

**ROS RADIO/TV-SERVICE**

**THE**



Regd. Trade Mark

**ELECTRONIC TESTMETER**

**Mk. IV**

**INSTRUCTIONS FOR USE**

**AVO LTD**

**AVOCET HOUSE, 92-96 VAUXHALL BRIDGE ROAD, LONDON, S.W.1**

Telephone: Victoria 3404 (12 Lines)

Grams: Avocet, London, S.W.1.



**A MEMBER OF THE METAL INDUSTRIES GROUP OF COMPANIES**

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**Printed in England**

**Reprinted August 1961**

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THE "AVO" ELECTRONIC TESTMETER Mk. IV

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## ELECTRONIC TESTMETER

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### *INSTRUCTIONS FOR USE*

#### INTRODUCTION

The field of electrical development has today become so vast that the time has passed when one type of multi-range testmeter would handle all requirements. It is now necessary for most engineers to be equipped to cover both power and electronic fields, the two having become closely allied, and it is to meet the demand of those who have been hitherto ill-equipped to undertake the higher grades of electronic work, that the "AVO" Electronic Testmeter has been developed. The instrument is based fundamentally upon the general principles appertaining to valve-volt meters, but its high degree of performance is due to ingenious design coupled with the various patented departures not found in any other make of meter. Whilst it is compact in size, several years of research in the laboratory and in the field were necessary to produce this instrument, which, although electronic in design, presents all the advantages of portability, range selection, a large number of ranges, and stability, only found hitherto in multi-range moving coil testmeters.

The high input resistance/impedance of the instrument renders it particularly suitable for use upon electronic circuits which are usually capable of supplying very little energy indeed, certainly not enough to drive directly a general purpose moving coil instrument without causing a serious volts drop in the power source. When working with R.F. it is usually particularly important that the circuit under test should not be loaded by the measuring instrument, or losses introduced into the circuit by virtue of capacity and leakage in the instrument. By the use of a novel type of probe, this testmeter overcomes these and other problems hitherto associated with R.F. testing.

The full capabilities of this instrument could hardly be described within the scope of this publication, and it is only intended to give in the following pages, concise details relating to the various functions of the Testmeter.

## WORKING INSTRUCTIONS

### Power Supply to Instrument

The Testmeter is designed to operate from 100-130V and 200-260V A.C. 50/60 c/s mains (some Home Market models operate from 190-250V A/C 50 c/s mains only). Upon receipt, the instrument should be opened up and the instructions set out upon page 17 followed to ensure that theappings on the transformer are correctly set for the power source to which the instrument is to be connected. If it is intended to operate the instrument from a 50 c/s A.C. rotary converter the user must ensure that a reasonably good wave form is given by the converter, for otherwise errors may be introduced in the readings shown by the instrument. The testmeter is substantially independent of quite wide variations of mains voltage, within the voltage excursions of the transformer tap selected.

### Power Consumption

The power consumed on 230V 50 c/s mains is approximately 17 watts.

### Instructions to be followed upon Receipt of the Testmeter

Check mechanical zero of instrument pointer and adjust, if necessary, by means of the small screw located in the "AVO" sign upon the escutcheon of the indicating instrument. Connect mains lead to a 3-pin plug, red and black leads being phase and neutral, the green or yellow lead being earthed. Where connection is to be made to a 2-pin socket, the green or yellow zero lead (which is connected to the instrument case) should, if possible, be connected to earth in accordance with the normal safety regulations relating to metal cased apparatus.

*Note.*—Upon some home market models due to the form of stabilisation used, there will not necessarily be D.C. continuity between line and neutral leads.

### General Instructions

Having connected the instrument to the supply, ensuring that the earth lead is used correctly, switch on the instrument by means of the mains switch to the left of the indicating meter, and note that the range switch indicating panel becomes illuminated.

The instrument needle will rapidly move across the scale, hitting either or both end stops before coming to rest at some point upon the meter scale. With the Electronic Testmeter set to one of its D.C. current ranges, the meter needle should now be set to zero by means of the control marked "Instrument Set Zero." (Do not initially set instrument zero on A.C. volts capacity or power ranges.)

The instrument is now ready for use and should be operated in accordance with the detailed instructions which follow. No serious drift of zero should be noted after the first few minutes following switching on, when any small variation that does occur can be corrected by the use of the "Instrument Set Zero" control before taking a reading. Note that the resetting of the zero control should only take place when the meter is set to a D.C. current range.

