OPERATING INSTRUCTION MANUAL

FOR

TYPE 800-A

VACUUM TUBE VOLTMETER

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Acton Laboratories. Incorporated
533 Main Street
Acton Massachusetts

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SECTION I

GENERAL DESCRIPTION

1.1 Purpose of Equipment

The purpose of the Type 800-A Vacuum Tube Voltmeter is to measure direct and alternating voltage, direct current, and d.c resistance. The instrument is characterized by its wide operating range in both amplitude and frequency. Accuracy of measurement is assured by the use of precision components and liberal use of inverse feedback.

The instrument is available as a single unit in a cabinet, Type 800-A.

1.2 Purpose of Instruction Manual

The purpose of this Instruction Manual is to familiarize the operator with the operating procedure, theory of operation, maintenance, and any special procedures of techniques which might aid in the use of the instrument.

1.3 Equipment Supplied

Type 800-A (Cabinet Mounted):

- Dimensions: 9" high x 7" wide x 7" deep
- Weight: (including cabinet) 11 ¾ pounds
- D. C. Probe
- A. C. Probe
- A 6-foot power cord
- Spare Fuse

1.4 Specifications

1.4.1 D. C. Voltage Ranges:

Full scale ranges of .1, .3, 1, 3, 10, 30, 100, 300, and 1000 volts are provided.

1.4.2 A. C. Voltage Ranges

Full scale ranges of .1, .3, 1, 3, 10, 30, 100, and 300 volts (rms) are provided. The meter scale is calibrated using a sine wave.

The reading for a complex wave is therefore approximately .707 of the peak value.

1.4.3 Resistance Ranges:

The meter scale is calibrated in resistance over a range from .2 ohm to 500 ohm with multiplying factors of .1, 1, 10, 100, and 100, 104, 105, 106 and 107. Resistances may therefore be measured in overlapping ranges from .02 ohms to 5000 megohms.

1.4.4 Current Ranges:

Full scale ranges of .001 ua, .01 ua, 1 ua, 10ua, 1ma, 10ma, and 100ma direct current are provided. The full scale voltage drop on any range is 100 mv.

1.4.5 Accuracy:

D. C. Volts ± 2% of full scale for 1.0 v range and higher
± 3% of full scale for .1 and .3 v ranges.

A.C. Volts (Sine Wave) (Low Frequency) ± 3% of full scale for 1.0v ranges and higher
± 5% of full scale for .1 and .3 v ranges

Current (D.C.) ± 2% of full scale for .1 us and higher
± 3% of full scale for .001 us and .01 us ranges

1.4.6 Frequency Response:

The response of the A. C, voltage probe is given by the family of curves shown in Section 5.2.

1.4.7 Input Impedance:

D. C. Volts: The input resistance is 100 megohms on all ranges.

A. C. Volts: The input capacitance is 5 uuf (nominal). The input resistance is 10 megohms (nominal) at low frequency becoming somewhat lower as frequency increases.

Current (D.C.): The input resistance is such that the input voltage drop is 100 mv. Full scale on all ranges.

Resistance: The voltage is applied to the resistor to be measured does not exceed .1 v d.c.

1.4.8 Line Voltage Stability:

The meter indication does not vary by more than ± 1.0% for a line voltage variation from 95 to 130 volts for any d.c. voltage, current, or resistance range.

1.4.9 Power Supply:

105-125 volts, 60 cycles, self-contained power supply requiring approximately 25 watts.

1.4.10 Tubes:

1	5751
1	12AY7
2	9006
1	6X4

1.5 Identification of Controls

1.5.1 SELECTOR Switch:

This switch controls the selection of the proper circuitry to measure direct voltage of either polarity with respect to the common ground connection, alternating voltage, resistance, and direct current of either polarity with respect to common ground.

1.5.2 RANGE Switch:

This switch allows the selection of the appropriate range for each of the above mentioned measurements.

1.5.3 AC ZERO:

This control allows the zero adjustment of the meter for a.c. voltage measurement and should be made with the a.c. voltage probe connected to common ground. The adjustment should be made on the

.1 v a.c. voltage range. Its setting is independent of the setting of the DC ZERO.

1.5.4 DC ZERO:

This control allows the zero adjustment of the meter for the measurement of direct voltage, resistance, and direct current. This setting may be made on any resistance and current range or on the .1 V direct voltage range with the appropriate probe connected to common ground. Its setting is independent of the setting of AC ZERO.

1.5.5 OHMS ADJUST:

This control allows the adjustment of the meter to full scale with the selector switch in the Ω position. The adjustment should be made with the Ω-I probe open-circuited.

1.5.6 LINE Switch:

The power switch for the instrument is included on the SELECTOR SWITCH. The extreme counter-clockwise position of the switch disconnects one side of the power line.

SECTION II

OPERATING INSTRUCTIONS

2.1 General Operating Procedure

2.1.1 The Type 800-A is ready for immediate use when received. Make sure all accessories have been removed from the packing box and examine the instrument for any damage which may have occurred in shipment. If the instrument has been damaged in shipment, refer to Section 5.3 "Material Damaged in Shipment".

2.1.2 Connect the instrument to a 115 v, 60 cycle, a.c. power line and turn the SELECTOR switch from the OFF position to any operating position. In general, allow an initial 5 minute "warm-up" period. If operation is desired on the two most sensitive ranges, allow a 20 minute "warm-up" period.

2.1.3 The measurement of direct voltage is made using the COMMON test lead and the D. C. V. probe with the SELECTOR switch in the -V or +V position, depending on the polarity of the voltage to be measured. These markings indicate the conventional sigh of measured voltage with respect to the common ground connection. The DC ZERO adjustment should be made on the .1 v range with the leads connected together. The zero adjustment does not have to be readjusted as the RANGE switch is change. Adjustment of the zero is usually not required if the .1 v and the .3 v ranges are not being used.

CAUTION: The cabinet and A.C. probe housing are at the same potential is the COMMON test lead. Do not connect to high potential.

2.1.4 The measurement of alternating voltage is made using the COMMON test lead and the A. C. probe with the SELECTOR SWITCH in the a. c. position. The AC ZERO adjustment should be made on the .1 v range with the A.C. probe connected to the COMMON lead. The zero adjustment does not have to be readjusted as the RANGE switch is changed. Adjustment of the zero is usually not required if the .1 v and .3 v ranges are not being used. The DC and AC ZERO adjustments are independent. For high frequencies, the short ground clip attached to the probe should be used instead of the COMMON test lead.

CAUTION: The cabinet and A.C. probe housing are at the same potential is the COMMON test lead. Do not connect to high potential.

2.1.5 The measurement of resistance is made using the COMMON test lead and the I-Ω probe with the SELECTOR switch in the –I or +I position, depending on the polarity of the current to be measured. These markings indicate the conventional direction of current flow into the I-Ω probe. The DC ZERO adjustment should be made with the input leads connected together. An initial 29 minute "warm-up" period is desirable.

2.1.6 The measurement of direct current is made using the COMMON test lead and the I- probe with the SELECTOR switch in the –I or +I position, depending on the polarity of the current to be measured. These markings indicate the convential direction of current flow into the I- probe. The DC ZERO adjustment should be made with the input leads connected together. An initial 20 minute "warm-up" period is desirable.

CAUTION: The cabinet and A.C. probe housing are at the same potential is the COMMON test lead. Do not connect to high potential. This means that current must be measured in a low potential (preferably grounded) section of the circuit under test.

2.2 Special Operating Instructions

2.2.1 The DC ZERO control for the Type 800-A operates on an absolute basis. It inserts a fixed voltage (depending upon its setting) into the measuring circuit in an additive manner. It therefore has its major effect on the low full scale voltage ranges with decreasing effect on the 1.0 full scale range and higher, where is use is rarely necessary.

2.2.2 The AC ZERO control for the Type 800-A operates similarly to the DC ZERO (see 2.2.1 above).

2.2.3 For measurement of very low resistance, the Type 800-A on the X.1 range will show a low resistance reading rather than zero for the usual setting of the DC ZERO. This is due to the finite low resistance of the external measuring leads and internal connections. This may be compensated for by resetting the DC ZERO on this range with the input leads solidly connected together.

Similarly, for the measurement of very high resistance, the Type 800-A on the X10M range will show a high resistance reading rather than infinity for the usual setting of the OHMS ADJUST control. This is due to internal and external leakage and may be compensated for by resetting the OHMS ADJUST on this range with the input leads isolated from one another.

2.3 General Operating Techniques

2.3.1 The Type 800-A is to a large extent self-protecting in case of mild or severe overload. This is particularly true on any of the voltage ranges. Resistor overload or burn-out will occur, however, if appreciable voltage from a low impedance source is inadvertently applies to the current probe with the range switch in the low-current positions.

2.3.2 If any of the probe tips is handled by the operator, thus injecting relatively large "pick-up" voltages into the measuring system, erratic behavior of the meter will result, particularly on the low ranges. No permanent damage will be done because of the self-protective feature.

2.3.3 To avoid excessive "wear and tear" on the indicating meter, it is suggested that the RANGE switch be set to a range above the lowest two whenever the SELECTOR switch is operated.

2.3.4 If at any time the meter cannot be set to zero using the appropriate ZERO control, the internal coarse zero controls must be readjusted according to the instructions in Section IV of this manual. This in general will be necessary as the instrument ages, or, if tube changes are made, or the instrument is subject to excessive mechanical shock.

SECTION III

THEORY OF OPERATION

3.1 Detailed Description

3.1.1 Basic Measuring Circuit:

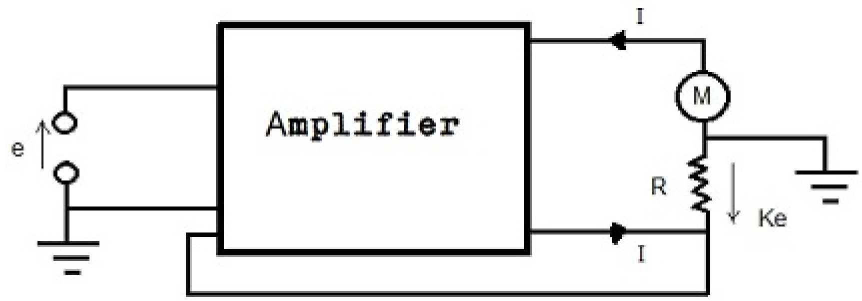
The conventional d. c. voltmeter consists of a moving-coil current meter in series with a precision resistor usually referred to as a multiplier resistance. In this system the applied voltage necessary to cause a full-scale deflection of the meter is simply give by E = IR where I is the full scale current of the current meter and R is the sum of the resistance of the precision resistor and the current meter. The accuracy of this system is good, principally because of its simplicity.

In the above system the current necessary to actuate the meter must be supplied by the source of the voltage being measured, resulting in disturbance of that source. In a portable voltmeter the maximum practical sensitivity is of the order of 20,000 Ω per volt or a current of the order of 50 ua is necessary.

