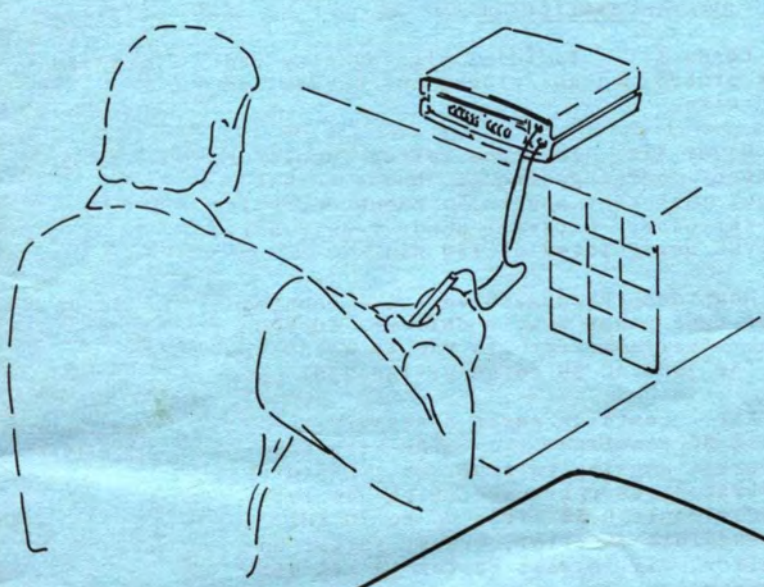
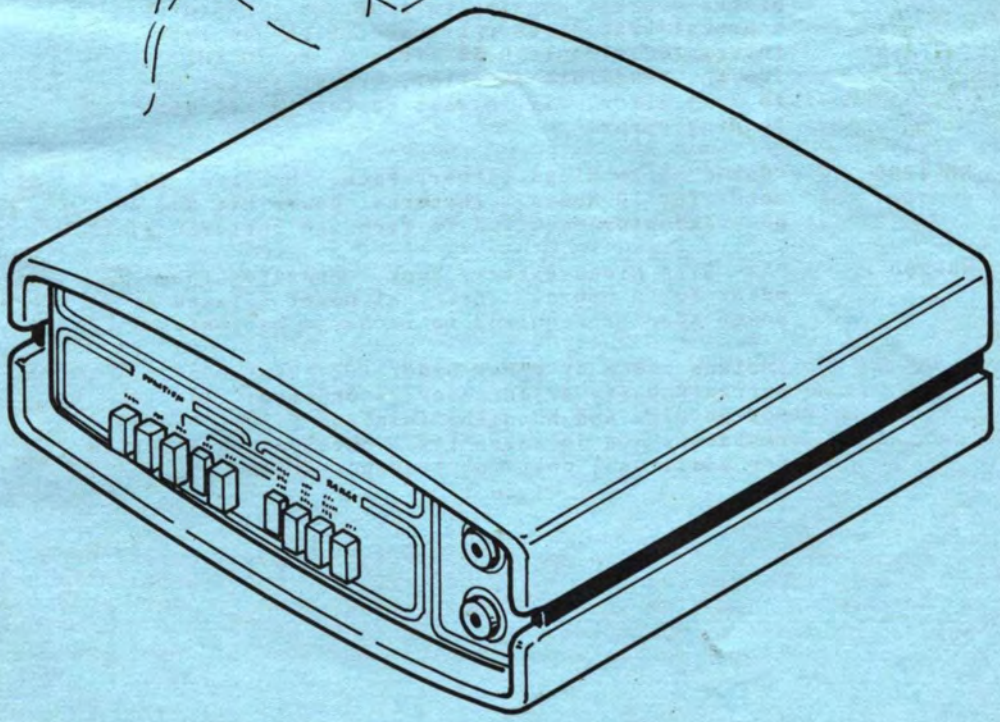
MODEL 2000 DMM

ASSEMBLY & OPERATION MANUAL





sabtronics INTERNATIONAL INC.
P.O. BOX 64683,
DALLAS, TX 75206, U.S.A.

ADDITIONAL ACCESSORIES FOR THE MODEL 2000 DIGITAL MULTIMETER

Part No.	Description	Price
TL-36P	36" Test Leads Kit. Includes high-quality red and black probes, banana plugs, and 6KV Belden test lead wire.	$3.50
EP-12V	External Power Kit. Includes Voltag regulator, Nicad battery charging circuit, and external power input jack that mounts to knock out holes in the meter case. External power required is 8.5 to 15VDC unregulated at 150 Ma.	$3.95
AC-115 AC-230	AC Power Adapter. Preassembled, plug-mounted calculator type power supply delivers 10 VDC at 150 Ma. Available for 115 VAC 50 to 60 Hz (AC-115), or 230 VAC 50 to 60 Hz (AC-230) power.	$6.95
RMS-2000	True RMS Kit. Contains parts necessary to upgrade all AC functions from sine wave calibrated average sensing to true RMS. Features a precalibrated laser-trimmed, high-accuracy integrated circuit 0.5% error up to 20 KHz, 100 KHz bandwidth 1% error, creast factor up to 7 1% error, max. creast factor 10 -3% of reading error.	Available Late 1977
NB-1200	"Sub-C" Size Nicad Battery Pack. Operates the meter for 10 hours. (External power kit and AC power adaptor required to recharge batteries.)	$12.95
NB-500	"AA" Size Nicad Battery Pack. Operates the meter for 4 hours. (External power kit and AC power adaptor required to recharge batteries.)	$7.75

Include check or money order for total non-warranty parts or accessories ordered. Add 10% for postage and handling (minimum $.50). Texas residents add 5% sales tax. Outside U.S.A. write for additional cost for transportation

OPERATING INSTRUCTIONS

1. Introduction

This section of the manual contains information regarding the correct operation of the Model 2000 DMM. It is recommended that the contents of the section be read and understood before attempting to operate the instrument.

2. Shipping Information

The Model 2000 was packed and shipped in a container especially designed to provide adequate protection. Upon receipt, inspect the instrument for possible shipping damage or missing parts.

3. Input Power

Operating power for the standard Model 2000 comes from four non-rechargeable, alkaline (heavy duty) "C" size batteries. This power source typically provides 25 hours of instrument operation. Optionally available power sources include rechargeable Ni Cad batteries and an AC Power Adapter. To use these power sources, the meter must be fitted with an external power kit. The instrument equipped with rechargeable batteries (4 "C" cells) will typically operate for 15 hours; recharging, using the AC Power Adapter, takes approximately 16 hours. If the batteries measure below 4.4V under load, they need to be replaced or recharged. Don't leave low voltage batteries in the meter; acid corrosion may result. The first indication of low batteries will be a dim display.

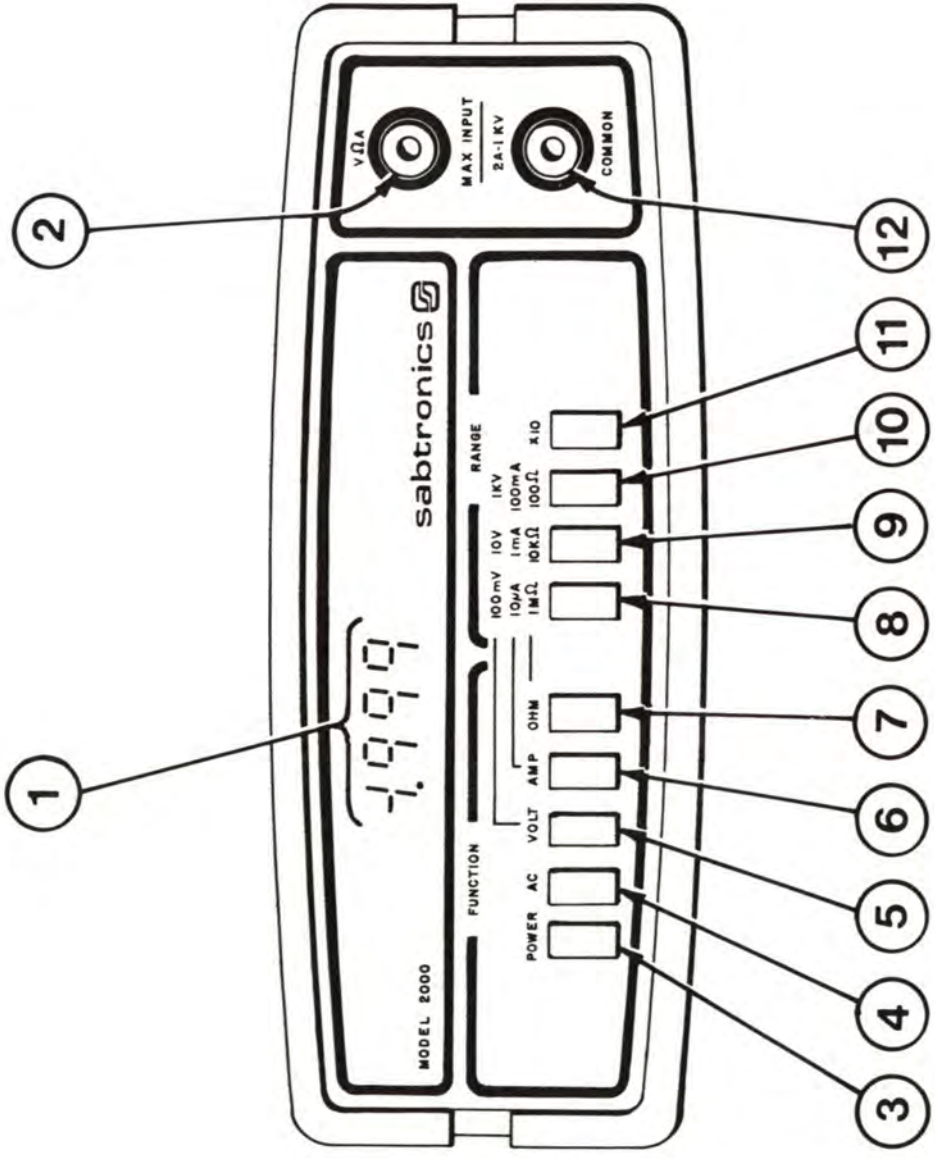
4. Fuse Replacement

The Model 2000 is equipped with a current overload fuse to protect the instrument circuitry from inadvertent applications of current in excess of 2 amps. This fuse is located in fuse clips on the main P.C. board. Replace with a 2 amp AGC or AGX fuse by removing the four screws holding the case halves together and lifting off the top case half.