Inasmuch as the testmeter contains valves and a transformer it will run at a fairly high

temperature, but no concern need be felt on this account, for the circuit has been so designed as to minimise long term drift due to temperature rise. The design of the instrument renders it free from range to range zero drift, except upon the 250mV range, but it should be noted that the zero on the 1V A.C. range is automatically set at approximately 0.07V when the meter reverse switch is set to "normal," in order to overcome the non-linearity of the diode rectifier. This offsetting of the zero is proportional on all A.C. ranges and will be seen to be negligible above 10V A.C. Since the power and capacity ranges use the A.C. volt section of the instrument, this offsetting of zero is also noticed when those ranges are used.

For normal D.C. and A.C. voltage ranges, D.C. current ranges, power, resistance and capacity ranges, the measuring leads are connected to the two terminals L.P. and H.P., the L.P. terminal being earthy and normally positive for D.C. voltage and current ranges. D.C. voltage and current measurements may be made with the L.P. terminal negative by operating the meter reverse switch, which reverses the polarity of the moving coil indicating instrument. (See notes which follow.)

The selection of ranges is made by the range and multiplier switches, the range in use being shown in the illuminated window, all unwanted indications being automatically masked.

**The Reverse Meter Switch and Safety Precautions to be taken when making Measurements at High Voltages**

In the interest of safety, and to ensure stability of high frequency measurements, the case of the Electronic Testmeter has been earthed, the L.P. terminal being connected to the case via a condenser and leak. (See Fig. 1.)

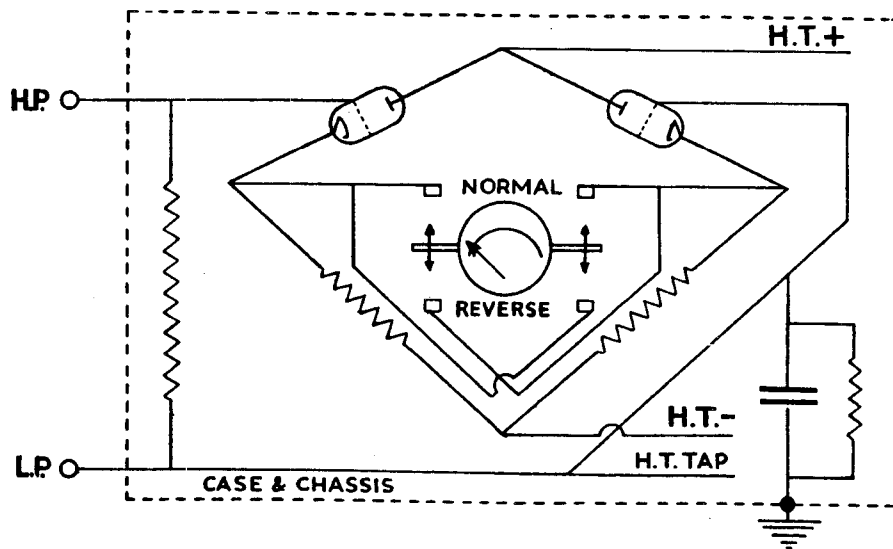
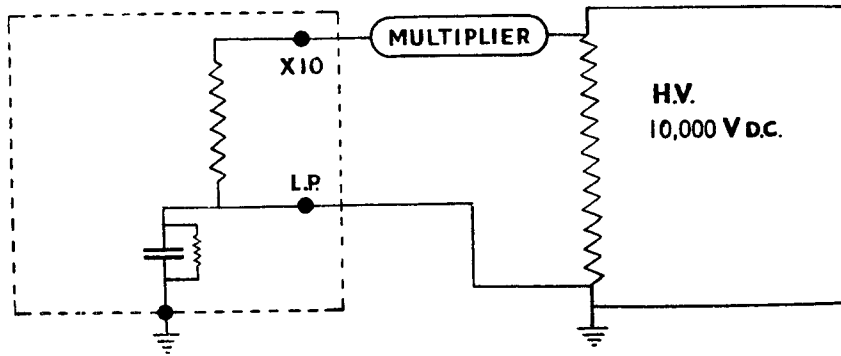


Fig. 1

It is essential that no high potential difference shall exist between the L.P. terminal of the Electronic Testmeter and the adjacent chassis of the apparatus under test or earth. Thus the L.P. terminal should always be connected as near as possible to the earthy side of the high voltage circuit being measured, the high potential lead being connected to the high voltage point with respect to earth. (See Fig. 2.) In no case should the voltage existing between the L.P. terminal of the Electronic Testmeter and its case or earth exceed 1,000V D.C. or 250V A.C.