A vacuum tube voltmeter can be devised to make full use of the inherent accuracy of the basic voltmeter by interposing a highly degenerative amplifier between the voltage to be measured and the conventional voltmeter. If the amplifier is totally fed back and the loop gain is large, the amplifier voltage gain may be very nearly unity. The amplifier therefore serves simply to transfer the unknown voltage at a high impedance level to the terminals on the voltmeter a low impedance level with negligible error. The current taken from the source may now be a fraction of a micro-amp.

The Type 800-A is a vacuum tube voltmeter of this type with the further improvement in that the feedback voltage is developed across

The precision resistor alone, not including the resistance of the current meter. The basic measuring circuit therefore has the following appearance.



k is very nearly unity

IR = k e

I = $\underline{k\ e/}$R

I = $\underline{\ e/}$R (very nearly)

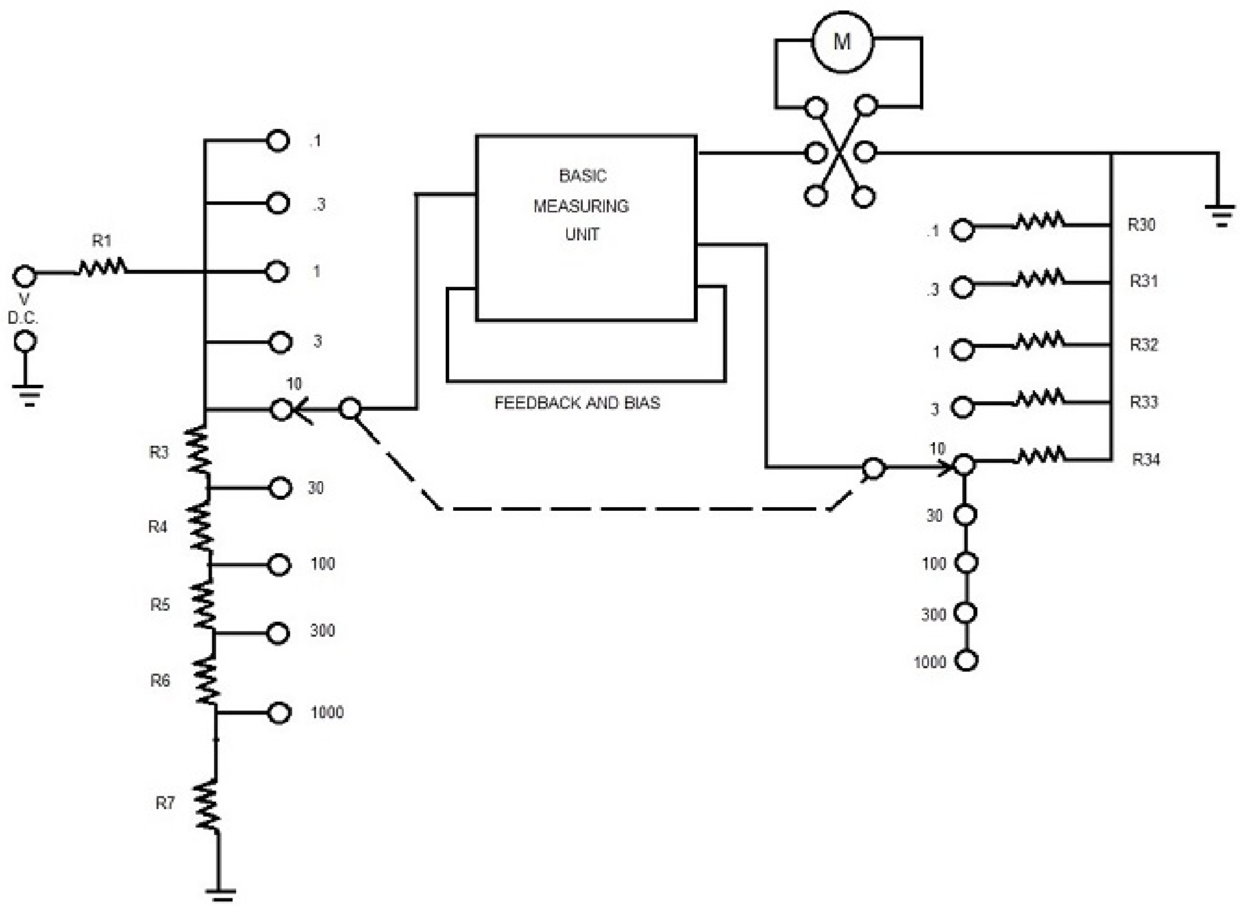
The calibration therefore depends only upon the current indication of the meter and the precision resistor R. Changes in meter resistance due to temperature (copper wound coil) and differences in meter resistance from one unit to another (in production) have no effect. It is also possible to use a multiplier R having a value smaller than the resistance of the meter, therefore providing lower full-scale ranges.

We have then in this basic measuring circuit a unit which accepts an input d.c. voltage e and produces a reading I on a d.c. microammeter which is simply related to e by multiplier resistance R. Change of voltage range is therefore readily accomplished by changing R (within the voltage handling capability of the circuit). In fact, due to the large feedback factor the measured result has a precision substantially determined by the precision of the microammeter and multiplier, the vacuum tube circuit not appreciably affecting the calibration. Furthermore, this unit can easily be zero adjusted, has excellent stability, and demands very little input current (of the order of 10^{-11} amps).

Referring to the schematic diagram of connections shown after Section V, the basic measuring unit consists of tubes V_2, V_4 and their immediately associated circuitry.

3.1.2 Measurement of Direct Voltage

For the measurement of direct voltage of either polarity, the following schematic applies:



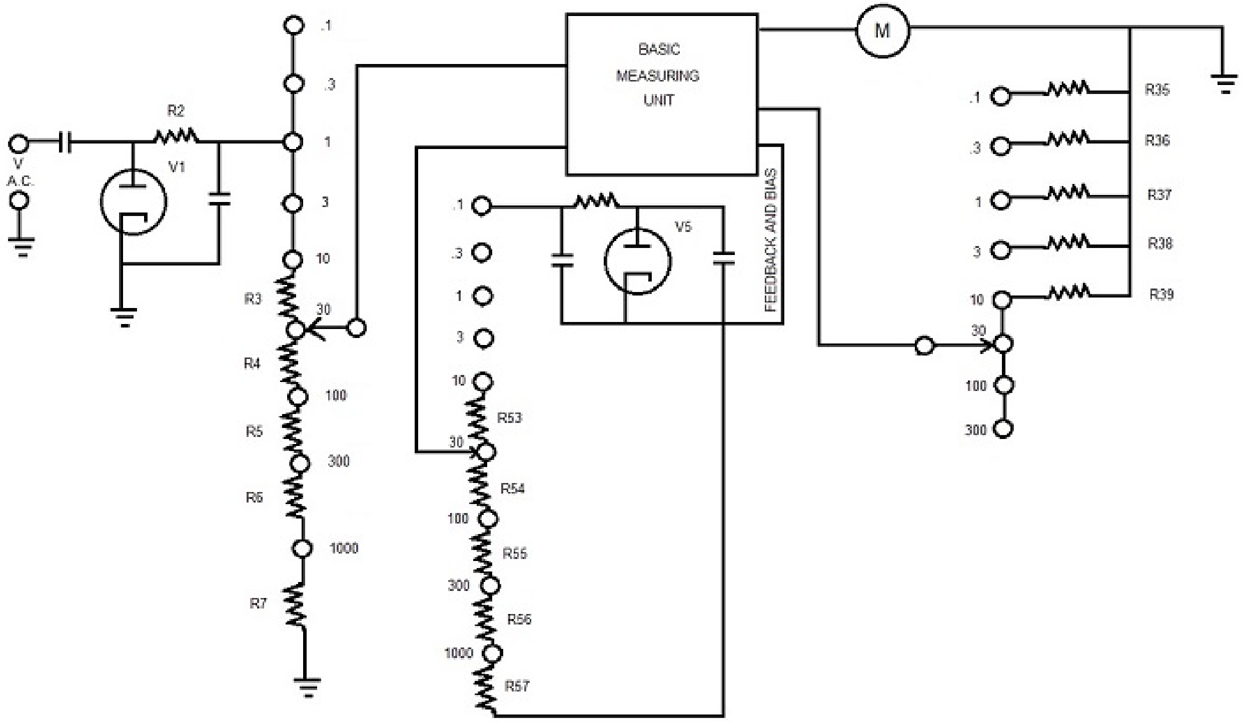
The resistor R_1 is an isolating resistor of high value contained in a probe tip to allow the measurement of direct voltage in a circuit also having a.c. components without introducing undesirable shunt capacitance. R_1 together with R_3, R_5, R_6, and R_7 constitute a voltage divider. For the measurement of low voltage (first 5 switch positions), a fixed fraction of the input voltage is applied to the basic measuring unit, with the particular range selected by the choice of multiplier resistance R_{30} through R_{34}. For the four higher ranges, the multiplier is fixed at a value R_{34} while the input divider has been so proportioned that the same full-scale voltage is applied to the basic unit for each of the desired

Input ranges.

Voltages of either polarity may be measured by simply reversing the current meter. The input divider may be made to have a very high (100 megs) input resistance without disturbing the calibration because of the very high input resistance of the measuring unit. The precision of measurement is determined primarily by the precision of the meter, the precision of the multiplier resistors, and the precision of the resistors making up the input voltage divider.