5. Overrange Indication

When the full scale capability of the selected range for any function is exceeded, the display will be blank. The overrange indication does not necessarily mean that the instrument is being exposed to a damaging input condition. The exact overload conditions for each range is contained in the specifications.

ITEM NUMBER	NAME	DESCRIPTION
1	Display	A 3 1/2 digit display (1999 maximum) of the measured input, including decimal point and polarity sign when appropiate.
2	V Ω A	Jack for high (red) lead connection to Model 2000 for voltage, current, (AC or DC) and resistance measurements.
3	Power Switch	Turns meter ON and OFF. AC adapter still charges batteries while Power Switch is off.
4	AC	This switch, when depressed in conjunction with item 5 or 6, selects AC voltage or alternating current measurement capability.
5	Volt	Works in conjunction with the AC and range switches to select voltage function (AC or DC).
6	Amp	Works in conjunction with the AC and range switches to select current function (AC or DC).
7	Ohm	Selects resistance measurement mode of operation. Common lead is positive.
8	Range 1	Selects 100mv, 10ua, or 1MΩ full scale ranges. May be used in conjunction with item 11 (X10) to select 1V, 100ua, or 10MΩ full scale ranges.
9	Range 2	Selects 10V, 1ma, or 10KΩ full scale ranges. May be used in conjunction with item 11(X10) to select 100V, 10ma, or 100KΩ full scale ranges.
10	Range 3	Selects 1KV, 100ma, or 100Ω full scale ranges. May be used in conjunction with item 11 (X10) to select 1A and 1KΩ full scale ranges.
11	X10	Used in conjunction with items 8,9, and 10 to raise the full scale capability by a factor of 10.
12	Common	Jack for low (black) lead connection to Model 2000 for all functions.



PARTS LIST

REFERENCE DESIGNATOR	DESCRIPTION	QUANTITY
Z1,4	IC, Voltage Reference, 20-25 (AD580 or MC1403)	2 X
Z2,3	IC, OP Amp, 20-41 (LF356N) X	2 X
Z5	IC, Digit Driver (75492 or 492-5)	1 X
Z6	IC, A/D Converter, 20-786	1 X
Z7	IC, Segment, Driver, 20-788	1 X
VR1,2,3,4	Diode, Zener, 9.1V	4 X
CR1,2,3,4,5, 6,7,8	Diode, Signal, 1N4148	8 X
Q1	Transistor, 2SC1849Q	1 X
Q2	Transistor, 2N4403	1 X
Q3,4	Transistor, 2N4400	2 X
TRC1,2	TRIAC T2500B (30-208)	2 X
R14	Resistor, Wirewound, 1 ohm, 1%,5W	1 X
R8	Resistor, Carbon Film, 100 ohm,5%, 1/4W	1
R57	Resistor, Metal Film, 105 ohm, 1%,1/4W	1
R30	Resistor, Metal Film, 121 ohm, 1%, 1/4W	1
R48,49,50,51, 52,53,54,55,56	Resistor, Carbon Film, 150 ohm, 5%,1/4W	9
R27	Resistor, Metal Film, 536 ohm, 1%,1/4W	1
R26	Resistor, Metal Film, 887 ohm, 1%, 1/4W	1
R6	Resistor, Metal Film, 976 ohm, 1%, 1/4W	1
R44	Resistor, Carbon Film, 1K, 5%,1/4W	1
R41	Resistor, Carbon Film, 1.2K,5%, 1/4W	1
R29	Resistor, Metal Film, 1.21K, 1%, 1/4W	1
R12	Resistor, Carbon Film, 1.5K, 5%, 1/4W	1
R37	Resistor, Carbon Film, 1.8K, 5%, 1/4W	1
R24	Resistor, Metal Film, 1.87K, 1%, 1/4W	1

PARTS LIST

REFERENCE DESIGNATOR	DESCRIPTION	QUANTITY
R17	Resistor, Metal Film, 2K, 1%, 1/4W	1
R23	Resistor, Metal Film, 3.32K, 1%, 1/4W	1
R33	Resistor, Metal Film, 4.64K, 1%, 1/4W	1
R19	Resistor, Metal Film, 5.23K, 1%, 1/4W	1
R35	*Resistor, Carbon Film, 7.5K, 5%, 1/4W	1
R18	Resistor, Metal Film, 8.06K, 1%, 1/4W	1
R10	Resistor, Metal Film, 9.76K, 1%, 1/4W	1
R32	*Resistor, Metal Film, 10K, 1%, 1/4W	1
R7,20,40,45	Resistor, Carbon Film, 10K, 5%, 1/4W	4
R36	Resistor, Carbon Film, 16K, 5%, 1/4W	1
R21	Resistor, Carbon Film, 47K, 5%, 1/2W	1
R4	Resistor, Metal Film, 97.6K, 1%, 1/4W	1
R22,34,47	Resistor, Carbon Film, 100K, 5%, 1/4W	3
R43	Resistor, Carbon Film, 470K, 5%, 1/4W	1
R15,39,46	Resistor, Carbon Film, 1M, 5%, 1/4W	3
R42	Resistor, Carbon Film, 1M, 5%, 1/2W	1
R38	*Resistor, Carbon Film, 1.8M, 5%, 1/4W	1
R2	Resistor, Metal Film, 4.64M, 1%, 1/4W	1
R1	Resistor, Metal Film, 4.99M, 1%, 1/4W	1
	Resistor, Carbon Film, 10M, 5%, 1/4W	1
R9	Trimpot, 100 ohm	1
R25	Trimpot, 250 ohm	1
R11	Trimpot, 500 ohm	1
R13	Trimpot, 1K	1
R5	Trimpot, 5K	1
R31	Trimpot, 10K	1

PARTS LIST

REFERENCE DESIGNATOR	DESCRIPTION	QUANTITY
R16,28	Trimpot, 100K	2
R3	Trimpot, 500K	1
C1	Capacitor, Trimmer 6-35 pf	1
C2	Capacitor, Disc, 24 pf, 500V	1
C10	Capacitor, Disc, 470 pf	1
C3	Capacitor, Mylar, .001uf, 200V	1
C5,6,12,13,19	Capacitor, Disc, .01uf	5
C18	Capacitor, Disc, .1uf	1
C20	Capacitor, Mylar, .082uf, 50V	1
C14,17	Capacitor, Mylar, .1uf, 50V	2
C7	Capacitor, Mylar, .22uf, 50V	1
C4,8,9	Capacitor, Elect., 10uf, 16V, Axial	3
C15	Capacitor, Elect., 100uf, 10V	1
C16	Capacitor, Elect., 100uf, 16V	1
C11	Capacitor, Elect., 220uf, 16V	1
	P.C. Board, Main	1
	P.C. Board, Display	1
	P.C. Board, Switch Assembly	1
	Switch Assembly	1
	Jack, Red	1
	Jack, Black	1
	Fuse, Clip	2
	Fuse, 2 amp, Type AGC	1
	Component Socket, 18 position	1
	IC Socket, 8 pin	1
	LED, Display, Common Cathode	4
	Calibration Parts Set	1

PARTS LIST

REFERENCE DESIGNATOR	DESCRIPTION	QUANTITY
	Transformer, Cores	2
	Transformer, Bobbin	1
	Battery Holder	1
	Case, Half, Bottom	1
	Case, Half, Top	1
	Front Panel	1
	Standoff, Display	2
	Foot, Case	2
	Panel, Plastic, Rear	2
	Switch, Button, Red	1
	Switch, Button, Grey	4
	Switch, Button, Yellow	4
	Wire Stand, Case	1
	Cable, Ribbon, 15 conductor	4 in.
	Magnet, Wire	11 ft.
	Buss Wire, #22	2 ft.
	Insulated Wire, White	2 ft.
	Insulated Wire, Black	2 ft.
	Tape, Black, 1/4" Wide	1 1/2 ft.
	Screw, 4 x 40 x 1/4" Self Tapping	6
	Screw, 6 x 32 x 1 3/4"	4
	Spacer, Switch	2
	Assembly Manual	

*These parts are supplied as a set with the calibration numbers they produce. Two identical voltage references are used in the meter, but only one has been measured.

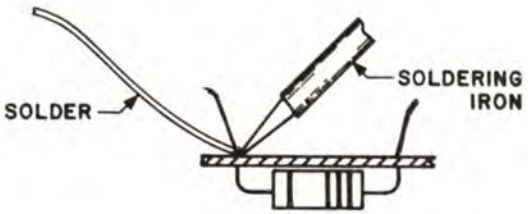
ASSEMBLY TECHNIQUES

Before the assembly process is begun, verify that all parts are present by examining the parts bags and comparing against the parts list. To speed the assembly process, examine and familiarize yourself with all parts in the kit so that identification will be readily accomplished. When capacitors and resistors are installed in the board, ensure that they are seated flush against the board. Then bend out the leads slightly to prevent them from falling out when soldering. After soldering, clip off any excess lead lengths.

A major cause of kit malfunctions is improper soldering. Another is improper component locations. Be sure you have the right part in the right place. Pay particular attention to the polarity on electrolytic capacitors, diodes, transistors and other semi-conductor devices.