Always ensure that L.P. Terminal is Connected before Commencing Tests

Fig. 2

It is therefore obvious that the low potential terminal (normally positive) may have to assume either positive or negative polarity dependent on the polarity of the earthy connection of the voltage being measured. If the internal polarity of the Electronic Testmeter low potential terminal was fixed with respect to the Electronic Testmeter circuit, this could result in the meter giving a backward reading under certain conditions. To overcome such a difficulty, the meter reverse switch is provided to enable the Electronic Testmeter to give a forward meter reading. For the measurement of A.C. voltages, the meter reverse switch should always be in its "normal" position. The switch is also obviously useful in avoiding the continuous changing of lead connections when making a succession of D.C. voltage or current measurements having varying polarity with respect to a common circuit point (e.g., H.T. and G.B. measurements with respect to the chassis or zero potential line in radio apparatus). When making current measurements in high tension circuits the Electronic Testmeter *must always* be connected at the low potential end of the circuit with respect to earth. (See Figs. 3 and 4.)

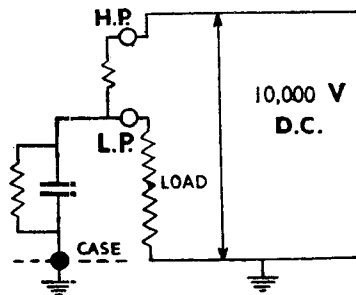


Fig. 3

**WRONG**

Never insert any type of Testmeter into a supply thus, when measuring current. In this instance, we have 10,000 volts likely to break through the 1,000 volt working condenser to the instrument case.

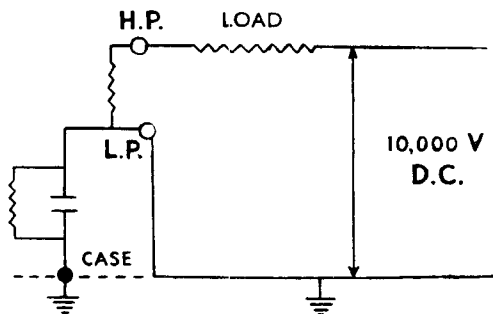


Fig. 4

*CORRECT*

Now the meter is placed at the earthy end of the supply. Practically no voltage appears across the condenser and the arrangement is perfectly safe.

### Measurement of D.C. Volts

Turn the range Selector Switch to volts D.C. and the multiplier switch to a convenient range high enough to cover the expected voltage measurement. When measuring voltages up to 1,000V the leads should be connected to the L.P. and H.P. terminals, the instrument resistance being 11 Megohms on all ranges. When measuring voltages higher than 1,000V D.C. the multiplier lead and external voltage multiplier should be used plugged into the high voltage socket (marked X10). When using the external multiplier, the D.C. voltage range indicated by the multiplier switch will be multiplied by 10, whilst the input resistance of the instrument will be 110 Megohms. The linear scale is used on all D.C. voltage ranges and accuracy is within  $\pm 2$  per cent. of full-scale deflection.

*Note.*—It is particularly important that where it is suspected that R.F. is super-imposed upon a D.C. level, that the external multiplier shall be used. The multiplier in this instance acts as an R.F. stopper in addition to multiplying by ten the D.C. range set on the instrument.

The external multiplier also enables an input resistance of 110 Megohms to be obtained with a full scale value of 2.5V upwards. (See Table on p. 20.)

### Measurement of A.C. Volts

Turn the range selector to volts A.C. and set the multiplier switch to a voltage range sufficiently great to cover the expected magnitude of the voltage to be measured. (*Note.*—The 250mV and 1,000V positions marked in red upon the switch are for use upon D.C. only.)

The first A.C. voltage range is 1.0V. When the instrument is set to this range it will be noticed that the indicating needle, although having been correctly set to Zero on a D.C. current range, now shows a reading of approximately 0.07V. (This reading may vary from 0.05V to 0.085V, depending upon the particular characteristics of the instrument.) As mentioned above, this zero shift is deliberately introduced to compensate for the non-linearity of the diode rectifier. From this point onwards all A.C. voltage measurements are read on the linear scale, the first effective reading being 0.1V. Since this zero shift is proportional on all A.C. ranges, it is only readily apparent on the 1V and 2.5V ranges, and is thereafter scarcely noticeable.