3.1.3 <u>Measurement of Alternating Voltages:</u>

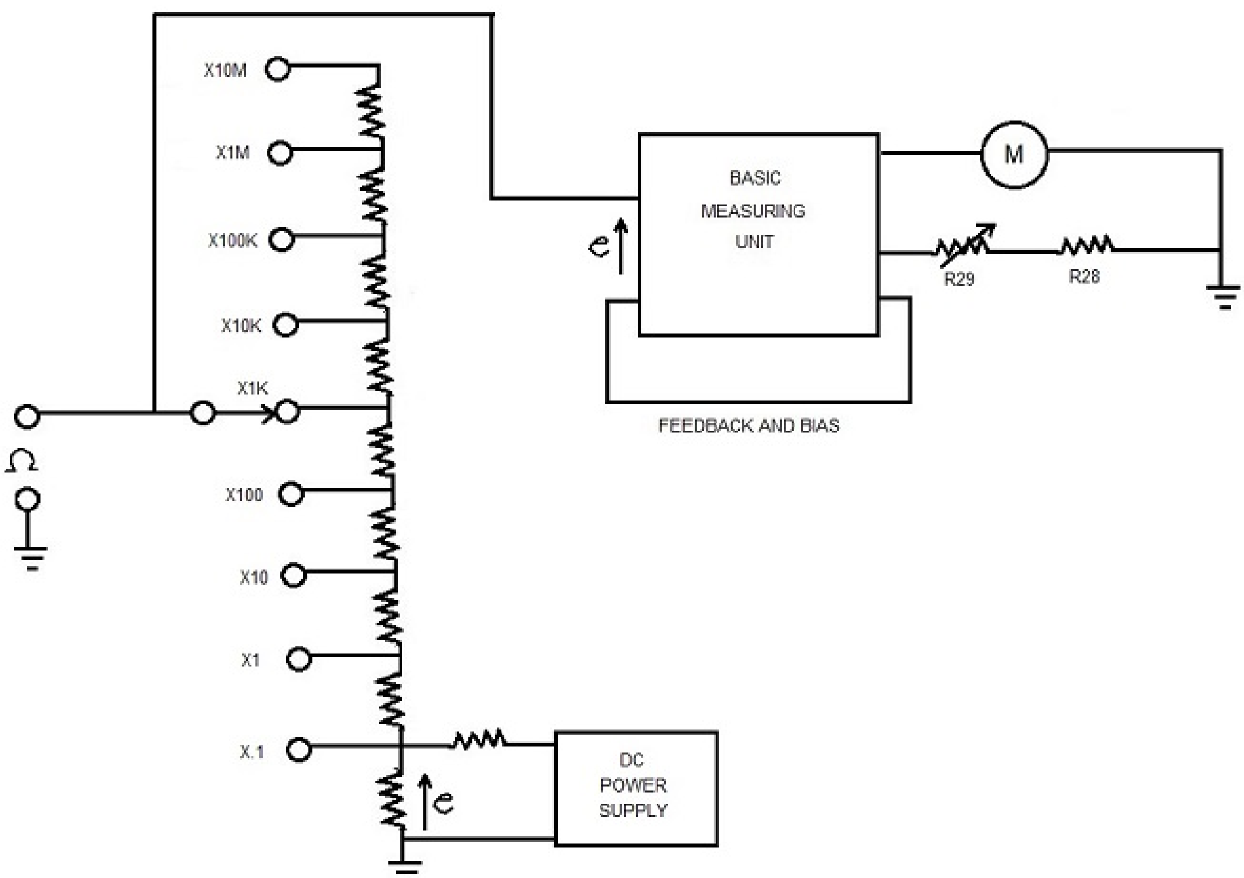
In this case the following schematic applies:



The alternating input voltage is rectified by V_1 acting as a linear peak diode to produce negative direct voltage applied to the divider consisting of R_2 through R_7 (May be the same divider as used for d.c. voltage). This divided voltage is measured by the basic unit in a manner similar to the employed for d.c. voltage.

Since the thermionic diode V_1 produces an initial voltage without signal, a second similar diode V_5 is inserted in the feedback connection to balance the effect of V_1. Since the input divider varies the effect of the initial V_1 diode voltage, a similar divider is associated with V_5 to balance this effect. As is well known, the diode rectifier is non-linear at low voltage becoming nearly linear at high voltages. For this reason the multiplying resistors R_{35} through R_{39} are chosen to yield full-scale current at each of the several full-scale input voltages in the non-linear region. Over the higher voltage range where operation is linear, the same input divider may be used as for d.c. voltage. The precision of measurement at high voltage is determined principally by the precision of measurement of the d.c. voltage developed by the diode. In the non-linear region the precision is reduced due to the diode.

3.1.4 Resistance Measurement:



In this circuit, a stabilized d.c. power source furnished a fixed voltage E which is applied to the basic measuring unit and to the input terminals through an adjustable resistance. If the input terminals are open circuited, the voltage E is present at the input to the measuring unit and the part of the multiplier resistance (R_{29}) may be adjusted to yield full scale current on the meter. If an unknown resistor is then connected, the measured voltage e is reduced according to the equation.

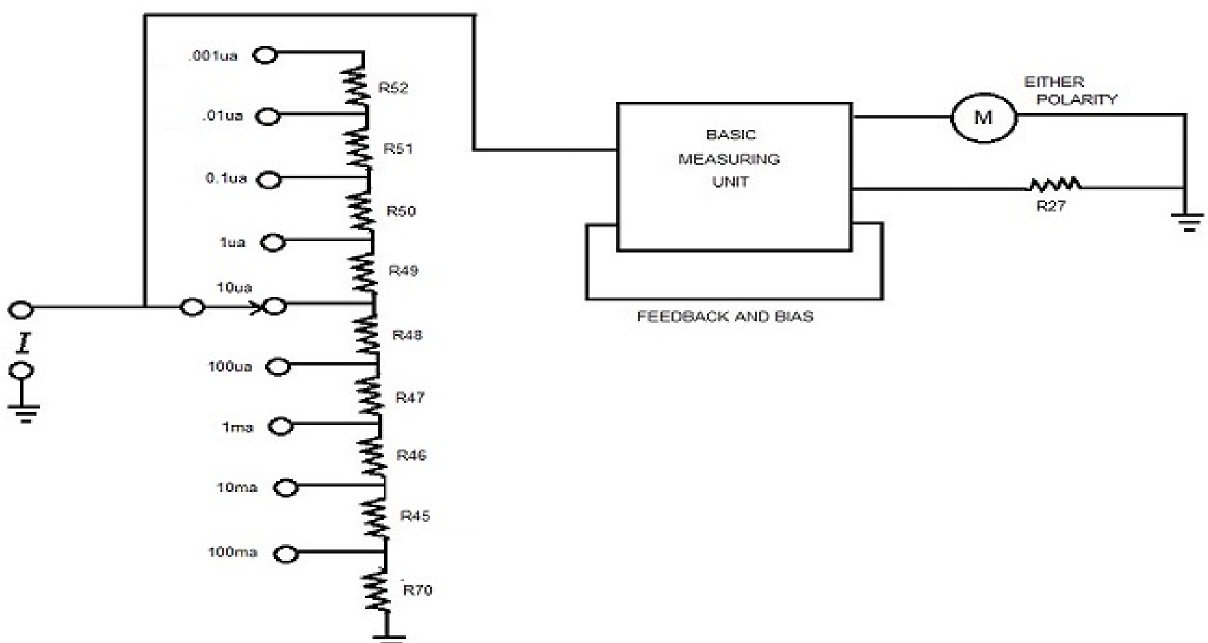
$$E = E \frac{R_x}{R_s + R_x}$$

where: R_x = unknown resistance

R_s = standard resistance

The standard resistor R_s consists of an appropriate series connection of resistors R_{70} and R_{45} through R_{52} as chosen by the range switch. Obviously, from the above equation, the meter may be directly calibrated in resistance with the setting of the range switch serving as a multiplier. The precision of measurement is consistent with the precision as d.c. voltmeter as far as the current indication is concerned. However, due to the non-linear relation between the resistance and current indications the resulting precision of the resistance measurement would have to be computed for each case. The high input resistance of the measuring unit allows the measurement of very high resistance without appreciable error.

3.1.5 Measurement of Current:



For the measurement of direct current, a fixed multiplier R_{27} is used to fix the voltage range of the instrument. The input current is applied to a series combination of resistors selected from the resistor bank R_{70} and R_{45} through R_{52}. The resistor combinations are chosen for each range that when the required full-scale input current for that range is flowing through the resistor, a voltage is developed which just causes full-scale deflection. Currents of either polarity with respect to ground can be measured by the use of the meter reversing switch. The precision of measurement is the same as for d.c. voltage. Because of the inherent stability of the basic measuring unit which allows a low full-scale voltage to be used (.1 volt), the voltage drop across the input terminals is never excessive in most applications. Very small currents (.001 us full-scale) can also be measured because of the low input current requirement of the measuring unit.

SECTION IV

MAINTENANCE

4.1 Routine Maintenance

Under normal conditions, the Type 800-A will give trouble free service over long periods of time. If, however, tube changes are made or if the instrument or its probes receive severe mechanical shock as may occur during shipment, attention is called to the following section.

4.2 Special Maintenance

If the instrument does not appear to be operating properly, the trouble may fall under one of the following categories.

4.2.1 DC ZERO

Sufficient drift may occur over a period of time or because of mechanical shock such that the zero setting of the meter is not possible using the panel control. In this case, the coarse zero-set control (R_{61}) should be readjusted. This adjustment can be made readily by removing the small snap-cap located on the top of the cabinet directly in back of the corresponding panel control.

4.2.2 AC ZERO

Sufficient drift may occur over a period of time or because of mechanical shock such that the zero setting of the meter is not possible using the panel control. In this case, the coarse zero-set control (R_{66}) should be readjusted. This adjustment can be made readily by removing the small snap-cap located on the top of the cabinet directly in back of the corresponding panel control.

4.2.3 Grid Current

Excessive grid current taken by V2 manifests itself by a shift of zero setting on the lowest d.c. voltage range when the d.c. probe is alternately connected and disconnected to the COMMON lead. Adjustment is readily made by means of R73 which is made available by removing the snap-cap on the top of the cabinet directly in back of the OHMS ADJUST panel control. Adjustment should be made such that the reading of the meter on the ± .1 v d.c. range is not changed as the d.c. probe is alternately connected and disconnected to the COMMON lead. This adjustment will change the d.c. zero setting which then must be made according to sections 1.5.4 or 4.2.1.

4.2.4 Calibration

Calibration on the d.c. voltage and current ranges should remain within the specifications of the instrument as long as the instrument is operative and can be zeroed. If inoperative, on these ranges, replacement of V_2, V_4, and V_6 is suggested.

4.2.5 AC Calibration

Calibration on the a.c. voltage ranges from .1 v to 10 v inclusive should remain within specifications unless V_1 is replaced. If this is found necessary, the full-scale calibration of these ranges should be checked and compensated if necessary by changing to appropriate resistor of the set of resistors R35A through R39A which are readily available on a terminal strip located on the side of the instrument.

4.2.6 Tube Replacement

Tube replacement should be necessary in the Type 800-A only at infrequency intervals, since all tubes except V_6 are operated at reduced heater voltage and all tubes are operated well within their ratings.

Replacement of V_2, V_4, and V_6 require no special consideration

With the possible exception of readjustment of grid current and the d.c. zero as given in sections 4.2.3 and 4.2.1.

If replacement of V1 is necessary, refer to the drawing of the a.c. probe in Section 5.2.3. Mechanical disassembly of the a. c. probe must be carefully done by removing the screw holding the plastic nose cap in place and removing the Allen-head set-screw at the cable end of the probe. The nose cap and internal assembly together with the cable can be moved as a unit to slide V_1 out of the probe housing. The new tube (Type 9006) should be prepared by cutting off pins 5, 6, and 7 as close to the glass envelope as possible with a pair of diagonal cutters. The tube should then be inserted in the segmented socket with pins 2, 3, and 4 making contact. The clip attached to C_1 and R_2 is then fastened to pin 1 of the tube. The entire assembly is then returned to the probe housing making sure that the grounding strap from the cathode (pin 2) is securely compressed between the plastic nose cap and the housing.