Apply only enough heat and solder to make a good mechanical and electrical bond. Too much solder can cause solder bridges between adjacent foil areas on the P.C. Board. You will notice a green solder mask has been applied to the board to minimize this.

It is recommended that a 25 to 40-watt soldering iron be used with a tip small enough to allow easy soldering to the small IC pads but not so small that heat is not retained for soldering the larger parts. When solder is applied to a component, be sure that the heat is simultaneously applied to both the component lead and the component pad on the P.C. Board so that good solder flow will occur. Be sure that after the soldering operation is complete that the lead still extends thru the solder smoothly, indicating a good solder joint. Do not ever blob the solder over the lead because this can result in a cold solder joint.



After the entire P.C. Board is assembled, and prior to installing the board in the case, it is recommended that a solvent be used to clean the flux off the solder side of the printed circuit card. This will prevent any dirt from accumulating and shortening the life of your completed instrument. When applying solvent, be sure that you hold the board such that no solvent is allowed to enter the IC sockets, trimpots or switch assembly.

In addition to the parts supplied with the kit, the following are required to complete assembly:

Resin core solder, flux remover solvent and epoxy glue.

ASSEMBLY PROCEDURE

It is required that the Assembly Procedure be performed in the order described in this manual. Before assembly is started, refer to the Parts List and verify that all parts listed are actually present.

After a component has been installed and soldered in place, clip off any excess leads from the solder side.

Refer to Figure 1 for the following steps.

Install the following jumper wires using the bare wire provided.

[ ] J1 [ ] J2 [ ] J3 [ ] J4 [ ] J6 [ ] J8 [ ] J9

[ ] J10 [ ] J11

Install the following jumpers using the white insulated wire provided.

[ ] J7 [ ] J15

Open the packet containing the 5% resistors. Set aside the nine 150 ohm resistors (brown-green-brown-red or brown-green-brown-gold).

Install the following resistors. All are 1/4-watt, 5% tolerance (fourth band = gold) unless otherwise noted.

[ ] R12, 1.5K ohm (brown-green-red)

[ ] R8, 100 ohm (brown-black-brown)

[ ] R41, 1.2K ohm (brown-red-red)

[ ] R43, 470K ohm (yellow-violet-yellow)

[ ] R44, 1K (brown-black-red-red or brown-black-red-gold)

[ ] R21, 47K 1/2-watt (yellow-violet-orange)

[ ] R42, 1M, 1/2-watt (brown-black-green)

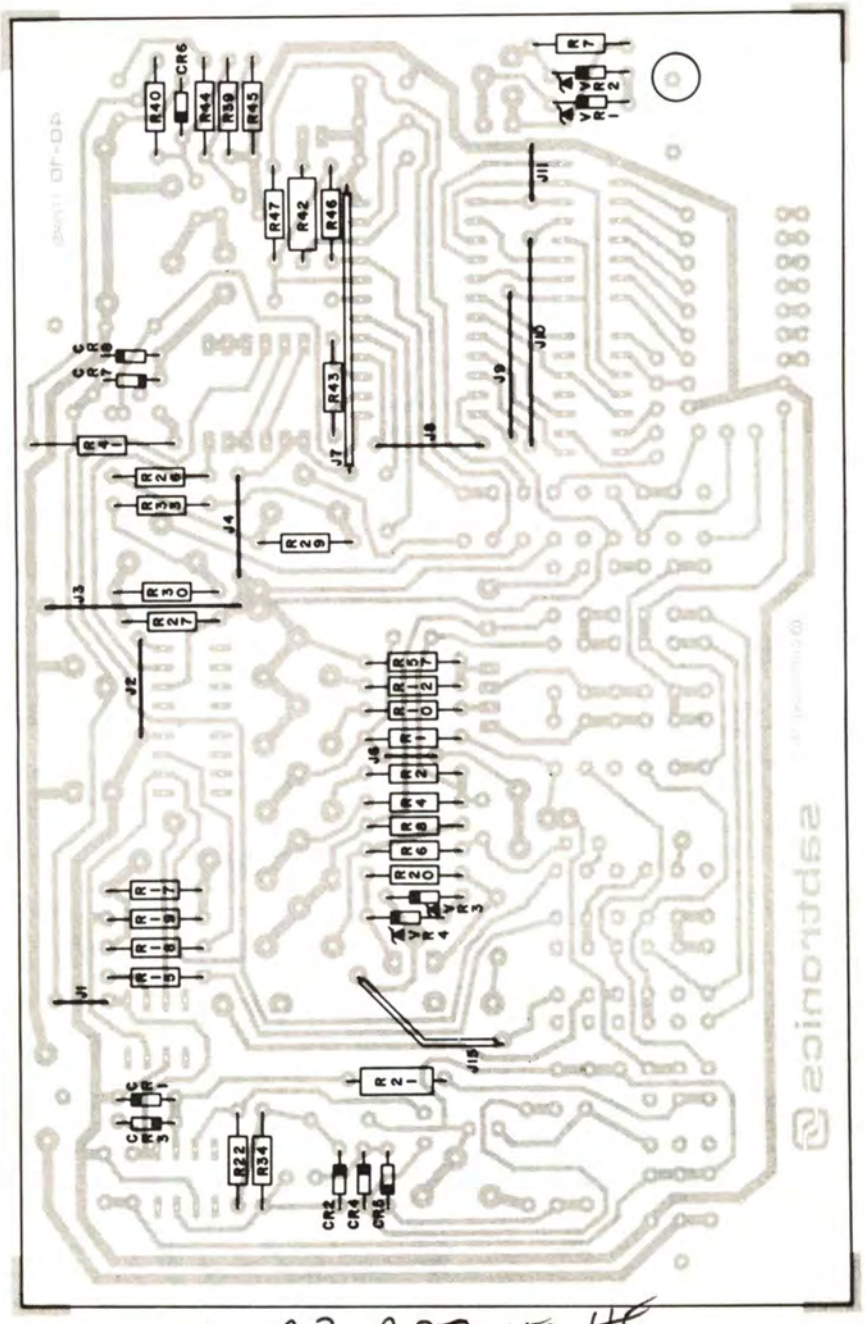


Figure 1

10K R7 R20 ~~40~~ 46

~~100K~~ 100K 22 34 47

Install three 1M (brown-black-green) resistors at the following locations.

[ ] R15 [ ] R39 [ ] R46

Install four 10K (brown-black-orange) resistors at the following locations.

[ ] R7 [ ] R20 [ ] R40 [ ] R45

Install three 100k (brown-~~green-black~~ BLK Y/EL resistors at the following locations.

[ ] R22 [ ] R34 [ ] R47

Open the diode package and install eight 1N4148 diodes at the following locations. NOTE POLARITY. The polarity on these diodes is difficult to read. The red tape indicates cathode, the white tape indicated anode.

[ ] CR1 [ ] CR5

[ ] CR2 [ ] CR6

[ ] CR3 [ ] CR7

[ ] CR4 [ ] CR8

Install four 9.1V Zener diodes at the following locations. NOTE POLARITY.

[ ] VR1 [ ] VR3

[ ] VR2 [ ] VR4

Open the packet containing the precision resistors and install the following. * means 1% value.

[ ] R1: 4.99 Meg 1%

[ ] R2: 4.64 Meg 1%

[ ] R4: 97.6K

[ ] R6: 976 ohm 1%

[ ] R10: 9.76K (9760 ohms) 1%

or

[ ] R57: 105 ohm 1%

[ ] R17: 2K (2000 ohms) 1%

[ ] R18: 8.06K (8060 ohms) 1%

[ ] R19: 5.23K (5230 ohms) 1%

[ ] R26: 887 ohm 1%

[ ] R33: 4.64K (4640 ohms) 1%

[ ] R27: 536 ohm 1%

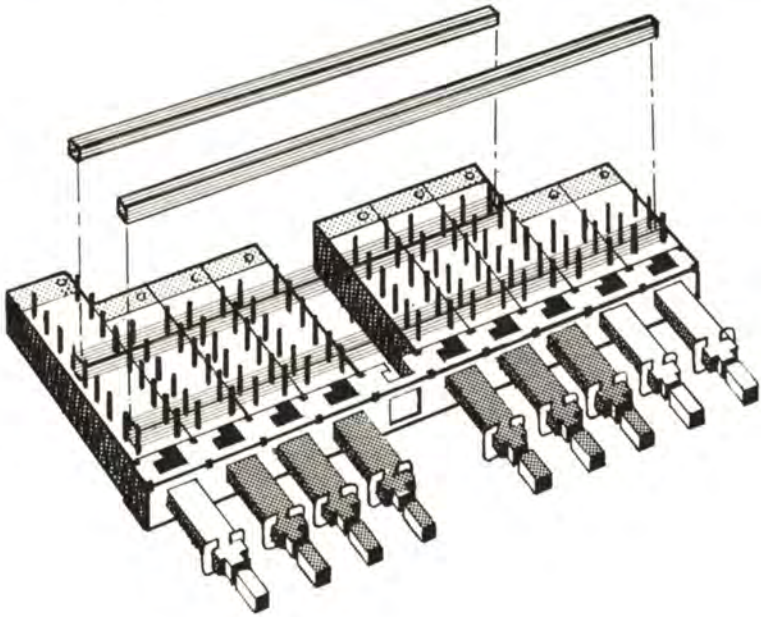
[ ] R30: 121 ohm 1%

[ ] R29: 1.21K (1210 ohm) 1%

Place the remaining precision resistors in their bag. These will be installed later.

[] Before proceeding with the switch assembly, verify that only the parts shown in Figure 1 are installed.

[] Carefully unpack the switch assembly and place it on a flat surface.



[ ] Locate the two plastic spacers and place them on the switch assembly (between switch pins) as shown.