Owing to the high input impedance of the testmeter, stray readings may appear upon the move-



ment due to pick up at the input terminals when using low voltage ranges. The 0.07V zero shift on the 1V A.C. range should therefore be checked with the input leads shorted together. A.C. voltage measurements up to 250V are measured from the normal terminals, whilst higher voltage readings up to 2,500V R.M.S. are measured by means of the high potential lead plugged into the X10 socket. The A.C. voltage ranges indicated upon the instrument will now be multiplied by 10. This multiplication function only operates with the probe housed internally. With the probe internal using the normal measuring terminals there will be negligible error up to 2Mc/s, the instrument having an input impedance of 250,000 ohms in parallel with 30pF. With the X10 measuring terminal in use, negligible error can be expected up to 1.5Mc/s, the input impedance being 2.5 Megohms in parallel with 15pF. *Do not include the X10 D.C. multiplier in the circuit when measuring A.C. voltages up to 2,500V R.M.S.*

Accuracy of A.C. ranges is within  $\pm 3$  per cent. of full scale indication, and this degree of accuracy is reasonably maintained up to 1Mc/s at the normal measuring terminals. The Valve Bridge responds to the peak voltage value of the waveform under test, but since this value is rarely required, the movement is scaled in R.M.S. values, proportional to the peak input voltage. The R.M.S. calibration on the movement will therefore only be correct when sinusoidal voltages are being measured. The peak measurement obtained by multiplying the scale reading by 1.414 will, however, hold for voltages of distorted waveform.

For normal measurements at high frequency the probe may be withdrawn from the probe box and measurements made between the terminal marked "C" on the insulated end of the probe, and the terminal on the probe casing which is made movable to allow very short connections to be used at V.H.F. With the probe withdrawn the ranges are selected as for normal A.C. ranges up to 250V. Above 50Mc/s, however, the voltage measurements should be kept below 100V, and if possible should be further restricted at frequencies of the order of 200Mc/s. Where it is not possible to limit the applied voltage in this manner, the probe should only be connected to the circuit under test sufficiently long to make a measurement. This will avoid undue heating in the diode internal insulation.

When making measurements at H.F. and V.H.F. the connection between the probe terminals and the voltage test points should be kept as short as possible. Ensure that the case terminal of the probe is connected *via* the shortest possible path to "true" R.F. earth when making tests upon Radio or H.F. equipment. The input impedance of the diode probe (measured at 1Mc/s) when used externally is approximately 1.75 Megohms in parallel with 7pF. The maximum frequency at which reasonable measurements can be made is 200Mc/s.

It is important to note that when measuring A.C. voltages the indicating needle will read in the correct direction irrespective of which line is connected to the two terminals L.P. and H.P. Before making tests, particularly when measuring mains circuits, it is important to ascertain which, if either, of the two lines is earthy. It will be remembered that the instrument case is earthed and if the unearthed line is applied to the L.P. terminal, then the whole of the applied voltage will be developed across the internal condenser and resistive network which exists between L.P. terminal and case. The correct connections to be used are shown in Fig. 5, and should always be employed to obtain accurate readings.

It is most important that the peak value of the voltage supply should not exceed 350V if applied to the meter in the reverse manner to that stated. It is always desirable to connect the earthy line to the L.P. terminal wherever circuit arrangements will permit. When using mains supplies

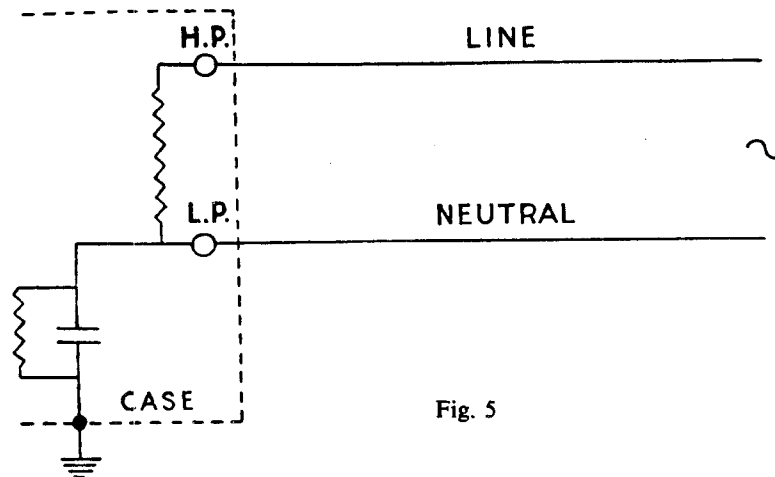


Fig. 5

upon which the neutral line is earthed, it is possible to distinguish which is the earthy line, provided that the case of the instrument is earthed correctly *via* the third core of the lead, by connecting the H.P. terminal first to one line, then the other, and noting which produces an indication upon the instrument. The line which does produce the indication should be left connected to the H.P. terminal, the other line then being connected to the L.P. terminal. This practice must be limited to lines less than 350V above earth.