SECTION V

SUPPLEMENTARY DATA

5.1 Parts List

Identification of Manufacturers;

Abbreviation	Manufacturer
A. Bradley	Allen Bradley Company
Allies	Allies Products Corporation
Buss	Bussman Manufacturing Company
C.D.	Cornell-Dubilier Electric Corporation
Centralab	Centralab Division of Globe Union, Inc.
C. T. S.	Chicago Telephone Supply Corporation
Federal	Federal Telephone and Radio Corporation
G.E.	General Electric Company
Good-All	Good-All Electric Manufacturing Company
I. R. C.	International Resistance Company
Marion	Marion Electrical Instrument Company
Mystic	Mystic Transformers
RCA	Radio Corporation of America
Solar	Solar Electric Company

SECTION V

COMPONENT LIST

COMPONENT	VALUE	VOLTS OR WATTS	TOLERANCE	MFGR.	TYPE	REMARKS
CAPACITORS:						
C1	.01 UF	450 V	-20% +80%	Centralab	BC-disc	Ceramic
C2	.005 uf	500 V	±20%	Centralab	BC-disc	Ceramic
C3	.01 UF	450 V	-20% +80%	Centralab	BC-disc	Ceramic
C4	.01 uf	600V	±20%	Good-All	COMY-6-103-20	Mylar
C5	.005 uf	200 V	±20%	Good-All	COMY-6-502-20	Mylar
C6	.005 uf	200 V	±20%	Good-All	COMY-6-502-20	Mylar
C9	.005 uf	200 V	±20%	Good-All	COMY-6-502-20	Mylar
C10	500 uf	25 V	±20%	C. D.	BRH-255	Electrolytic
C11	.02 uf	200 V	±20%	Good-All	COMY-6-203-20	Mylar
C12	12 uf	350 V	±20%	C. D.	BRH-255	Electrolytic
RESISTORS						
R1	25 meg.	1 W	1%	Allies	APBT1	
R2	22 meg.	½ W	5%	A. Bradley	EB2265	
R3	50 meg.	1 W	1%	Allies	APBT1	
R4	17.5 meg.	1 W	1%	Allies	APBT1	
R5	5.0 meg	½ W	1%	Allies	APST½	
R6	1.75 meg.	½ W	1%	Allies	APST½	
R7	.75 meg.	½ W	1%	Allies	APST½	
R9	6.8 meg.	½ W	10%	I. R. C.	BTS ½	
R11	10 meg.	½ W	10%	I. R. C.	BTS ½	
R12	1.0 meg.	½ W	10%	I. R. C.	BTS ½	
R13	1.0 meg.	½ W	10%	I. R. C.	BTS ½	

COMPONENT	VALUE	VOLTS OR WATTS	TOLERANCE	MFGR.	TYPE	REMARKS
R14	10 meg.	½ W	10%	I. R. C.	BTS ½	
R22A	10 meg.	½ W	1%	Allies	APST½	
R22B	10 meg.	½ W	10%	A. Bradley	EB10610	
R23A	17.5 meg.	1 W	1%	Allies	APBT1	
R23B	2.2 meg.	½ W	5%	A. Bradley	EB2255	
R24	470 KK	½ W	10%	I. R. C.	BTS ½	
R25	470 K	½ W	10%	I. R. C.	BTS ½	
R26	10 K	½ W	10%	I. R. C.	BTS ½	
R27	2.0 K	½ W	1%	Allies	APST½	
R28	1.8 K	½ W	1%	Allies	APST½	
R29	500 ohms			Centralab	Model 1 Control	
R30	1.5K	½ W	1%	Allies	APST½	
R31	4.5 K	½ W	1%	Allies	APST½	
R32	15 K	½ W	1%	Allies	APST½	
R33	45 K	½ W	1%	Allies	APST½	
R34	150 K	½ W	1%	Allies	APST½	
R35	620 ohms	½ W	1%	Allies	APST½	
R36	3.9 K	½ W	1%	Allies	APST½	
R37	18 K	½ W	1%	Allies	APST½	
R38	62 K	½ W	1%	Allies	APST½	
R39	220 K	½ W	1%	Allies	APST½	
R40	4.7 meg.	½ W	10%	I. R. C.	BTS ½	
R45	9 ohms	½ W	1%	Allies	APST½	
R46	90 ohms	½ W	1%	Allies	APST½	
R47	900 ohms	½ W	1%	Allies	APST½	
R48	9 K	½ W	1%	Allies	APST½	

COMPONENT	VALUE	VOLTS OR WATTS	TOLERANCE	MFGR.	TYPE	REMARKS
R49	90 K	½ W	1%	Allies		APST½
R50	900 K	½ W	1%	Allies		APST½
R51	9 meg	½ W	1%	Allies		APST½
R52-52A	45 meg	1 W	1%	Allies		APBT1
R53	6.8 meg	½ W	10%	I. R. C.		BTS ½
R54	2.2 meg	½ W	10%	I. R. C.		BTS ½
R55	680 K	½ W	10%	I. R. C.		BTS ½
R56	220 K	½ W	10%	I. R. C.		BTS ½
R57	selected	½ W	10%	I. R. C.		BTS ½
R60	470 K	½ W	1%	Selected		APST½
R61	100 K			C. T. S.	X-3538	LT-2 Shaft Control
R62	10 K	½ W		Centralab	Model	1 Control
R63	270 K	½ W	1%	Allies		APST½
R65	470 K	½ W	1%	Allies		APST½
R66	100 K			C. T. S.	X-3538	LT-2 Shaft Control
R67	10 K	½ W		Centralab	Model	1Control
R68	270 K	½ W	1%	Allies		APST½
R70	1 ohm	½ W	1%	Allies		APST½
R71	100 ohm	2 W	10%	A Bradley		HB1011
R73	100 K			C. T. S.	X-3538	LT-2 Shaft Control
R75	1.0 ohm	2 W	10%	I. R. C.		BW-2
T1				Solar		30488
T2				Mystic		TRP-41
M	50 ua		1%	Marion		MRDS-19
Rectifier				Federal		1016
Fuse	.5 amp			Buss		3AG

COMPONENT	VALUE	VOLTS OR WATTS	TOLERANCE	MFGR.	TYPE	REMARKS
S1				Centralab		SRW-128
S2				Centralab		SRW-129
Pilot Lamp	.15 amp			G. E.	47	
TUBES:						
V1				R.C.A.	9006	
V2				R.C.A.	5751	
V4				R.C. A.	12AT7	
V5				R. C. A.	9006	
V6				R. C. A.	6X4	

5.3 Material Damaged in Shipment

Address correspondence to:

ACTON LABORATORIES, INCORPORATED

SERVICE DEPARTMENT

531 MAIN STREET

ACTON, MASSACHUSETTS

Telephone: Colonial 3-7756

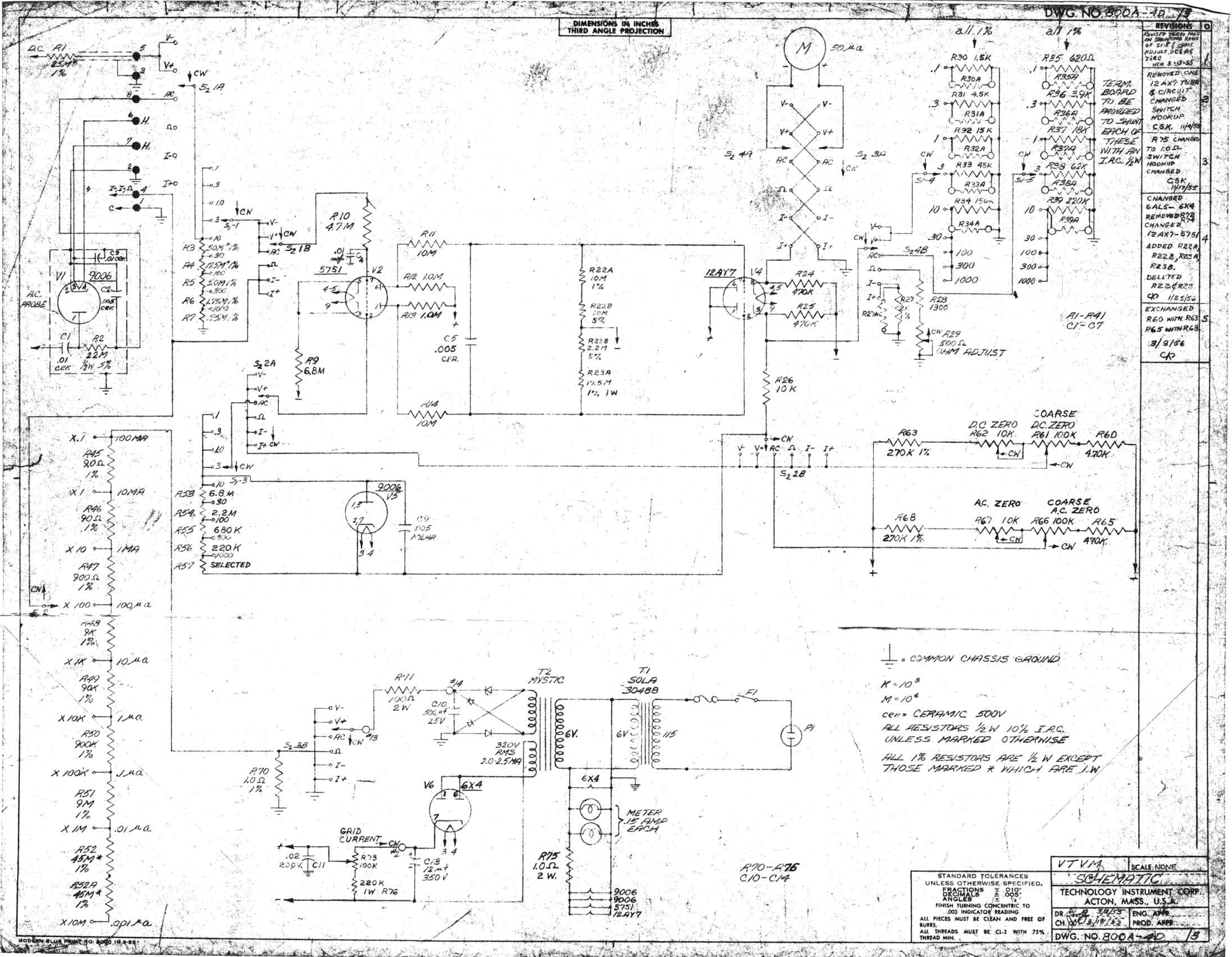
If, upon receipt of your instrument, the packing case shows evidence of damage, or if upon unpacking, damage is found which appears to have been caused by shipment, do not unpack or discard any of the packing. Notify immediately the local office of the carrier and request the they inspect the damage. Also notify Acton Laboratories, Inc., of the type number, serial number, extent and type of damage, our invoice number, carrier's number, date received, and any other pertinent information so that we may contact our local carrier office in order to facilitate a speedy settlement of any Claim.

5.4 Warranty

Acton Laboratories, Incorporated, warrants that each instrument shipped is in accordance with all published specifications. Any deviation from those specifications of defects or workmanship or material will be corrected by Acton Laboratories, Incorporated, provided the instrument has been properly used under normal operating conditions. This warranty is in effect for one year from delivery date except for failures attributable the tubes, fuses, or batteries after 90 days from the above date. Acton Laboratories, Incorporated, will be the sole judge of the validity of all claims.

All returns made under the warranty must be authorized in writing by Acto Laboratories, Incorporated. Such authorization will be given only upon receipt of information concerning type, serial number, and the defect claimed. Return shipments must be prepaid, except returns authorized within thirty days form the date of the warranty, in which case Railway Express Collect will be authorized. All rework done under this warranty will be reshipped from our plant Railway Express Prepaid.