[ ] Carefully place the main printed circuit board (etch side up) over the switch assembly so that all the holes mate with the switch pins.

[ ] Press down on the printed circuit board around the switch assembly so that the pins will protrude out the holes. Do this gently so that the pins do not bend. Do not force the pins through the holes. It may be necessary to gently move the printed circuit board until all the pins are in the appropriate holes.

[ ] After the printed circuit board is installed, apply pressure until the board is seated.

[ ] Solder all the pins on the switch assembly that protrude through the P. C. board.

[ ] After turning the P. C. board over so that the component side faces up, remove the two plastic spacer bars by sliding them out the side of the switch assembly.

[ ] Cut, form and strip a 7" length of white insulated wire for jumper J5.

[ ] Route the wire through the switch assembly and solder only the end installed between the switch assembly. (See Figure 2)

[ ] Install J14 using the bare wire provided.

[ ] Cut, form and strip a 3" length of white insulated wire for jumper J16.

[ ] Route J16 through the switch assembly as shown and solder.

Refer to Figure 2 to complete the P. C. Board Assembly.

Install nine 150 ohm (brown-green-brown-red or brown-green-brown-gold) resistors at the following locations.

[ ] R48	[ ] R51	[ ] R54
[ ] R49	[ ] R52	[ ] R55
[ ] R50	[ ] R53	[ ] R56

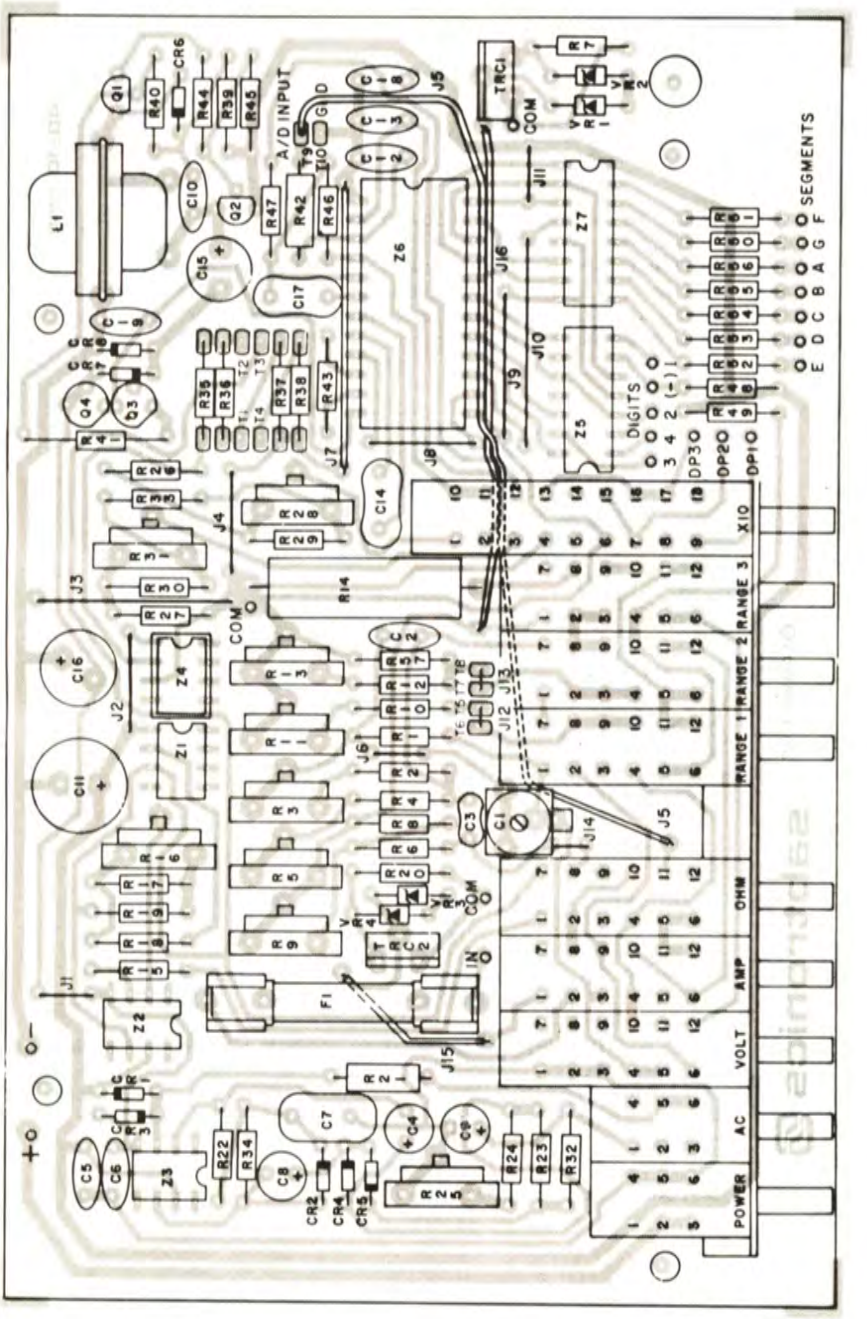


Figure 2

Install the following precision resistors.

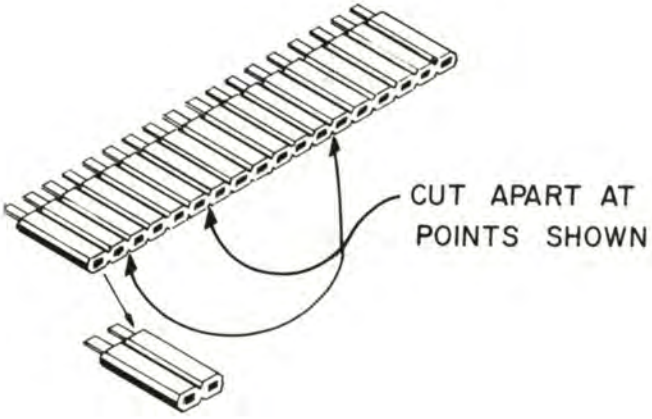
[ ] R23: 3.32K (3320 ohms) 1%

[ ] R24: 1.87K (1870 ohms) 1%

[ ] R32: 10K ohms 1%

[ ] Install an 8-pin IC socket at location Z4.

[ ] Cut the 18-pin single-in-line socket into lengths of 6,6,4, and 2 pins as shown. Cut on a flat surface with a sharp blade or knife. Do not cut any other way or damage to the socket will result.



[ ] Insert the 4-pin strip into holes marked T5, T6, T7 and T8.

[ ] Insert one 6-pin strip into the holes which include test points T2 and T3.

[ ] Insert the other 6-pin strip into the holes which include test points T1 and T4.

[ ] Insert the 2-pin strip into the holes marked T9 and T10 (A/D INPUT and GND).

[ ] Install the unconnected end of J5 in test point T9 (A/D Input).

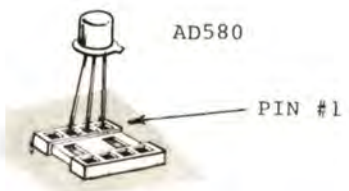
[] Install IC sockets, if available. IC sockets are not provided with the kit nor are they required. However, it is recommended that you use IC sockets.

[] Form J12 using the bare wire provided and install into test points T5 and T6.

[] Form J13 using the bare wire provided and install into test points T7 and T8.

[] Open the packet marked "Calibration Parts" and install integrated circuit Z4 into the 8-pin socket as shown below. NOTE: Z4 (20-25) may be one of two types; either an 8-pin dual-in-line package (MC1403) or a three lead transistor type (AD580). If the transistor type is supplied, install Z4 as shown below. If dual-in-line is supplied, note polarity notch.

MC1403



Install the following calibration parts into the 6-pin socket.

[] R35: 7.5K (violet-green-red-gold or violet-green-black-brown)

[] R36: 16K (brown-blue-orange-gold)

[] R37: 1.8K (brown-gray-red-gold)

[] R38: 1.8M (brown-gray-green-gold)

Install the following transistors.

[ ] Q1: 2SC1849Q Note Polarity flat.

[ ] Q2: 2N4403 Note Polarity flat.

Install two 2N4400 transistors. Note Polarity flat.

[ ] Q3 [ ] Q4

[ ] Locate and install the two fuse clips. Note the fuse clips have a stop ridge. This must face away from the fuse body.

[ ] Install the fuse into the fuse clips.

Install two triacs. Note polarity. For TRC2, the metal tab should face towards the fuse clip. Insure that the metal tab does not touch the fuse clip.

[ ] TRC1

[ ] TRC2

Locate and install the 1 ohm 1%, 5-watt resistor at R14.

Open the capacitor package and install C1: Trimmer Capacitor.

Install the following Disc Capacitors:

[] C2: 24pf NPO

[] C5: .01uf
[] C6: .01uf
[] C12: .01uf
[] C13: .01uf
[] C19: .01uf

Marked .01 or 103

[] C10: 470pf

[] C18: .1uf (or Mylar) Marked 104 or .1

Install the following Mylar Capacitors:

[] C3: .001uf, 200V (Marked .001 or 1000K)

[] C7: .22uf (Marked .22 or 224)

[] C14: .1uf
[] C17: .1uf
Marked 104 or .1

Install the following Electrolytic Capacitors, Note Polarity.

[] C4: 10uf

[] C8: 10uf

[] C9: 10uf

[] C11: 220uf

[] C15: 100uf, 10V

[] C16: 100uf, 16V or 20V

Open the packet containing nine trimpots.