#### THE USE OF THE PROBE (20Kc/s—200Mc/s)

It will be noted when removing the probe from the case that the terminal marked "D" is connected to the instrument by a short length of wire. This wire is to be detached when removing the probe from its compartment and reconnected when the probe is replaced. With the probe external, measurements between 20kc/s and 200Mc/s can be made between the terminal marked "C" on the end of the probe and its sliding terminal on the side of the casing.

#### SPECIAL USES OF PROBE

If it is necessary to make measurements of voltages up to 250V A.C. at frequencies below, say, 30c/s, the impedance of the diode coupling condenser used with the probe housed internally (having a value of  $0.05\mu\text{F}$ ) may become appreciable in comparison with the parallel diode load resistance of approximately 10 Megohms at these frequencies. In such circumstances the time-constant of the input circuit may be increased by using the probe externally and connecting a good quality condenser of suitably high value to the probe terminal marked "D." The voltage to be measured is then applied between the free end of this condenser and either the L.P. terminal or the sliding terminal on the diode casing.

Similarly, when making high audio frequency measurements where a reasonably high value of input condenser is required, and where the input capacitance with the probe internal (approximately 30pF) may cause losses, the probe should again be used externally with an input condenser of suitable value ( $0.05\mu\text{F}$ ) connected to the probe terminal marked "D." The voltage to be measured is then applied between the free end of the condenser and the probe sliding terminal. These methods of procedure thus provide the following advantages:—

- (1) Enable measurements to be made below the normal low operating frequency of 30c/s.
- (2) Enable measurements to be made at audio and upper-audio frequency with input capacity of only approximately 8pF.
- (3) Enable measurements to be made with fully screened leads to the point of application without the normal high capacity associated with screened leads.

For convenient measurements at power and audio frequencies where the above limitations do not apply and for wattage or capacity measurements, the probe should be reinserted in the probe box.

*Note.*—If D.C. is present when using the probe, the sum of D.C. voltage and the peak A.C. voltage across the diode terminal and probe case should not exceed 350V.

### Measurement of Capacity

(PROBE MUST BE INTERNAL)

Two ranges of capacity are provided when the Range Selector Switch is turned to " $\mu\text{F}$ " and " $\mu\text{F} \times 100$ " respectively. The scale is marked directly in  $\mu\text{F}$  from  $0.0001\mu\text{F}$  to  $0.5\mu\text{F}$ . To obtain the higher range the scale readings are multiplied by 100 and thus cover a range of  $0.01\mu\text{F}$  to  $50\mu\text{F}$ . Measuring leads are connected to the normal terminals for these tests. After having set the Selector Switch to the appropriate capacity range, the leads should be shorted and the "R" and "C" zero control adjusted until the meter needle reads full scale deflection. If the leads are now open circuited and the unknown condenser connected between them, the capacity of the condenser will be directly indicated upon the instrument. When measuring condensers with one terminal earthy, this should be connected to the lead going to the L.P. terminal of the instrument. Full scale adjustment should be made in this instance with L.P. terminal already connected to earthy terminal of condenser. The maximum voltage impressed across a condenser in this measurement is 10V R.M.S.

Electrolytic condensers can be checked by either of two methods:

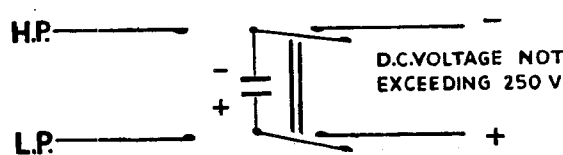


Fig. 6

- (1) Double-pole double-throw switch enables condenser to be polarised from D.C. source and then immediately transferred to Test-meter leads. (See Fig. 6.)

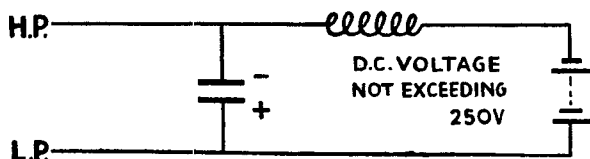


Fig. 7

- (2) Condenser is connected in parallel with choke of value greater than 30H. D.C. polarising voltage is applied from battery and Electronic Testmeter leads are then connected across the condenser. (See Fig. 7.)

It should be noted that this method may give rise to considerable error if used to check condensers of less than  $4\mu\text{F}$ .