Acton Laboratories, Incorporated, will not be held responsible or assume any expense or liability for damage or loss in shipment, loss of profit, or any other damages or claims not herein specifically provided for.


DWG. NO. 800A-4D
DIMENSIONS IN INCHES
THIRD ANGLE PROJECTION
REVISIONS
REMOVED ONE 12AX7 TUBE & CIRCUIT CHANGED SWITCH HOOKUP CSK. 11/4/55
R75 CHANGED TO 1.0Ω SWITCH HOOKUP CHANGED CSK 11/17/55
CHANGED 6AL5 - 6X4 REMOVED R72 R74 CHANGED 12AX7 - 5751 ADDED R22A, R22B, R23A R23B. DELETED R22 & R23 CK 11/25/56
EXCHANGED R60 WITH R63 R65 WITH R68. 3/9/56 CK
D.C. R1 25M* 1%
A.C. PROBE
V1 9006
C1 .01 cer.
R2 22M ½W 5%
R3 50M* 1%
R4 17.5M* 1%
R5 5.0M 1%
R6 1.75M 1%
R7 .75M 1%
R9 6.8M
R10 4.7M
5751 V2
C5 .005 CER.
R11 10M
R12 1.0M
R13 1.0M
R14 10M
R22A 10M 1%
R22B 10M 5%
R23B 2.2M 5%
R23A 17.5M 1% 1W
12AY7 V4
R24 470K
R25 470K
R26 10K
R27
R28 1300
R29 500Ω OHM ADJUST
M 50 μa
all 1%
R30 1.5K
R31 4.5K
R32 15K
R33 45K
R34 150K
R35 620Ω
R36 3.9K
R37 18K
R38 62K
R39 220K
TERM. BOARD TO BE PROVIDED TO SHUNT EACH OF THESE WITH AN I.R.C. ½W
R1-R41 C1-C7
R53 6.8M
R54 2.2M
R55 680K
R56 220K
R57 SELECTED
9006 V3
C9 .005 MYLAR
D.C ZERO R62 10K
COARSE D.C. ZERO R61 100K
R63 270K 1%
R60 470K
A.C. ZERO R67 10K
COARSE A.C. ZERO R66 100K
R68 270K 1%
R65 470K
X.1 100MA
R45 9.0Ω 1%
X1 10MA
R46 90Ω 1%
X10 1MA
R47 900Ω 1%
X100 100μa
R48 9K 1%
X1K 10μa
R49 90K 1%
X10K 1μa
R50 900K 1%
X100K .1μa
R51 9M 1%
X1M .01μa
R52 45M* 1%
R52A 45M* 1%
X10M .001μa
R70 1.0Ω 1%
R71 100Ω 2W
C10 500μf 25V
T2 MYSTIC
320V RMS 2.0-2.5MA
T1 SOLA 30488
6V. 115
F1 P1
V6 6X4
GRID CURRENT
.02 200V C11
R73 100K
220K 1W R76
C13 12μf 350V
R75 1.0Ω 2W.
METER .15 AMP EACH
9006 9006 5751 12AY7
R70-R76 C10-C14
= COMMON CHASSIS GROUND
K = 10³
M = 10⁶
cer = CERAMIC 500V
ALL RESISTORS ½W 10% I.R.C. UNLESS MARKED OTHERWISE
ALL 1% RESISTORS ARE ½W EXCEPT THOSE MARKED * WHICH ARE 1W
STANDARD TOLERANCES UNLESS OTHERWISE SPECIFIED.
FRACTIONS ± .010"
DECIMALS ± .005"
ANGLES ± ½°
FINISH TURNING CONCENTRIC TO .003 INDICATOR READING
ALL PIECES MUST BE CLEAN AND FREE OF BURRS.
ALL THREADS MUST BE Cl-2 WITH 75% THREAD MIN.
VTVM SCHEMATIC
SCALE: NONE
TECHNOLOGY INSTRUMENT CORP. ACTON, MASS., U.S.A.
ENG. APPR.
PROD. APPR.
DWG. NO. 800A-4D
MODERN BLUE PRINT NO. 8000 IN 6-55

OPERATING INSTRUCTION MANUAL

FOR

TYPE 800 A

VACUUM TUBE VOLTMETER

Published: November, 1955

Acton Laboratories, Incorporated
533 Main Street
Acton, Massachusetts

TABLE OF CONTENTS

SECTION I

GENERAL DESCRIPTION

1.1 Purpose of Equipment

The purpose of the Type 800-A Vacuum Tube Voltmeter is to measure direct and alternating voltage, direct current, and d.c. resistance. The instrument is characterized by its wide operating range in both amplitude and frequency. Accuracy of measurement is assured by the use of precision components and liberal use of inverse feedback.

The instrument is available as a single unit in a cabinet, Type 800-A.

1.2 Purpose of Instruction Manual

The purpose of this Instruction Manual is to familiarize the operator with the operating procedure, theory of operation, maintenance, and any special procedures or techniques which might aid in the use of the instrument.

1.3 Equipment Supplied

Type 800-A (cabinet mounted):

Dimensions: 9" high x 7" wide x 7" deep

Weight: (including cabinet) 11 3/4 pounds

D. C. Probe

A. C. Probe

A 6-foot power cord

Spare Fuse

1.4 Specifications

1.4.1 D. C. Voltage Ranges:

Full scale ranges of .1, .3, 1, 3, 10, 30, 100, 300, and 1000 volts are provided.

1.4.2 A. C. Voltage Ranges

Full scale ranges of .1, .3, 1, 3, 10, 30, 100, and 300 volts (rms) are provided. The meter scale is calibrated using a sine wave.

The reading for a complex wave is therefore approximately .707 of the peak value.

1.4.3 Resistance Ranges:

The meter scale is calibrated in resistance over a range from .2 ohm to 500 ohm with multiplying factors of .1, 1, 10, 100 and 1000, 104, 105, 106 and 107. Resistances may therefore be measured in overlapping ranges from .02 ohms to 5000 megohms.

1.4.4 Current Ranges:

Full scale ranges of .001 ua, .01 ua, 1 ua, 10 ua, 100 ua 1 ma, 10 ma, and 100 ma. direct current are provided. The full-scale voltage drop on any range is 100 vm.

1.4.5 Accuracy:

D. C. Volts ± 2% of full scale for 1.0 v range and higher

± 3% of full scale for .1 and 3 v ranges.

A. C. Volts (Sine Wave) (Low Frequency) ± 3% of full scale for 1.0 v ranges and higher

± 5% of full scale for .1 and .3 v ranges

Current (D.C.) ± 2% of full scale for .1 us and higher

± 3% of full scale for .001 us and .01 us ranges

1.4.6 Frequency Response:

The response of the A. C. voltage probe is given by the family of curves shown in Section 5.2.

1.4.7 Input Impedance:

D. C. Volts: The input resistance is 100 megohms on all ranges.

A. C. Volts: The input capacitance is 5 uuf (nominal). The input resistance is 10 megohms (nominal) at low frequency becoming somewhat lower as the frequency increases.

Current (D.C.): The input resistance is such that the input voltage drop is 100 mv. full scale on all ranges.

Resistance: The voltage is applied to the resistor to be measured does not exceed .1 v d.c.

1.4.8 Line Voltage Stability:

The meter indication does not vary by more than ± 1.0% for a line voltage variation from 95 to 130 volts for any d.c. voltage, current, or resistance range.

1.4.9 Power Supply:

105-125 volts, 60 cycles, self-contained power supply requiring approximately 25 watts.

1.4.10 Tubes:

1 5751
1 12AY7
2 9006
1 6X4

1.5 Identification of Controls

1.5.1 SELECTOR Switch:

This switch controls the selection of the proper circuitry to measure direct voltage of either polarity with respect to the common ground connection, alternating voltage, resistance, and direct current of either polarity with respect to common ground.

1.5.2 RANGE Switch:

This switch allows the selection of the appropriate range for each of the above mentioned measurements.

1.5.3 AC ZERO:

This control allows the zero adjustment of the meter for a.c. voltage measurement and should be made with the a.c. voltage probe connected to common ground. The adjustment should be made on the

.1 V a.c. voltage range. Its setting is independent of the setting of the DC ZERO.

1.5.4 DC ZERO:

This control allows the zero adjustment of the meter for the measurement of direct voltage, resistance, and direct current. This setting may be made on any resistance and current range or on the .1 V direct voltage range with the appropriate probe connected to common ground. Its setting is independent of the setting of the AC ZERO.

1.5.5 OHMS ADJUST:

This control allows the adjustment of the meter to full scale with the SELECTOR switch in the Ω position. The adjustment should be made with the R-I probe open-circuited.

1.5.6 LINE Switch:

The power switch for the instrument is included on the SELECTOR Switch. The extreme counter-clockwise position of this switch disconnects one side of the power line.

SECTION II

OPERATING INSTRUCTIONS

2.1 General Operating Procedures

2.1.1 The Type 800-A is ready for immediate use when received. Make sure all accessories have been removed from the packing box and examine the instrument for any damage which may have occurred in shipment. If the instrument has been damaged in shipment, refer to Section 5.3 "Material Damaged in Shipment".

2.1.2 Connect the instrument to a 115 v, 60 cycle, a.c. power line and turn the SELECTOR switch from the OFF position to any operating position. In general, allow an initial 5 minute "warm-up" period. If operation is desired on the two most sensitive ranges, allow a 20 minute "warm-up" period.

2.1.3 The measurement of direct voltage is made using the COMMON test lead and the D. C. V. probe with the SELECTOR switch in the -V or + V position, depending upon the polarity of the voltage to be measured. These markings indicate the conventional sign of the measured voltage with respect to the common ground connection. The DC ZERO adjustment should be made on the .1 v range with the input leads connected together. The zero adjustment does not have to be readjusted as the RANGE switch is change. Adjustment of the zero is usually not required if the .1 v and .3 v ranges are not being used.

CAUTION: The cabinet and A.C. probe housing are at the same potential as the COMMON test lead. Do not connect to high potential.

2.1.4 The measurement of alternating voltage is made using the COMMON test lead and the A. C. probe with the SELECTOR SWITCH in the a. c. position. The AC ZERO adjustment should be made on the .1 v range with the A.C. probe connected to the COMMON lead. The zero adjustment does not have to be readjusted as the RANGE switch is changed. Adjustment of the zero is usually not required if the .1 v and .3 v ranges are not being used. The DC and AC ZERO adjustments are independent. For high frequencies, the short ground clip attached to the probe should be used instead of the COMMON test lead.

<u>CAUTION:</u> The cabinet and A.C. probe housing are at the same potential as the COMMON test lead. Do not connect to high potential.

2.1.5 The measurement of resistance is made using the COMMON test lead and the I- probe with the SELECTOR switch in the position. The DC ZERO adjustment should be made with the input leads connected together, and the OHMS ADJUSTMENT made for full scale with the input leads open. An initial 20 minute "warm-up" period is desirable.

