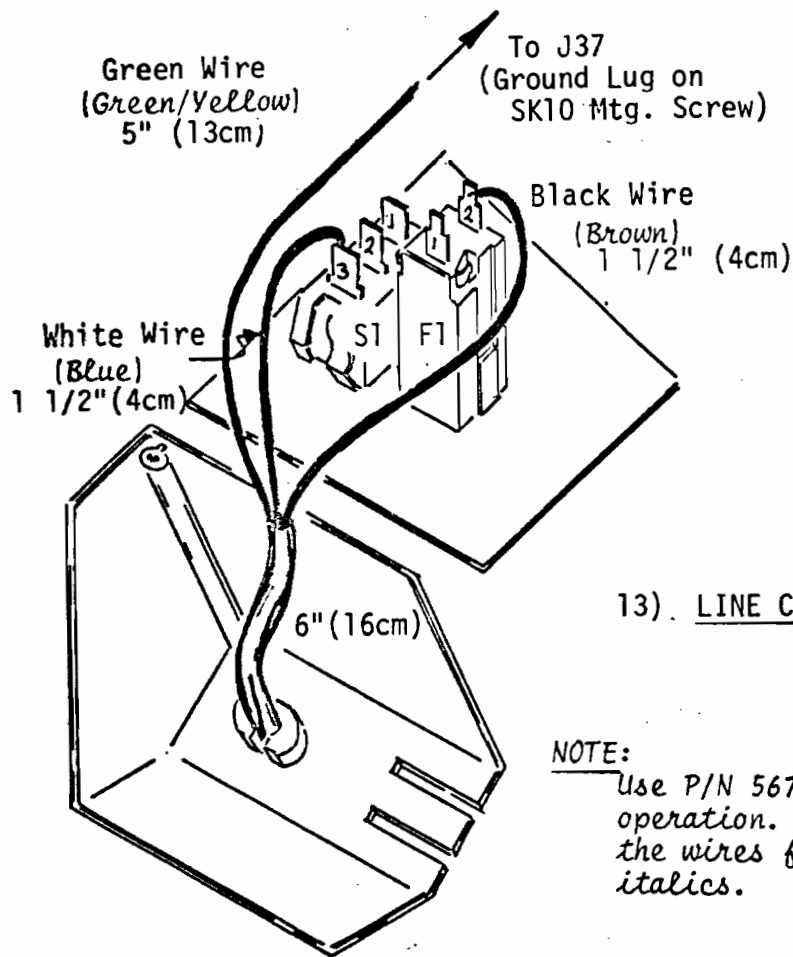
E. Final Assembly CONST. CHECK

- | | | |
|--|-------|-------|
| 1. Inspect unit for missed solder joints and loose hardware. | _____ | _____ |
| 2. Prepare the line cord as follows, referring to Illustration 13. | | |