#### Measurement of Resistance on the Ohms Ranges

Three ohms ranges are provided when the Selector Switch is turned to "ohms  $\div$  100," "ohms," and "ohms  $\times$  100" respectively. Readings are taken from a scale graduated to correspond to the range and calibrated from a first indication of 20 ohms to a maximum reading of 100,000 ohms, the centre scale reading corresponding to 1,500 ohms. With the range Selector Switch turned to the "ohms  $\div$  100" range, the scale readings then give a first indication of 0.2 ohms, with 15 ohms at mid-scale, whilst with the range selector switch set to "ohms  $\times$  100," the first indication is 2,000 ohms, mid-scale corresponding to 150,000 ohms and the maximum being 10 Megohms. With the range selector at the appropriate range the "R and C set zero" control should be turned until full scale deflection (i.e., 100 on black A.V. scale) is obtained with the leads open, zero readings being shown when the leads are shorted. Having selected a suitable range in accordance with the foregoing instructions, the insertion of the unknown resistance between the test leads will directly indicate the value of the unknown resistance upon the scale. The L.P. and H.P. terminals are used to make these measurements, the voltage across the resistance varying from 0—25V D.C. whilst measurements are being made.

#### Measuring Resistance on the Megohms Range

With the range selector turned to "Megohms" a special high resistance range gives readings from a fraction of a Megohm to 1,000 Megohms. The range is set up by rotating the "R and C set zero control" until the instrument reads full scale deflection (zero Megohms) with the leads, connected to the H.P. and L.P. terminals, shorted together. With the leads open, the pointer should be at the normal instrument zero, but it should be noted that upon humid days it is possible that this zero reading may rise slightly due to leakage existing between the L.P. and H.P. terminals. The maximum voltage across the resistance under test is only 2.5V D.C. whilst measurements are being made.

#### Measurements of Audio Watts and dB

The output power ranges are provided by turning the range Selector Switch to "5 watts" or "500mW" respectively. These ranges cover "5mW" to "500mW" and "50mW" to "5 watts." There are six load resistances which may be used with either of these ranges, selection being made by reading the load switch, the resistance value in use being indicated in the right-hand indicator window. It will be noted that on both power ranges, which utilise low A.C. voltage

ranges, the instrument pointer does not fall to zero, this function being deliberately introduced as described earlier when speaking about the A.C. voltage ranges. The instrument should not therefore be set to zero when in use upon the wattage ranges.

When using the power ranges to check output power, any D.C. component present in the circuit being measured should be removed by the insertion of a suitably large capacitor in series with instrument. The limitation of the size of paper capacitors will usually make it impossible to satisfactorily measure power in loads below 1,000 ohms when D.C. is present. This, however, should not cause difficulty since most cases of lower loadings occur in secondary circuits of transformers in which there is usually no D.C. component. Having selected a suitable range and load upon the instrument and connected the leads to terminals H.P. and L.P., the internal load resistance in the Electronic Testmeter should be inserted in place of the normal load in the circuit being measured, for example, in place of the speaker coil or in series with a suitable large capacity across the primary of an output transformer (with speech coil disconnected).

The Electronic Testmeter will now directly indicate the watts developed in the load in question. Readings of watts are made on the scale printed to correspond with the 0.05—5 watts range. On the 500mW range the scale readings in watts should be divided by 10.

Immediately below the watts scale is a dB scale so arranged that when taking measurements of watts the corresponding dB figures can be read directly, the zero dB mark corresponding with 500mW on the 5W range and 50mW on the 500mW range. Readings obtained on the 5W range can be referred to a zero level of 50mW by adding 10 dB to the dB scale readings. It should be noted that readings greater than 3 watts should not be maintained for long periods in order to avoid excessive heat dissipation in the internal load resistance.

#### **Instructions for Replacement of Lamps, Valves, etc.**

##### **REPLACEMENT OF DIODE IN PROBE**

When this diode fails it must be replaced by an Osram D77 or American type 6AL5 valve. Valves taken from stock will generally be found to be perfectly satisfactory after having been aged for a period of 50—100 hours to reduce the initial instability of contact potential within the valve. It is, however, preferable that a specially selected valve should be obtained from Avo Ltd., upon payment of the list price of the valve plus a very small charge for the selection and ageing work involved. When replacing this component some slight adjustment of the 1V A.C. Zero setting may be necessary. (See notes on p. 16.)

To open the probe, remove two screws from the rear of probe case and withdraw plate. The outer case of the probe can then be withdrawn to enable the valve to be replaced.