2.1.6 The measurement of direct current is made using the COMMON test lead and the I- probe with the SELECTOR switch in the -I or +I position, depending upon the polarity of the current to be measured. These markings indicate the conventional direction of current flow into the I- probe. The DC ZERO adjustment should be made with the input leads connected together. An initial 20 minute "warm-up" period is desirable.

CAUTION: The cabinet and A.C. probe housing are at the same potential as the COMMON test lead. Do not connect to high potential. This means that current must be measured in a low potential (preferably grounded) section of the circuit under test.

2.2 Special Operating Instructions

2.2.1 The DC ZERO control for the Type 800-A operates on an absolute basis. It inserts a fixed voltage (depending upon its setting) into the measuring circuit in an additive manner. It therefore has its major effect on the low full scale voltage ranges with decreasing effect on the 1.0 full scale range and higher, where is use is rarely necessary.

2.2.2 The AC ZERO control for the Type 800-A operates similarly to the DC ZERO (see 2.2.1 above).

2.2-3 For the measurement of very low resistance, the Type 800-A on the X.1 range will show a low resistance reading rather than zero for the usual setting of the DC ZERO. This is due to the finite low resistance of the external measuring leads and internal connections. This may be compensated for by resetting the DC ZERO on this range with the input leads solidly connected together.

Similarly, for the measurement of very high resistance, the Type 800-A on the X1OM range will show a high resistance reading rather than infinity for the usual setting of the OHMS ADJUST control. This is due to internal and external leakage and may be compensated for by resetting the OHMS ADJUST on this range with the input leads isolated from one another.

2.3 General Operating Techniques

2.3.1 The Type 800-A is to a large extent self-protecting in case of mild or severe overload. This is particularly true on any of the voltage ranges. Resistor overload or burn-out will occur, however, if appreciable voltage from a low impedance source is inadvertently applied to the current probe with the range switch in the low-current conditions.

2.3.2 If one of the probe tips is handled by the operator, thus injecting relatively large "pick-up" voltages into the measuring system, erratic behavior of the meter will result, particularly on the low ranges. No permanent damage will be done because of the self-protective feature.

2.3.3 To avoid excessive "wear and tear" on the indicating meter, it is suggested that the RANGE switch be set to any range above the lowest two whenever the SELECTOR switch is operated.

2.3.4 If at any time the meter cannot be set to zero using the appropriate ZERO control, the internal coarse zero controls must be readjusted according to the instructions in Section IV of this manual. This in general will be necessary as the instrument ages, or if tube changes are made, or the instrument is subject to excessive mechanical shock.

SECTION III

THEORY OF OPERATION

3.1 Detailed Description

3.1.1 Basic Measuring Circuit:

The conventional d.c. voltmeter consists of a moving-coil current meter in series with a precision resistor usually referred to as a multiplier resistance. In this system the applied voltage necessary to cause full-scale deflection of the meter is simply given by $E = IR$ where I is the full-scale current of the current meter and R is the sum of the resistances of the precision resistor and the current meter. The accuracy of this system is good, principally because of its simplicity.

In the above system the current necessary to actuate the meter must be supplied by the source of voltage being measured, resulting in disturbance of that source. In a portable voltmeter the maximum practical sensitivity is of the order of 20,000 Ω per volt or a current of the order of 50 ua is necessary.

A vacuum tube voltmeter can be devised to make full use of the inherent accuracy of the basic voltmeter by interposing a highly degenerative amplifier between the voltage to be measured and the conventional voltmeter. If the amplifier is totally fed back and the loop gain is large, the amplifier voltage gain may be very nearly unity. The amplifier therefore serves simply to transfer the unknown voltage at a high impedance level to the terminals of the voltmeter at low impedance level with negligible error. The current taken from the source may now be a fraction of a micro-amp.

The Type 800-A is a vacuum tube voltmeter of this type with the further improvement in that the feedback voltage is developed across the precision resistor alone, not including the resistance of the current meter. The basic measuring circuit therefore has the following appearance.

k is very nearly unity

$IR = k\,e$

$I = \dfrac{k\,e}{R}$

$I = \dfrac{e}{R}$ (very nearly)

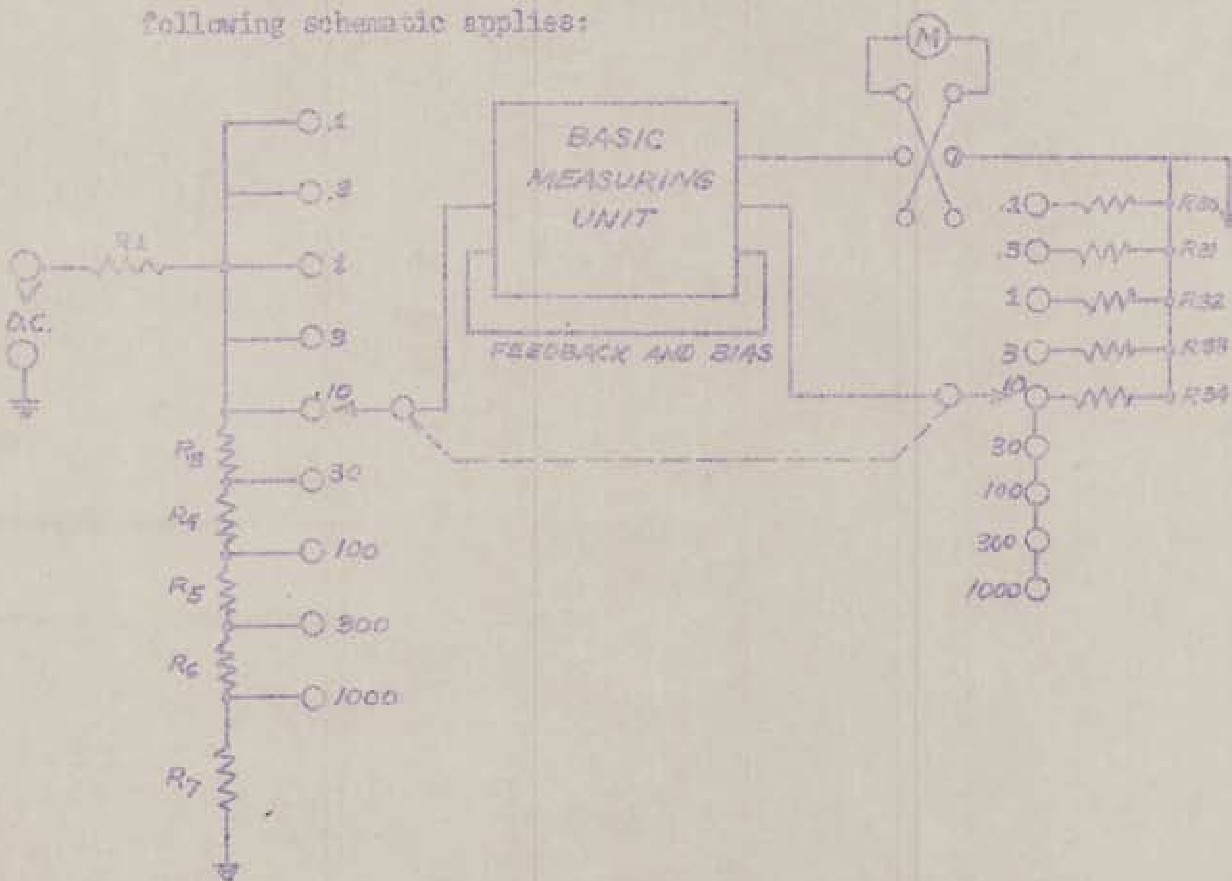
The calibration therefore depends only upon the current indication of the meter and the precision resistor R. Changes in meter resistance due to temperature (copper wound coil) and differences ih meter resistance from one unit to another (in production) have no effect. It is also possible to use a multiplier R having a valus smaller than the resistance of the meter, therefore providing lower full-scale ranges.

We have then in this basic measuring circuit a unit which accepts an input d.c. voltage e and produces a reading I on a d.c. microammeter which is simply related to e by multiplier resistance R. Change of voltage range is therefore readily accomplished by changing R (within the voltage handling capability of the circuit). In fact, due to the large feedback factor the measured result has a precision substantially determined by the precision of the microammetrr and multiplier, the vacuum tube circuit not appreciably affecting the calibration. Furthermore, this unit can easily be zero adjusted, has excellent stability, and demands very little input current (of the order of 10^{-11} amps).

Referring to the schematic diagram of connections shown after Section V, the basic measuring unit consists of tubes V_2, V_4 and their immediately associated circuitry.

3.3.2 Measurement of Direct Voltage

For the measurement of direct voltage of either polarity, the following schematic applies:

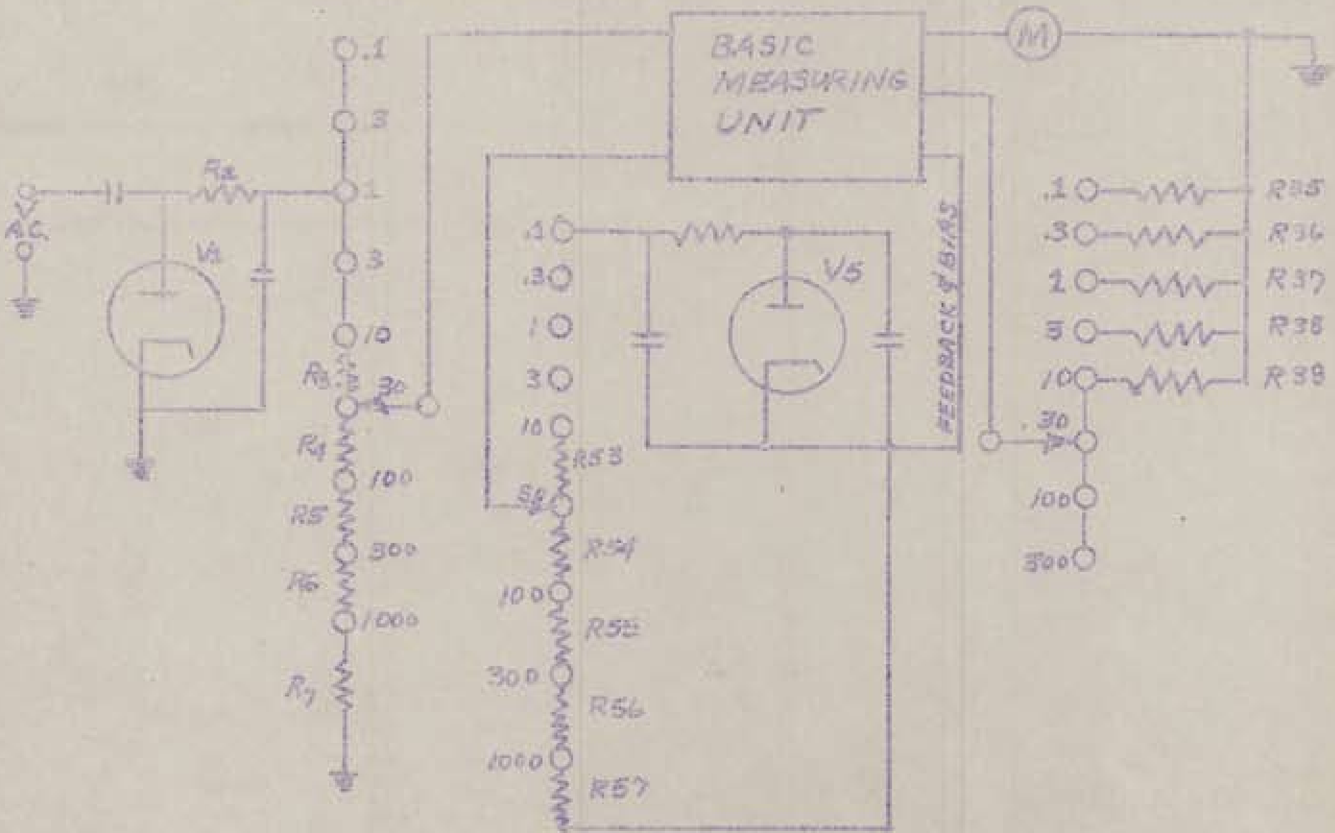


The resistor R_1 is an isolating resistor of high value contained in a probe tip to allow the measurement of direct voltage in a circuit also having a.c. components without introducing undesirable shunt capacitance. R_1 together with R_3, R_5, R_6, and R_7 constitute a voltage divider. For the measurement of low voltage (first 5 switch positions), a fixed fraction of the input voltage is applied to the basic measuring unit, with the particular range selected by the choice of multiplier resistance R_{30} through R_{34}. For the four higher ranges, the multiplier is fixed at a value R_{34} while the input divider has been so proportioned that the same full-scale voltage is applied to the basic unit for each of the desired input ranges

Voltages of either polarity may be measured by simply reversing the current meter. The input divider may be made to have a very high (100 mega) input resistance without disturbing the calibration because of the very high input resistance of the measuring unit. The precision of measurement is determined primarily by the precision of the meter, the precision of the multiplier resistors, and the precision of the resistors making up the input divider.

3.1.3 Measurement of Alternating Voltages:

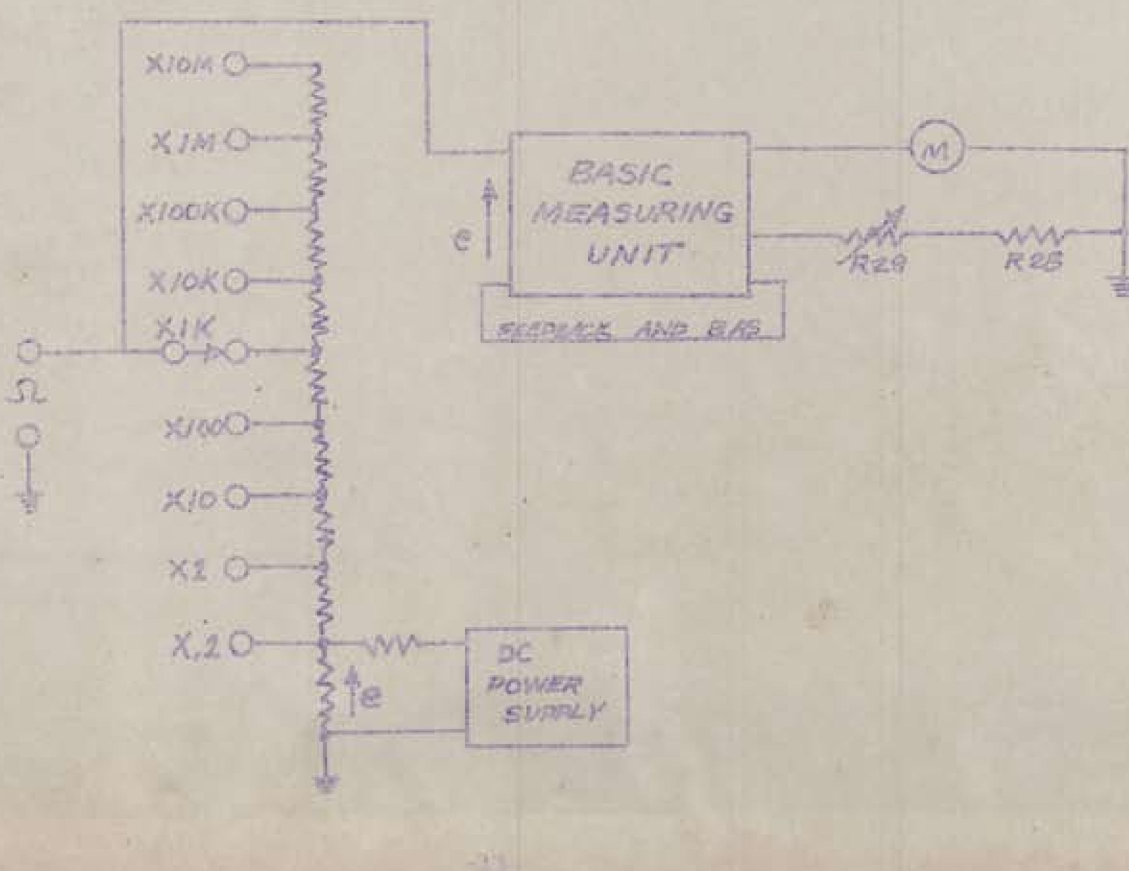
In this case the following schematic applies:



The alternating input voltage is rectified by V_1 acting as a linear peak diode to produce negative direct voltage applied to the divider consisting of R_2 through R_7 (May be same divider as used for d.c. voltage). This divided voltage is measured by the basic unit in a manner similar to that employed for d.c. voltage.

Since the thermionic diode V_1 produces an initial voltage without signal, a second similar diode V_5 is inserted in the feedback connection to balance the effect of V_1. Since the input divider varies the effect of the initial V_1 diode voltage, a similar divider is associated with V_5 to balance this effect. As is well known, the diode rectifier is non-linear at low voltage becoming nearly linear at high voltages. For this reason the multiplying resistors R_{35} through R_{39} are chosen to yield full-scale current at each of the several full-scale input voltages in the non-linear region. Over the higher voltage range where the operation is linear, the same input divider may be used as for d.c. voltage. The precision of measurement at high voltage is determined principally by the precision of measurement of the d.c. voltage developed by the diode. In the non-linear region the precision is reduced due to the diode.

3.1.4 <u>Resistance Measurement</u>:



In this circuit, a stabilized d.c. power source furnishes a fixed voltage E which is applied to the basic measuring unit and to the input terminals through an adjustable resistance. If the input terminals are open circuited, the voltage E is present at the input to the measuring unit and the part of the multiplier resistance (R_{29}) may be adjusted to yield full scale current on the meter. If an unknown resistor is then connected, the measured voltage e is reduced according to the equation.

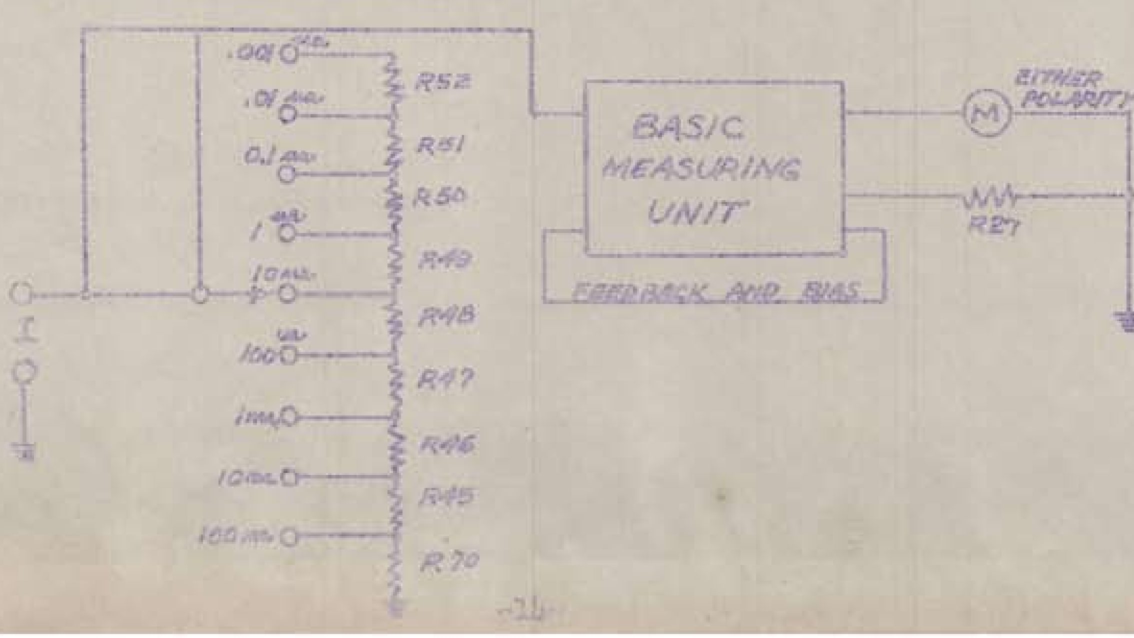
$$e = E \frac{R_x}{R_s + R_x}$$

where: R_x = unknown resistance

R_s = standard resistance

The standard resistor R_s consists of an appropriate series connection of resistors R_{70} and R_{45} through R_{52} as chosen by the range switch. Obviously, from the above equation, the meter may be directly calibrated in resistance with the setting of the range switch serving as a multiplier. The precision of measurement is consistent with the precision as d.c. voltmeter as far as the current indication is concerned. However, due to the non-linear relation between the resistance and current indications the resulting precision of the resistance measurement would have to be computed for each case. The high input resistance of the measuring unit allows the measurement of very high resistance without appreciable error.

3.2.5 <u>Measurement of Current:</u>



For the measurement of direct current, a fixed multiplier R_{27} is used to fix the voltage range of the instrument. The input current is applied to a series combination of resistors selected from the resistor bank R_{70} and R_{45} through R_{52}. The resistor combinations are so chosen for each range that when the required full-scale input current for that range is flowing through the resistor, a voltage is developed which just causes full-scale deflection. Currents of either polarity with respect to ground can be measured by use of the meter reversing switch. The precision of measurement is the same as for d.c. voltage. Because of the inherent stability of the basic measuring unit which allows a low full-scale voltage to be used (.1 volt), the voltage drop across the input terminals is never excessive in most applications. Very small currents (.001 us full-scale) can also be measured because of the low input current requirement of the measuring unit.

SECTION IV

MAINTENANCE

4.1 Routine Maintenance

Under normal conditions, the Type 800 A will give trouble free service over long periods of time. If, however, tube changes are made or if the instrument or its probes receive severe mechanical shock as may occur during shipment, attention is called to the following section.

4.2 Special Maintenance

If the instrument does not appear to be operating properly, the trouble may fall under one or more of the following categories.

4.2.1 DC ZERO

Sufficient drift may occur over a period of time or because of mechanical shock such that zero setting of the meter is not possible using the panel control. In this case, the coarse zero-set control (R_{61}) should be readjusted. This adjustment can be made readily by removing the small snap-cap located on the top of the cabinet directly in back of the corresponding panel control.