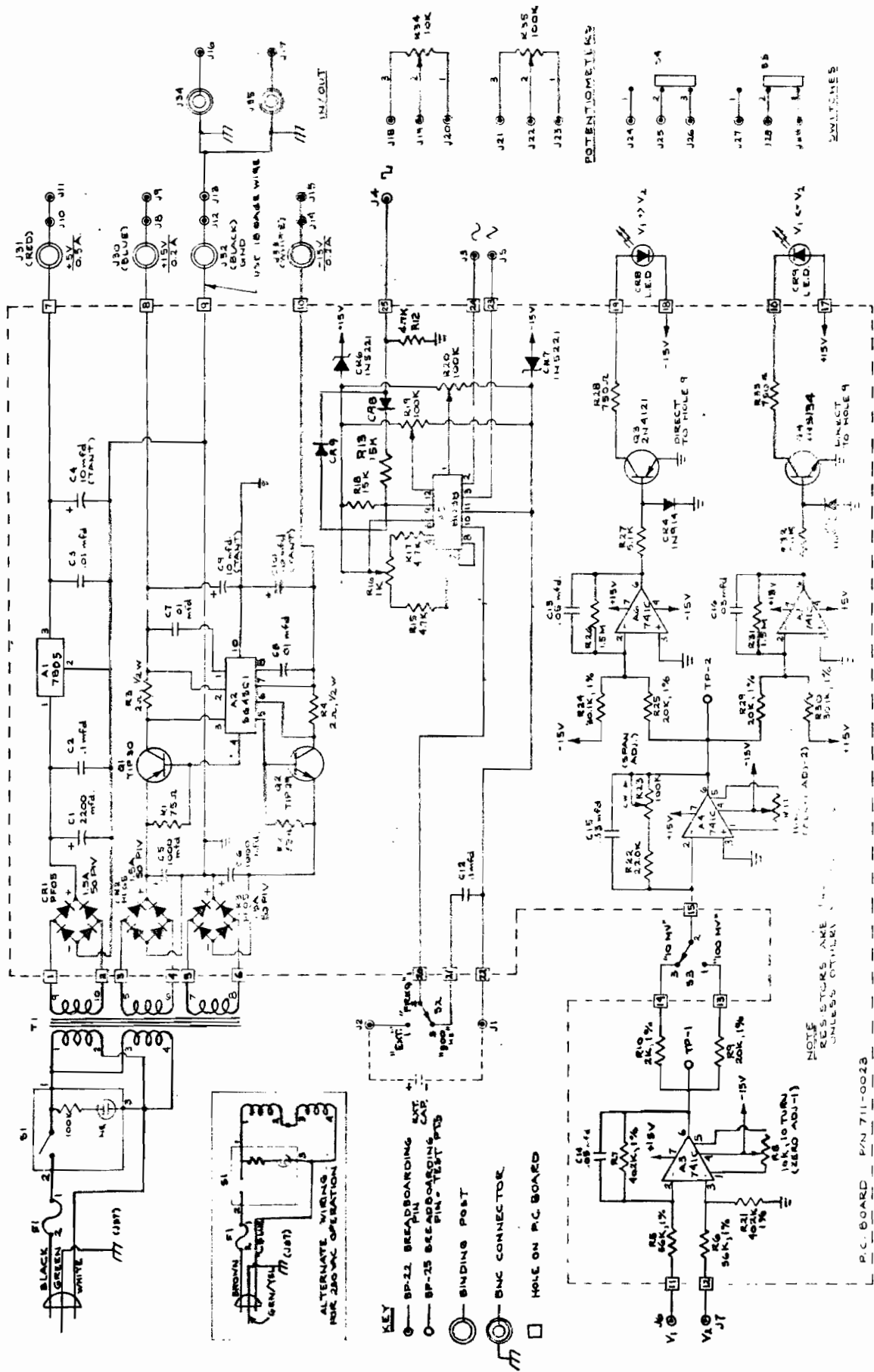
Since the color coding for the line cord used in the 230 VAC operational unit differs from that of the 115 VAC operational unit the 230 VAC colors are given in italics.

- | | | |
|---|-------|-------|
| a. Expose the inner conductors 5" (13cm) from end of cord. | _____ | _____ |
| b. Cut the black (<i>brown</i>) and the white (<i>blue</i>) wires leaving 1 1/2" (4cm) exposed. | _____ | _____ |
| c. Strip the ends of the three wires 1/4" (1cm) from end. | _____ | _____ |

3. a. Capture the unexposed portion of the line cord 6" (16cm) from the exposed portion with the Strain Relief (SR). _____
- b. Compress the Strain Relief and force into the hole in the back of the Housing (H). _____
- c. Connect the white (*blue*) wire to terminal 3 of the Power Switch (S1) (S). _____
- d. Connect the green (*green/yellow*) wire to the Ground Lug (J37) (S). _____
- e. Connect the black (*brown*) wire to terminal 2 of the Fuse Holder (FH) (S). _____



4. Follow checkout and calibration procedures (Section VIII) then mount the Panel to the Housing using four 6-32 x 5/16" Screws (SC7). _____
5. Place Rubber Feet (RF) in depressions on bottom of Housing. _____



14) SCHEMATIC

6. Install fuse.

VIII. Checkout and Calibration

Check

CAUTION: Set trimpots R16, R19 and R20 to their midposition BEFORE applying power to prevent serious component damage in the function generator circuit. These settings will yield fair results if an oscilloscope is not available for more accurate calibration.

1. Plug the unit into an appropriate power source and turn it on. The red neon indicator should light up.

2. D.C. Voltage Checks (no load):

Connect the negative lead of a voltmeter to the black binding post marked GND and check for the following voltages:

- a. "+5V" (red binding post) +4.75 to +5.25 V
- b. "+15V" (blue binding post) +14.25 to +15.75V
- c. "-15V" (white binding post) -14.25 to -14.75V

3. D.C. Voltage Checks (full load):

If available, attach specified loads and measure 120 HZ ripple using an oscilloscope:

	<u>Post</u>	<u>Load</u>	<u>Ripple</u>
a.	"+5V"	500 ma	less than 10 MV
b.	"+15V"	200 ma	less than 20 MV
c.	"-15V"	200 ma	less than 20 MV