##### **REPLACEMENT OF BRIDGE VALVE AND LAMPS**

The instrument should be opened by placing it carefully upon its face and removing the four self-tapping screws around the side of the casing. The six screws around the perimeter of the

back of the instrument should be withdrawn, the probe removed from its box and the rear half of the casing lifted off, taking care not to damage the probe box which fits into two slots on the inner side of this half of the casing.

*Note.*—When replacing the back of the instrument, ensure that the probe lead is correctly positioned in the slot in the probe box, and check that the probe box is correctly retained by the brackets inside the instrument casing. Replace the six screws upon the back of the instrument, the five self-tapping screws around the sides of the case and replace probe.

Upon a few models this procedure will have to be slightly modified owing to a variation in the construction in the casing.

Having thus opened the instrument, it is now possible to remove and replace the valve and lamps. (See Fig. 8.) Only lamps of the following (or equivalent) suggested type should be used: GEC 6.5V .3 amp. radio panel lamps. Inasmuch as these lamps are commercially standard, replacements are not supplied by Avo Ltd.

The bridge valve 12AU7 will be found mounted on a rubber suspension. The valve is removed in the normal way with the exception that the base must be held whilst the cover and valve are being handled.

Valves giving rise to the following defects should not be used.

(1) *Loose Electrode Assembly.*

This will cause a shift of zero when the instrument is subjected to either knocking or jolting.

(2) *Gas Current.*

This will cause a shift of zero when, with the instrument leads open circuited, the range switch is changed from 25 microamps D.C. to 250mV D.C. The change of zero should not exceed one division, that is 2 per cent. of full scale.

It may be necessary to try several valves in order to obtain the best results, and it should be noted that valves having gas current will often considerably improve after having been aged in the instrument continuously for a period of approximately 48 hours.

If required, Avo Ltd. can supply selected and aged valves at the list price of the valve, plus a small charge for the selection and ageing work involved.

#### REPLACEMENT OF FUSE

A Belling Lee Fuse No: L.1055-1A will be found located on the paxolin board adjacent to the main transformer.

### Instructions for Setting the Coarse Zero and A.C. Zero Controls

The preset controls for the adjustment of A.C. Zero and Coarse Zero are easily accessible from the outside of the instrument by the removal of "press-in" covers from the side of the instrument. The disposition of the controls are shown in the illustration (Fig. 8).

**NOTE**—The third preset control is a trimming adjustment for full scale deflection of the millivoltmeter circuit and should not be touched.