[] Install R16: 100K Trimpot

[] Install R28: 100K Trimpot

[] Install R31: 10K

[] Install R13: 1K

[] Install R11: 500 ohm

[] Install R3: 500K

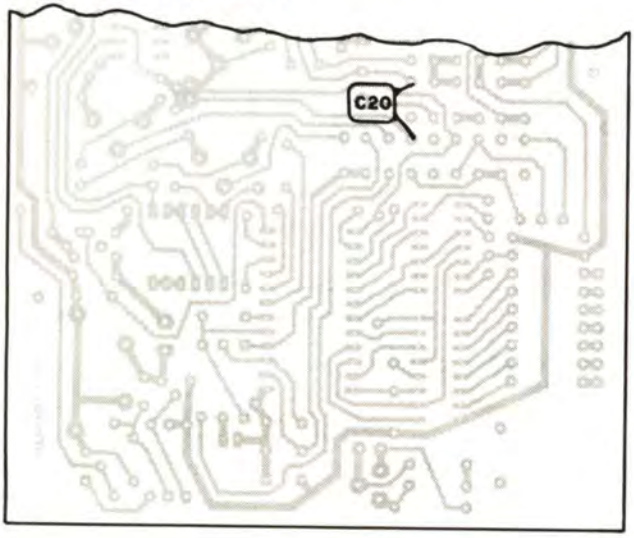
[] Install R5: 5K

[] Install R9: 100 ohm

[] Install R25: 250 ohm

Install the following capacitor on the solder side of the board at the location shown in the figure below. This is the only component mounted on the bottom of the P.C. board.

[] C20: .082 Mylar, 200V Capacitor
MARKED 823 K OR .82
100 U OR 200V



If sockets for IC's are not used, exercise care when soldering the IC pins. Avoid excessive heat and insure that your soldering iron is grounded.

[] Install Z1 (20-25 or AD580 or MC1403) in similar fashion as Z4 previously installed.

AD580

or

MC1403

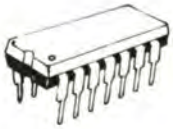
Install two IC's (20-41 or LF356N) observing polarity notch.

[] Z2

[] Z3

8-Pin DIP

[] Install Z5 (75492 or 492-5) observing polarity notch.

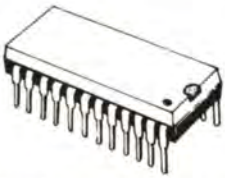


14-Pin DIP

[] Install Z7 (20-788) observing polarity notch.

16-Pin DIP

[] Install Z6 (20-786) observing polarity notch.



24-Pin DIP

[] Check to see if all IC's are installed correctly.

Locate all the parts for choke L1. These consist of one bobbin, two E cores, one 11' length of magnet wire, tape.

[] Wind all of the wire onto the bobbin as shown below. Be sure to leave both ends of the wire protruding from the bobbin. It is not critical which way the wire is wound, or if it is perfectly even.

Begin

Continue

Complete

[] Wrap some insulation tape around the bobbin.

[] Mate together the two cores around the bobbin as shown above. Be sure to put two layers of tape between the cores on each side of the "E".

[] Wind several layers of tape around the cores to hold the assembly together.

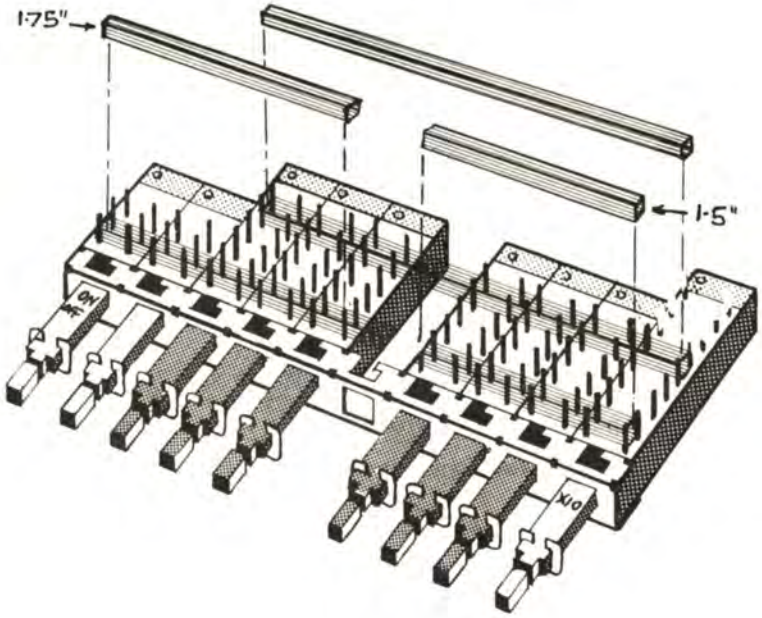
[] Scrape or sand insulation off choke leads.

[] Cut, strip and form a piece of black insulated wire and use the wire to hold L1 onto the board as shown above.

[] Tightly install and solder the ends of the wire on the solder side.

[] Install and solder the two leads of L1.

[] Place the two plastic spacer bars, used previously, on top of the switch assembly.



[] Install and solder the top P.C. board on the switch assembly. Be sure to solder all pins which protrude through the holes which have foil pads.

[] Remove spacer bars by sliding them out the side.

[] Cut and strip a black insulated wire to the length of 6" and solder one end of the wire to the common terminal adjacent to R14 leaving the other end unconnected.

[] Cut and strip a black insulated wire to a length of 2 1/2" and solder one end to the common terminal adjacent to TRC1 while leaving the other unconnected.

[] Cut and strip a black insulated wire to a length of 6" and solder one end of it to the common hole adjacent to the fuse while leaving the other end unconnected.

[] Find the molded ribbon cable provided, and segment the fifteen conductor cable into three cables; one of three conductors, one of five conductors, and one of seven conductors.

[] Strip and solder the three conductor cable into the holes on the main P.C. board labeled DP1, DP2, DP3.

[] Strip and solder one end of the five conductor cable into the holes labeled Digits 1, 2, 3, 4, (-).

[] Strip and solder one end of the seven conductor cable into the holes labeled Segments A, B, C, D, E, F, G.

[] Find the display board and the four LED display digits. Assemble the display digits to the P.C. board, observe polarity. Install the digits with their grooved surface up.

—Grooved Surface

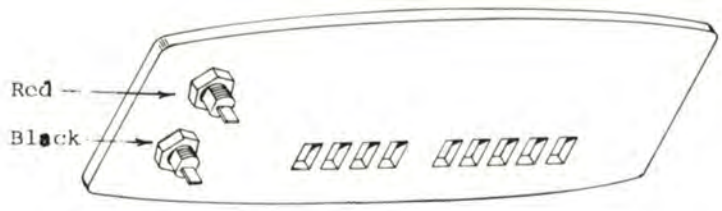
[] Strip and solder the seven conductor cable into the display board observing that the segment letters A through G correspond to the same color wires as used on the main P.C. board.

[] Strip and solder the three conductor cable into the display board while observing that the DP1, 2 and 3 signals correspond to the colors used on the main P. C. board.

[] Strip and solder the five conductor cable into the display board observing that the Digits 1, 2, 3, 4 and (-) correspond to the colors used on the main P.C. board.

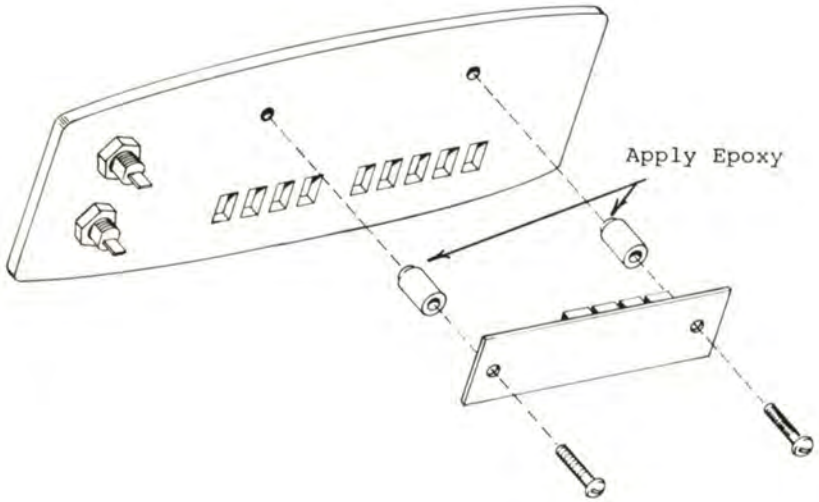
[] Find the front panel and the red and black input jacks.

[] Install the red input jack in the VΩA hole and install the black jack in the common hole.



[] Find the two plastic stand-offs used to mount the display to the front panel.

[] Install and bond the stand-offs to the rear of the front panel with epoxy as shown below. Allow the epoxy to cure before completing assembly.