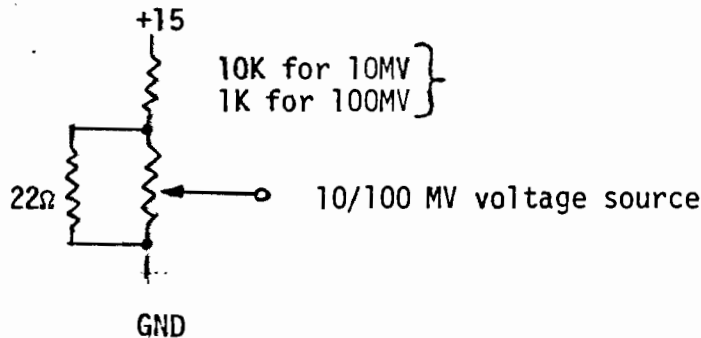
4. Function Generator Checks (oscilloscope method):

- a. Set the "FREQ" switch to 500 HZ.
- b. Scope the squarewave output. Its amplitude should be at least 5V peak to peak.
- c. Adjust R16 for 50% duty cycle.
- d. Scope the sine wave output. Its amplitude should be at least 5V peak to peak.
- e. Adjust R19 and R20 for minimum distortion. (1% if an harmonic distortion analyzer is available.)
- f. Scope the triangle wave output. Its amplitude should be at least 5V peak to peak. The linearity of this signal should be 0.1%.
- g. Put the "FREQ" switch in the "EXT" position. Install a 470 pf capacitor in the "EXT CAP" breadboarding pins and check for 100 KHZ output.

5. Null Detector Calibration

Check

*Calibration of this circuit requires an accurate 3-1/2 digital voltmeter and a noise-free voltage source with a 10 MV and 100 MV output. This voltage source can be constructed on the unit's breadboarding socket as shown below. Check the potentiometers (10K and 100K) on the unit before constructing the source.



- a. Set the NULL INDICATOR range switch (S3) to 10 MV. _____
 - b. Turn the unit on and allow two minutes for warmup. _____
 - c. Connect a jumper from V1 (J6) to GND (J12). _____
 - d. Connect a jumper from V2 (J7) to GND (J13). _____
 - e. Turn "Span Adj." (R23 on P.C. Board) full clockwise (toward TP-2). _____
 - f. Monitor TP-1 and adjust R8 for 0.000V. _____
 - g. Monitor TP-2 and adjust R11 for 0.0V. _____
 - h. Remove the jumper connected to V2. _____
 - i. Connect V2 to a 10MV source. _____
 - j. Adjust R23 for -10.0V at TP-2. _____
6. Null Detector Checkout
- a. Construct a 10 MV source (see Null Detector Calibration for details). _____
 - b. Run a jumper from V1 to GND. _____
 - c. Run a jumper from V2 to the 10MV voltage source. _____
 - d. Set the voltage source to 9.0 MV. Both LED indicators should be OFF. _____
 - e. Raise the voltage source to 11.0 MV. Only the + LED should be on. _____
 - f. Reverse the wires on V1 and V2 and adjust the voltage source for 11 MV. Only the - LED should be on. _____
 - g. Construct a 100 MV source. _____
 - h. Put the range selector switch in the "100 MV" position and repeat steps b through f, using 100, 90 and 110 MV in place of 10, 9 and 11 MV respectively. _____
7. All switches, potentiometers and buss strips should be checked with the ohmmeter portion of the VOM/VTVM to see that they meet specifications. _____