4.2.2 AC ZERO

Sufficient drift may occur over a period of time or because of mechanical shock such that zero setting of the meter is not possible using the panel control. In this case, the coarse zero-set control (R_{66}) should be readjusted. This adjustment can be made readily by removing the small snap-cap located on the top of the cabinet directly in back of the corresponding panel control.

4.2.3 Grid Current

Excessive grid current taken by V_2 manifests itself by a shift of zero setting on the lowest d.c. voltage range when the d.c. probe is alternately connected and disconnected to the COMMON lead. Adjustment is readily made by means of R_{73} which is made available by removing the snap-cap on the top of the cabinet directly in back of the OHMS ADJUST panel control. Adjustment should be made such that the reading of the meter on the ± .1 v d.c. range is not changed as the d.c. probe is alternately connected and disconnected to the COMMON lead. This adjustment will change the d.c. zero setting which then must be made according to sections 4.5.4 or 4.2.1.

4.2.4 Calibration

Calibration on the d.c. voltage and current ranges should remain withint the specifications of the instrument as long as the instrument is operative and can be zeroed. If inoperative, on these ranges, replacement of V_2, V_4, and V_6 is suggested.

4.2.5 AC Calibration

Calibration on the a.c. voltage ranges from .1 v to 10 v inclusive should remain within specifications unless V_1 is replaced. If this is found necessary, the full-scale calibration of these ranges should be checked and compensated if necessary by changing the appropriate resistor of the set of resistors R35A through R39A which are readily available on a terminal strip located on the side of the instrument.

4.2.6 Tube Replacement

Tube replacement should be necessary in the Type 800-A only at infrequency intervals, since all tubes except V_6 are operated at reduced heater voltage and all tubes are operated well within their ratings.

Replacement of V_2, V_4, and V_6 require no special consideration with the possible exception of readjustment of grid current and the d.c. zero as given in sections 4.2.3 and 4.2.1.

If replacement of V_1 is necessary, refer to the drawing of the a.c. probe in Section 5.2.3. Mechanical disassembly of the a. c. probe must be carefully done by removing the screw holding the plastic nose cap in place and removing the Allen-head set-screw at the cable end of the probe. The nose cap and internal assembly together with the cable can be moved as a unit to slide V_1 out of the probe housing. The new tube (Type 9006) should be prepared by cutting off pins 5, 6, and 7 as close to the glass envelope as possible with a pair of diagonal cutters. The tube should then be inserted in the segmented socket with pins 2, 3, and 4 making contact. The clip attached to C_1 and R_2 is then fastened to pin 1 of the tube. The entire assembly is then returned to the probe housing making sure that the grounding strap from the cathode (pin 2) is securely compressed between the plastic nose cap and the housing.

SECTION V

SUPPLEMENTARY DATA

5.1 Parts List

Identification of Manufacturers:

Abbreviation	Manufacturer
A. Bradley	Allen Bradley Company
Allies	Allies Products Corporation
Buss	Bussman Manufacturing Company
C.D.	Cornell-Dubilier Electric Corporation
Centralab	Centralab Division of Globe Union, Inc.
C. T. S.	Chicago Telephone Supply Corporation
Federal	Federal Telephone and Radio Corporation
G.E.	General Electric Company
Good-All	Good-All Electric Manufacturing Company
I. R. C.	International Resistance Company
Marion	Marion Electrical Instrument Company
Mystic	Mystic Transformers
RCA	Radio Corporation of America
Solar	Solar Electric Company

SECTION V

COMPONENT LIST

COMPONENT	VALUE	VOLTS OR WATTS	TOLERANCE	MFGR.	TYPE	REMARKS
CAPACITORS:						
C1	.01 uf	450 V	-20% +80%	Centralab	BC-disc	Ceramic
C2	.005 uf	500 V	±20%	Centralab	BC-disc	Ceramic
C3	.01 uf	450 V	-20% +80%	Centralab	BC-disc	Ceramic
C4	.01 uf	600 V	±20%	Good-All	COMY-6-103-20	Mylar
C5	.005 uf	200 V	±20%	Good-All	COMY-2-502-20	Mylar
C6	.005 uf	400 V	±20%	Good-All	COMY-4-502-20	Mylar
C9	.005 uf	400 V	±20%	Good-All	COMY-4-502-20	Mylar
C10	500 uf	25 V	±20%	C. D.	BRH-255	Electrolytic
C11	.02 uf	200 V	±20%	Good-All	COMY-2-203-20	Mylar
C13	12 uf	350 V	±20%	C. D.	BR-1235	Electrolytic
RESISTORS:						
R1	25 meg.	1 W	1%	Allies	APBT1	
R2	22 meg.	½ W	5%	A. Bradley	EB2265	
R3	50 meg.	1 W	1%	Allies	APBT1	
R4	17.5 meg.	1 W	1%	Allies	APBT1	
R5	5.0 meg.	½ W	1%	Allies	APST ½	
R6	1.75 meg.	½ W	1%	Allies	APST ½	
R7	.75 meg.	½ W	1%	Allies	APST ½	
R9	5.6 meg.	½ W	10%	I. R. C.	BTS ½	
R11	10 meg.	½ W	10%	I. R. C.	BTS ½	
R12	1.0 meg.	½ W	10%	I. R. C.	BTS ½	
R13	1.0 meg.	½ W	10%	I. R. C.	BTS ½	

COMPONENT	VALUE	VOLTS OR WATTS	TOLERANCE	MFGR.	TYPE	REMARKS
R14	10 meg	½ W	10%	I. R. C.	BTS ½	
R22A	10 meg	½ W	1%	Allies	APST½	
R22B	10 meg	½ W	10%	A.Bradley	EB10610	
R23A	17.5 meg	1 W	1%	Allies	APST1	
R23B	2.2 meg	½ W	5%	A. Bradley	EB2255	
R24	470 KK	½ W	10%%	I. R. C.	BTS ½	
R25	470 K	½ W	10%	I. R. C.	BTS ½	
R26	10 K	½ W	10%	I. R. C.	BTS ½	
R27	2.0 K	½ W	1%	Allies	APST ½	
R28	1.8 K	½ W	1%	Allies	APST ½	
R29	500 ohms			Centralab	Model 1 Control	
R30	1.5 K	½ W	1%	Allies	APST ½	
R31	4.5 K	½ W	1%	Allies	APST ½	
R32	15 K	½ W	1%	Allies	APST ½	
R33	45 K	½ W	1%	Allies	APST ½	
R34	150 K	½ W	1%	Allies	APST ½	
R35	620 Ohms	½ W	1%	Allies	APST ½	
R36	3.9 K	½ W	1%	Allies	APST ½	
R37	18 K	½ W	1%	Allies	APST ½	
R38	62 K	½ W	1%	Allies	APST ½	
R39	220 K	½ W	1%	Allies	APST ½	
R40	4.7 meg	½ W	10%	I. R. C.	BTS ½	
R45	9 ohms	½ W	1%	Allies	APST ½	
R46	90 ohms	½ W	1%	Allies	APST ½	
R47	900 ohms	½ W	1%	Allies	APST ½	
R48	9 K	½ W	1%	Allies	APST ½	

COMPONENT	VALUE	VOLTS OR RATING	TOLERANCE	MFGR.	TYPE	REMARKS
R 49	90 K	½ W	1 %	Allies	APST ½	
R50	900 K	½ W	1 %	Allies	APST ½	
R51	9 meg	½ W	1%	Allies	APST ½	
R52-52A	15 meg	1 W	1 %	Allies	APST1	
R53	6.8 meg	½ W	10%	I. R. C.	BTS ½	
R54	2.2 meg	½ W	10%	I. R. C.	BTS ½	
R55	680 K	½ W	10%	I. R. C.	BTS ½	
R56	220 K	½ W	10%	I. R. C.	BTS ½	
R57	selected	½ W	10%	I. R. C.	BTS ½	
R60	470 K	½ W	1 %	Selected	APST ½	
R61	100 K			C. T. S.	X-3538	LT-2 Shaft Control
R62	10 K	½ W		Centralab	Model 1	Control
R63	270 K	½ W	1 %	Allies	APST ½	
R65	470 K	½ W	1 %	Selected	APST ½	
R66	100 K	½ W		C. T. S.	X-3538	LT-2 Shaft Control
R67	10 K			Centralab	Model 1	Control
R68	270 K	½ W	1 %	Allies	APST ½	
R70	1 ohm	½ W	1 %	Allies	APST ½	
R71	100 ohm	2 W	10%	A.Bradley	HB1011	
R73	100 K			C. T. S.	X-3538	LT-2 Shaft Control
R75	1.0 ohm	2 W	10%	I. R. C.	BW-2	
T1				Solar	30488	
T2				Mystic	TRP-41	
M	50 ua		1 %	Marion	MRDS-19	
Rectifier				Federal	1016	
Fuse	5 amp			Buss	3AG	

COMPONENT	VALUE	VOLTS OR WATTS	TOLERANCE	MFGR.	TYPE	REMARKS
S1				Centralab	SRW-128	
S2				Centralab	SRW-129	
Pilot lamp	15 amp			G. E.	47	
TUBES:						
V1				R.C.A.	9006	
V2				R.C.A.	5751	
V4				R.C. A.	12AT7	
V5				R. C. A.	9006	
V6				R. C. A.	6X4	

5.3 Material Damaged in Shipment

Address correspondence to:

ACTON LABORATORIES, INCORPORATED

SERVICE DEPARTMENT

531 MAIN STREET

ACTON, MASSACHUSETTS

Telephone: COlonial 3-7756

If, upon receipt of your instrument, the packing case shows evidence of damage, or if upon unpacking, damage is found which appears to have been caused by shipment, do not unpack or discard any of the packing. Notify immediately the local office of the carrier and request that they inspect the damage. Also notify Acton Laboratories, Inc., of the type number, serial number, extent and type of damage, our invoice number, carrier's number, date received, and any other pertinent information so that we may contact our local carrier office in order to facilitate a speedy settlement of any claim.

5.4 Warranty

Acton Laboratories, Incorporated, warrants that each instrument shipped is in accordance with all published specifications. Any deviation from those specifications or defects or workmanship or material will be corrected by Acton Laboratories, Incorporated, provided the instrument has been properly used under normal operating conditions. This warranty is in effect for one year from delivery date except for failures of or attributable to tubes, fuses, or batteries after 90 days from the above date. Acton Laboratories, Incorporated, will be the sole judge of the validity of all claims.

All returns made under this warranty must be authorized in writing by Acton Laboratories, Incorporated. Such authorization will be given only upon receipt of information concerning type, serial number, and the defect claimed. Return shipments must be made prepaid, except returns authorized within thirty days from the date of the warranty, in which case Railway Express Collect will be authorized. All rework done under this warranty will be reshipped from our plant Railway Express Prepaid.

Acton Laboratories, Incorporated, will not be held responsible or assume any expense or liability for damage or loss in shipment, loss of profit, or any other damages or claims not herein specifically provided for.