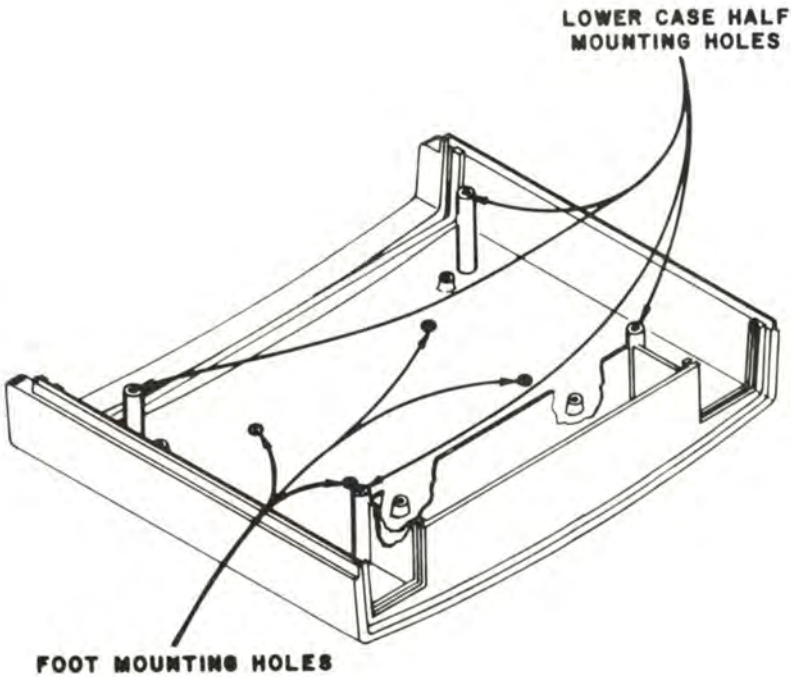


IDENTIFIED BY PLAIN STUDS UPPERCASE HAS BRASS STUDS

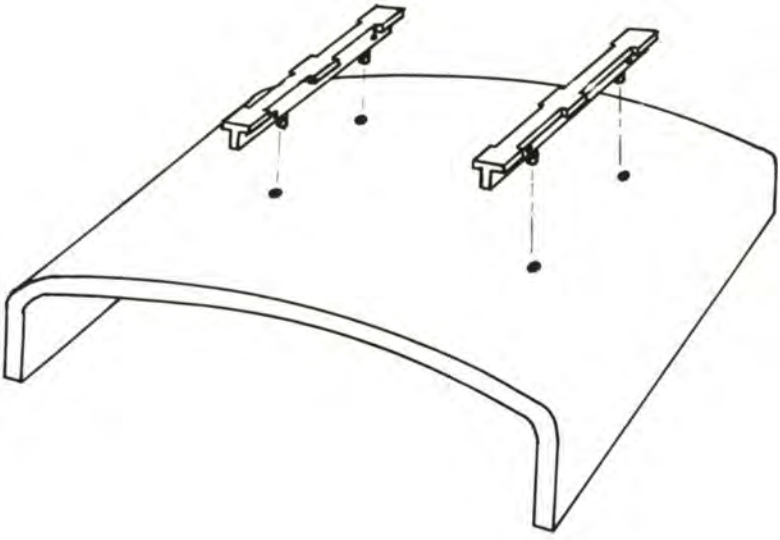
[] Locate the bottom case half and lay it on surface that won't be damaged by a drill.

[] Drill the four holes for mounting the feet, at the locations shown below. Use 1/8" drill.

[] Drill the four holes for holding the two case halves together, at the locations shown below. Use 5/32" drill.

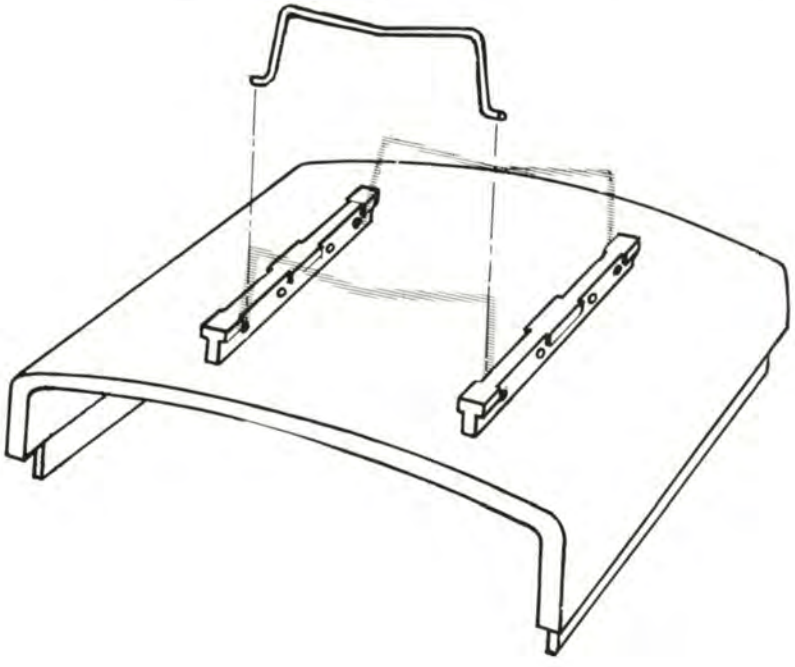


[] Install the plastic feet to the case half by inserting the two shafts on each foot into the holes in the case half as shown below.



[] Melt the two shafts on the inside of the cover with a soldering iron to secure each foot to the bottom cover. Epoxy may also be used.

[] Find and install the wire stand between the two feet as shown below. The case may be tilted up or down by changing the wire mounting position.



[] Install the two plastic panels in the slots in the rear of the case half as in Figure 3.

[] Find the red switch button and install it on the power switch.

[] Find the four gray switch buttons and install them on the AC, VOLT, AMP and OHM switches.

() Find the four yellow switch buttons and install them on the RANGE 1, RANGE 2, RANGE 3, and X10 switches.

SEE ADDENDUM → () ~~Mount~~ SLID DISPLAY BOARD the front panel, with the jacks and switch buttons installed, on the main P. C. board assembly as in Figure 3.

() Solder the three black common wire from the main P. C. board assembly to the black common input jack.

() Solder the white input wire from the main P. C. board assembly to the red input jack.

() Mount the display board onto the two plastic stand-offs on the rear of the front panel as previously shown.

() Find the plastic battery holder with blue or black and red wires.

() Install the red wire in the hole labeled + and the blue or black wire in the hole labeled - at the rear of the main P. C. board.

() Install the main P. C. board assembly, that has the front panel assembly attached, to the bottom case half as shown in Figure 3.

() Mount the P. C. board to the bottom case half with the four short screws provided.

() Install battery holder with batteries into battery compartment of the case.

() Perform Calibration Procedure, #1 or #2.

() The top cover is attached to the bottom cover with the four long screws provided.

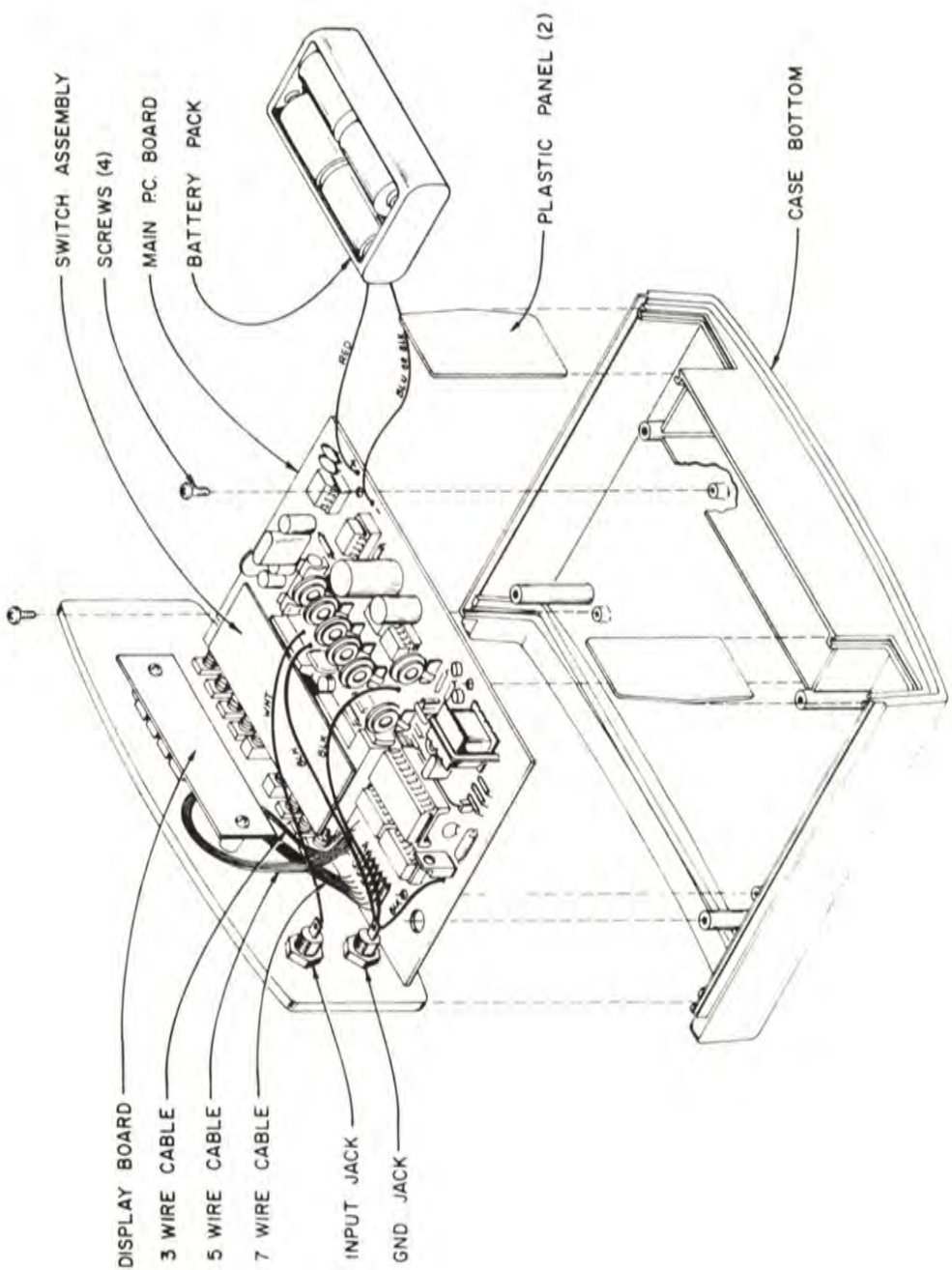


Figure 3

A = 1773 C = 1780 E = 1809
B = 1750 D = 1758

CALIBRATION PROCEDURE #1

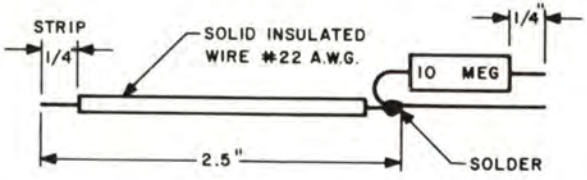
This Calibration Procedure has been prepared for the Kit Builder that has no other test equipment other than the Model 2000 digital multimeter just assembled. To get the best calibration accuracy, it is recommended that the Model 2000 be calibrated using Calibration Procedure #2. Calibration Procedure #2 will allow the calibration of the Model 2000 to within published specifications.