IX. TROUBLESHOOTING

Check

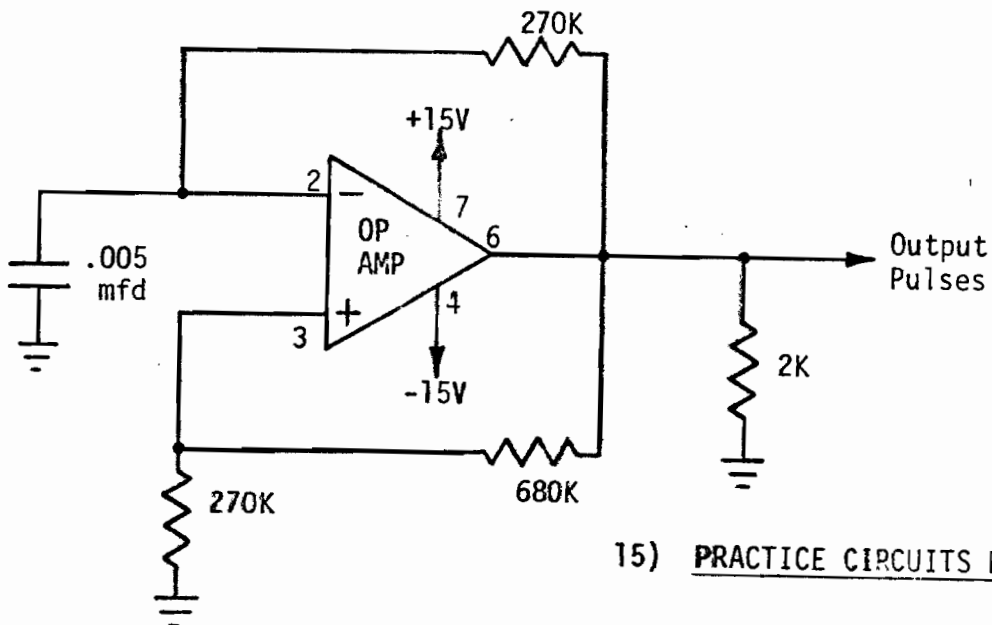
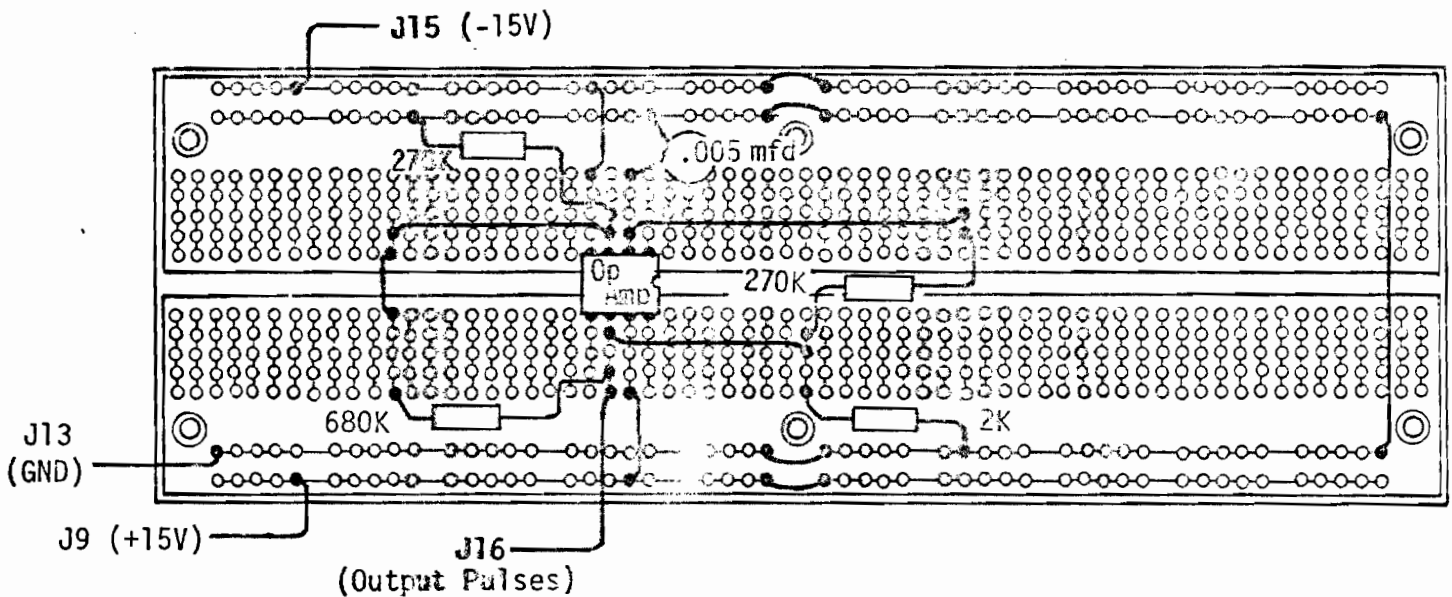
- A. In the event of failure to operate, check the following points--
time after time, they cause the most trouble:
1. Orientation of the diodes and LEDs and IC's. In addition,
watch for solder shorts, cold solder joints, etc. _____
 2. If examination reveals nothing, a more thorough investigation
is required. The circuit board is easily broken down function
by function, and it should be easy to localize the failure. In
these circuits, it usually comes down to excessive heat on the
semiconductors, particularly the IC's. _____
 3. If you are unable to fix the unit, E & L will repair it for
you. See the section on Repair (Page 23).

X

PRACTICE CIRCUITS

Here an Op Amp device (such as a 741, 740, or 709 integrated circuit) is operated in an oscillator circuit as a check out operation. The ability to produce the squarewave output depends, in part, on its ability to amplify, therefore the first output reading checks the operating condition under a nominal load.

This "quick-check" circuit can be used with many different types of Op Amps. Those Op Amps which have the same "standardized" pin-out arrangement as that given in the schematic below, can also be checked by this method. In each case, the values for the desired minimum limits depend upon the characteristics in the Data Sheets for each Op Amp.



15) PRACTICE CIRCUITS DIAGRAMS

16) SK10 SKETCH SHEET