Calibration Procedure #1 uses data supplied by Sabtronics on four resistors and a voltage reference. Accompaning these five components will be five calibration numbers: A through E. These numbers, when used with the following calibration procedure, will allow reasonably accurate calibration of the Model 2000.

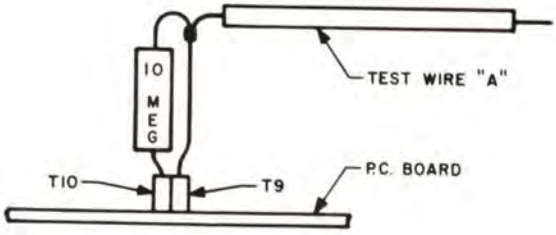
Z4 which is a voltage reference and the four resistors: R35, R36, R37, and R38 are used to provide both premeasured calibration voltages and premeasured resistance values. The premeasured voltages allow calibration of the voltage scales. The premeasured resistances allow calibration of the ohm scales and the current shunts for the amp scales.

Calibration Procedure

1. Assemble the test wire/resistor assembly shown in the figure below. This assembly will be used in calibration.



2. Remove the jumper wire running from the switch assembly to Test Point T9. Install the test wire/resistor assembly, described above into Test Points T9 and T10 as shown in the figure below.



3. Install the batteries into the battery holder and depress Power, Volt and 100mV.

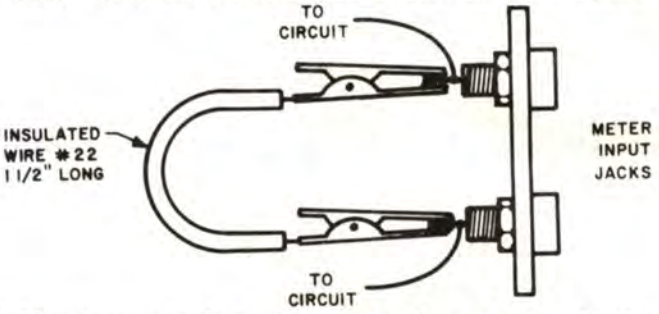
4. Connect the open end of the test wire to Test Point T1 and adjust R31 for a display reading that matches the calibration number A. This calibration number is included with the calibration kit enclosed with the voltmeter. With only the power switch depressed, this calibration number should be approximately 180.0. This adjustment is used to adjust the 200 millivolt reference voltage at Test Point T1.

5. Depress Power, Volt, 100mV, and X10.

6. Move the test wire from Test Point T1 to Test Point T2. Then adjust R28 for a display reading corresponding to calibration number B. This number should be approximately 1800. This adjustment calibrates the internal 2 volt reference voltage.

This completes the calibration of the two reference voltages used by the A/D converter. The following steps are used to calibrate the ohms circuitry.

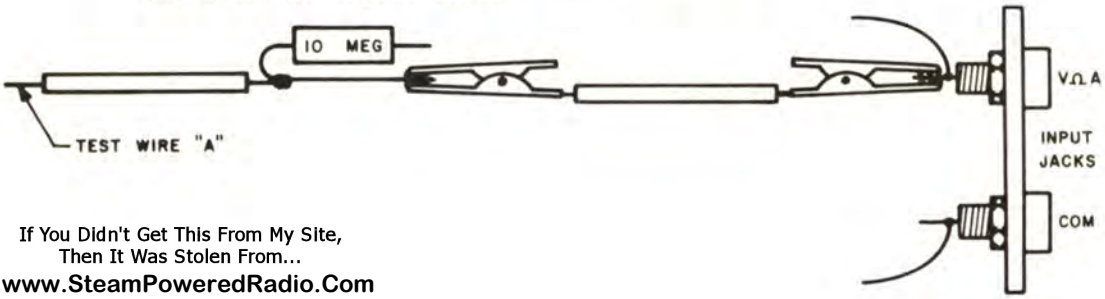
7. Remove the test wire from Test Point T2 and install in Test Point T3. Then short the two input jacks labeled V Ω A and common. To short the two jacks together, assemble an alligator clip lead and connect as shown in the figure below.



8. The following switches should be depressed: Power, Ohm, 100Ω, and X10.

9. Adjust R16 until the display jumps equally between (-) 999 and (-) 1000.

10. Remove the test wire/resistor assembly from the meter and disconnect the clip lead jumper shorting the input jacks. Attach the clip lead to the test wire/resistor assembly as shown in the figure below.



11. Install the jumper wire coming from the switch assembly to Test Point T9. This connects the A/D converter input to the switch assembly which is necessary for normal operation.

12. Depress the following switches: Power, Ohm, 100Ω, and X10.

13. Locate and remove R35 (7.5KΩ) from the socket that it is installed in.

14. Install the test wire in Test Point T1 and adjust trimpot R9 for a display reading corresponding to the calibration number C. This should be approximately (-) 1800.

15. Depress the following buttons: Power, Ohms, and 10K.

16. Remove the test wire from Test Point T1 and insert in Test Point T2. Monitor the display while adjusting R5 to correspond to calibration number D which will be approximately (-) 18.00.

17. Depress the following buttons: Power, Ohm, and 1 megaohm.

18. Remove the test wire from Test Point T2 and install in Test Point T4. While monitoring the display, adjust R3 to obtain the calibration number E. This will be approximately (-) 1.800. Now that the DC volt and ohm circuitry is calibrated, the current shunt resistors will be calibrated.

19. Reinstall R35 (7.5KΩ) in its socket and remove the jumper connecting Test Point T5 to Test Point T6 and the jumper connecting Test Point T7 to Test Point T8.

20. Remove the test wire from Test Point T4 and install in Test Point T5.

21. Depress the following switches: Power, Ohm, and 10K.

22. Locate and adjust trimpot R11 for a display reading of (-) 10.00.

23. Remove the test wire from the Test Point T5 and install in Test Point T8.

24. Depress the following switches: Power, Ohm, 100Ω.

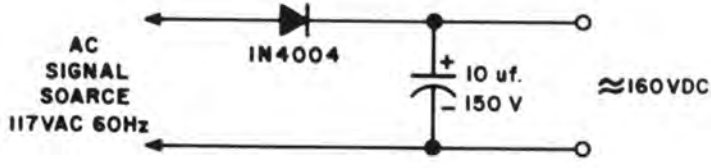
25. Find and adjust trimpot R13 until the display reads (-) 100.2.

26. Remove the test wire/resistor assembly and the clip leads from the input jacks. They will not be required for the rest of the calibration procedure.

27. Reinstall the wire jumpers from Test Points T5 and T6 and Test Points T7 to T8.

The AC volts will now be calibrated. This is accomplished by peak detecting 117 VAC 60 Hz and measuring this peak with the already calibrated DC scale. Once this DC peak is measured, the RMS equivalent may be calculated and will be used as the AC calibration number for the line voltage applied to the Model 2000 meter.

28. It will be required that an AC peak detector circuit be built as shown in the figure below. It will be used to obtain the peak DC voltage of the 117 VAC line.



29. Depress switches: Power, Volt, 10V, and X10.

30. Install test leads into the Model 2000 input jacks and measure the DC voltage across the 10uf capacitor in the peak detector circuit shown above. Record this voltage. This voltage is AC_{peak}.

31. Convert the measured DC voltage to the equivalent AC voltage using the following equation: $AC_{rms} = (AC_{peak} + .7)/1.414$.

32. Depress switches: Power, AC, Volt, 10V and X10.

33. With test leads, apply AC line voltage to the input terminals of the Model 2000.

34. Find and adjust R25 while observing the display. R25 should be adjusted until the display reads the value calculated in Step 31.

35. Find and adjust trimmer capacitor C1 to mid-range. This is a calibration of the high frequency AC response.

The calibration procedure is now complete. It is very important that the above calibration procedure be followed in order specified. If the procedure is performed out of sequence, errors will result.

CALIBRATION PROCEDURE #2

This Calibration Procedure is used to calibrate the Model 2000 with Test equipment normally found in an average calibration lab.

The equipment required is:

1. Fluke, Model #760 meter calibrator or equivalent.

2. Digital Multimeter (4 1/2 digit) with input impedence in excess of 10^{10} ohms (Example: HP3465A).

3. AC Signal Generator (10V at 10KHz).

SCOPE

The .2 volt reference, the 2 volt reference, and the ohm reference voltages are all calibrated using the external 4 1/2 digit multimeter. The input scaling resistances are adjusted by injecting a known resistance into the meter. The current shunt resistors are adjusted using the 4 1/2 digit multimeter. The AC calibration is accomplished at 60Hz and 10KHz by applying a calibrated AC input voltage and adjusting the trimmers until the correct reading is obtained.

PROCEDURE

1. Install the batteries into the battery holder and depress Power, Volt, and 100mv.

2. Connect the 4 1/2 digit meter to the .2V reference. Positive lead to R31 wiper and ground lead to Test Point T10(GND).

3. Adjust R31 trimmer until 4 1/2 digit meter measures 199.99mv.

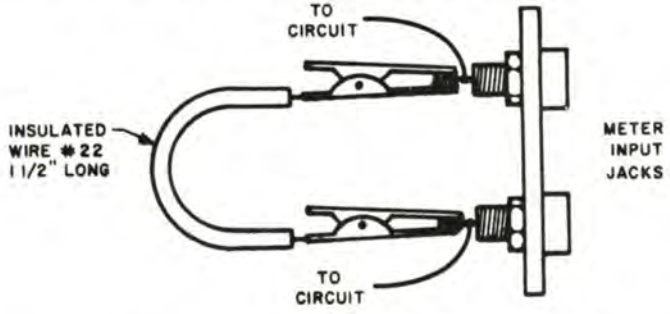
4. Depress Power, Volt, 100mv, and X10.

5. Connect the 4 1/2 digit meter to the 2V reference. Positive lead to R28 wiper and ground lead to Test Point T10(GND).

6. Adjust R28 trimmer until 4 1/2 digit meter measures 1.9999 volt.

7. Depress Power, Ohm, and 10K switches.

8. Short the input jacks with jumper as shown below. If necessary, assemble an alligator clip lead as shown.



9. Connect the 4 1/2 digit meter to the OHM reference. Positive lead to Test Point T3 and ground lead to Test Point T10(GND).

10. Adjust R16 trimmer until external 4 1/2 digit meter measures -1.0000VDC.

11. Remove clip lead from input jacks.

12. Depress Power, Ohm, and 100Ω switches.

13. All following precision resistance measurements require a .01% resistance source including lead resistance.

14. Connect precision 180 ohm resistance to input jacks.

15. Adjust R9 trimmer until Model 2000 measures -180.2. The .2 ohms allows for fuse resistance.

16. Depress Power, Ohm, and 10K switches

17. Connect precision 18K ohm resistance to input jacks.

18. Adjust R5 trimmer until Model 2000 measures -18.00.

19. Depress Power, Ohm, and 1MΩ switches.

20. Connect precision 1.8MΩ resistance to input jacks.

21. Adjust R3 trimmer until Model 2000 measures -1.800.

22. Repeat steps 14 to 21 to verify that R8, R5, and R3 are properly set.

23. Remove J12 from Test Points T5 and T6.

24. Remove J13 from Test Points T7 and T8.

25. Adjust trimmer R11 until the 4 1/2 digit meter reads 10.000K ohm from Test Point T5 to ground. Connect positive lead of 4 1/2 digit meter to Test Point T5 and ground lead to Test Point T10(GND).

26. Adjust trimmer R13 until the 4 1/2 digit meter reads 100.00 ohms from Test Point T8 to ground. Connect positive lead of 4 1/2 digit meter to Test Point T8 and ground lead to Test Point T10(GND). This calibrates the Range 2 current shunt.

27. Reinstall J12 from Test Points T5 and T6.

28. Reinstall J13 from Test Points T7 and T8.

29. Depress Power, AC, Volt, 100mv, and X10.

30. Apply a precision 1.0000 V 60Hz sinewave signal to the input jacks.

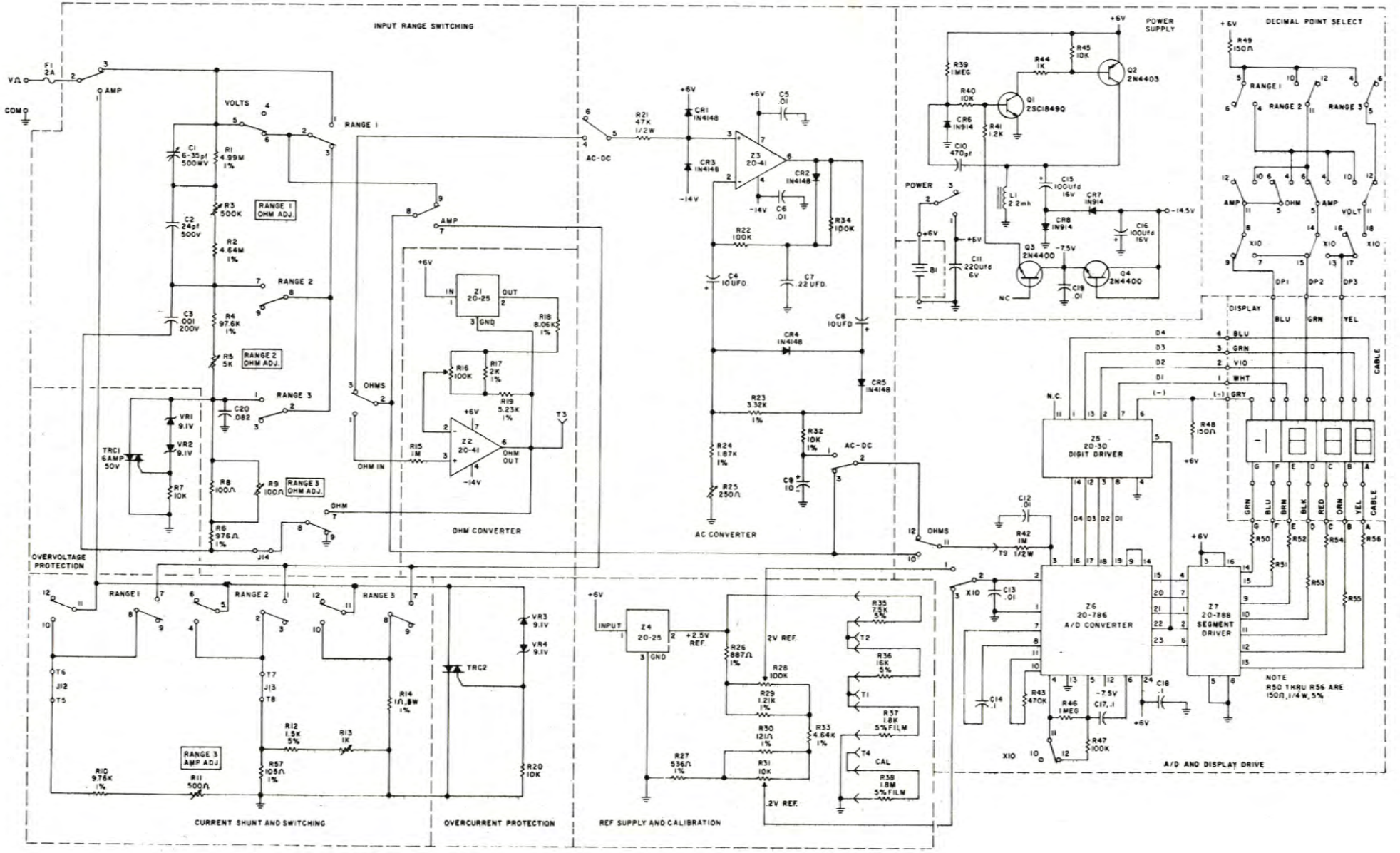
31. Adjust trimmer R25 until the Model 2000 displays 1.000V.

32. Depress Power, AC, Volt, and 10V.

33. Apply a precision 10.00VAC 10KHz sinewave signal to the input jacks.

34. Adjust trimmer capacitor C1 until the Model 2000 displays as close to 10.05V as possible. This gives the meter the best linearity over this range.

35. Calibration is now complete.



SCHEMATIC

All switches shown in the out position.

CIRCUIT DESCRIPTION

Power Supply. Basic power required for the meter circuit is +4 to 6.5 VDC at 120 Ma. It is supplied by batteries or the optional external power circuit. -14.5 VDC and -7.5 VDC are produced by a blocking oscillator Q1, Q2 and associated components; frequency of oscillation is approximately 25 KC. Q3 and Q4 base emitter junctions are reversed and act as low leakage zener diodes which regulate the output voltage of the power supply by starving base current from Q1.

Input Range Switching. R1 through R6 form a voltage divider network used for input scaling. Range switches 1, 2, and 3 select divide ratio by 1, 100 or 1000 respectfully. C1, C2, C3 and C20 are used to compensate for circuit high frequency AC variations and have no effect on DC and low frequency input signals.

Ohm converter. Z1 and Z2 form a precision current source. The input scaling voltage divider is used in ohm mode to program the current. This constant current is applied to the unknown resistance at input terminals; the voltage dropped by the resistance is displayed by the A/D converter as ohms.

Current Shunts and Switching. R10 through R13 form three current shunt resistances. In the amp mode current through the input terminals produces a voltage drop across the selected shunt; this voltage is displayed by the A/D converter as current.

AC Converter. Z3 and associated components form a precision rectifier circuit which produces a DC output scale factored to the AC input. Calibration adjustment R25 set the scale factor for sine wave inputs.

Reference Supply and Calibration. Z4 is a precision integrated circuit voltage regulator. The 2.5V output of Z4 is applied to voltage divider R26 through R31 to develop the 2V and .2V reference needed by the A/D convertor. R35 through R38 and Z4 provide a self-calibration methode. Although the resistors are 5%, they have been measured to .1% of their exact value and voltage divider output with Z4. R35 through R38 and Z4 are supplied as a set with accompanying calibrations numbers. These parts are installed in sockets to prevent soldering heat from changing their value.

A/D and Display Drive. Z6 is an integrated dual slope A/D converter circuit. Input voltages to be displayed feed into pin-3 through low pass filter C12 and R42. X1-X10 switch selects the appropriate .2V or 2V reference and slope time

constant R46 or R47 and C17. R43 sets the clock frequency to approximately 80 KHz. C14 is used in the auto zero function. The multiplexed outputs of the A/D IC are fed to the digit driver Z5 and segment driver Z7 to drive the LED display. R50 through R56 control the display current.

Decimal Point Selector. Current limited by R49 is directed by switch contact and light the appropriate decimal point.

Over Voltage and Over Current Protection. TRC1 and zener diodes VR1 and VR2 form a crowbar circuit which short out damaging current and voltages during the time it takes for the fuse to blow. TRC1 protects the Range 3 ohms section which does not have high enough circuit resistance to limit current to a safe value. TRC2 and zener diodes VR3 and VR4 operate in a sinular manner to TRC1 but protect the meter Range 1 and Range 2 current shunts. R15, R21, CR1, CR2, R42 and C12 also provide overload protection to their associated circuits by limiting overload current to a safe value.