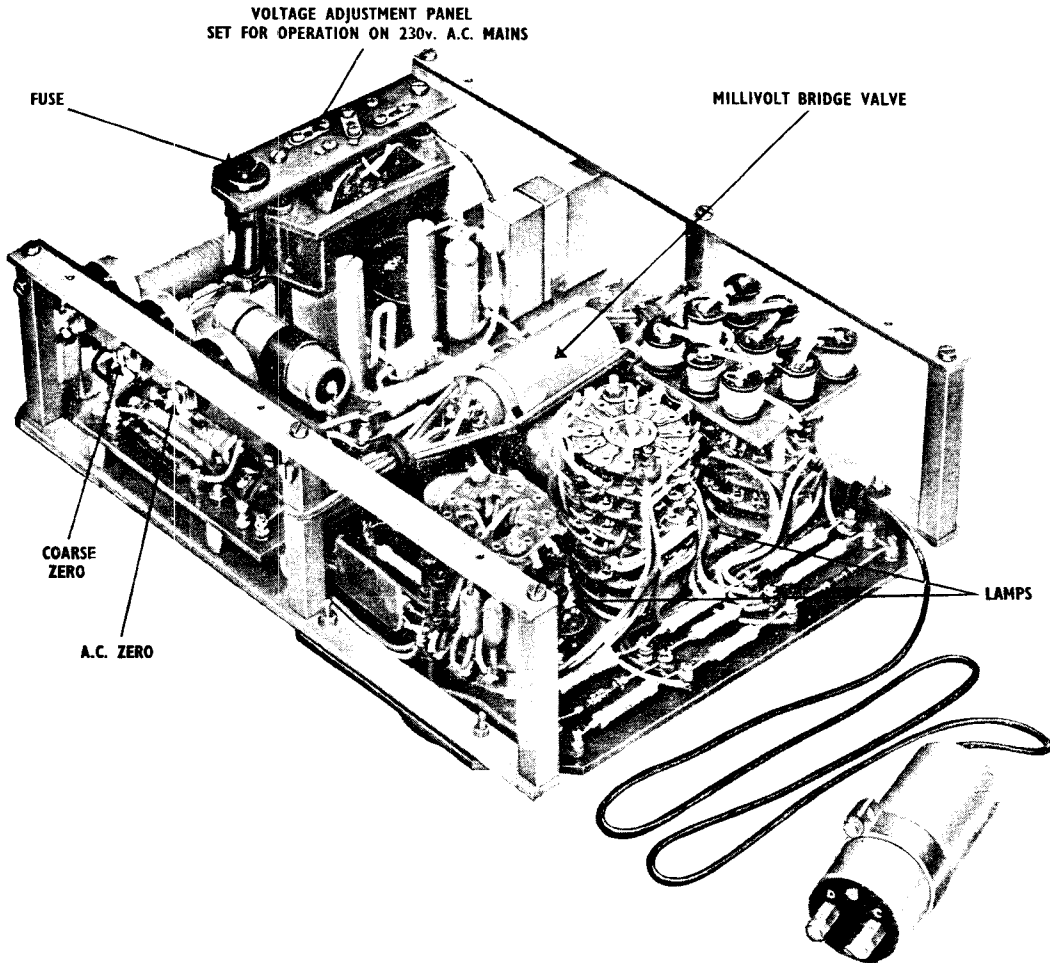


Fig. 8.

#### SETTING THE COARSE ZERO CONTROL

- (1) Set the testmeter to "amps. D.C."
- (2) Adjust the "Set Zero Instrument Control" on the front of the instrument half-way round its traverse.
- (3) Adjust the "Coarse Zero Control" on the side of the instrument until the movement pointer is at zero.

#### ADJUSTMENT OF A.C. ZERO

- (1) With the probe internal place finger on H.P. terminal with instrument set to 1V A.C. range and note that the meter reverse switch is positioned to produce a forward deflection of the movement, as the terminal is touched.
- (2) With the probe internal and the L.P. and H.P. terminals shorted or with the probe external and the probe terminal marked "C" shorted to the probe case terminal, set the instrument to its 1V D.C. range.
- (3) Set movement needle to zero by means of "Set Zero Instrument" Control.
- (4) Change to 1V A.C. range and set movement needle to 0.07V (3.5 divisions) by means of "A.C. Zero" control, with H.P. and L.P. terminals shorted.

#### Adjustment of Instrument for Operation upon Various Power Supplies

The instrument is suitable for connection to A.C. mains voltages between 100-130 volts 50-60 c/s and 200-260 volts 50-60 c/s. Should it be necessary to alter the mains voltage tapping from the normal 220-240 volt mains for which the instrument is initially adjusted, remove the small inspection plate from the rear of the instrument, thus exposing to view the tap changing board and fuse. The mains voltage connections for different values of voltage are then made as in the table below.

Operating Voltage.	Connect H to	Connect G to	Link
100/110V	B & D	C & E	—
110/130V	A & D	C & F	—
200/220V	B	E	C & D
220/240V	A	E	C & D
240/260V	A	F	C & D



## SERVICE NOTES AND ADJUSTMENTS

<i>Symptoms</i>	<i>Possible Fault</i>	<i>Procedure</i>
1. Failure of illumination.	1. Mains connecting lead faulty 2. Fuse open circuited. 3. Failure of lamps.	1. Check connections and cable. 2. Check fuse. (See p. 15.) 3. Replace lamps.
1. Meter needle failing to move.	1. Dirty contacts on toggle reverse switch. 2. Faulty 12AU7 valve. 3. Faulty movement or associated circuits.	1. Operate meter reverse switch several times. 2. Replace valve. (See p. 15.) 3. Return Testmeter to manufacturer.
1. Meter fails to zero correctly when H.P. and L.P. terminals are shorted with probe internal and range selector switch set to "amps" or "volts" D.C.	1. Incorrect setting of coarse zero control.  2. Faulty 12AU7. 3. Circuit faults.	1. See notes for setting coarse zero control. (P. 17.)  2. Replace valve. 3. Return Testmeter to manufacturer.
1. Large changes of zero when changing multiplier on "amps" or "volts" D.C.	1. Gassy 12AU7.  2. Open circuited multiplier chain.	1. Replace valve. (See p. 15.)  2. Return instrument to manufacturer.
1. Steady movement of needle away from zero on "amps" or "volts" D.C.	1. Faulty 12AU7.  2. Open circuited multiplier chain.	1. Replace valve. (See p. 15.)  2. Return instrument to manufacturer.
1. Instrument zero is satisfactory on D.C., but fails to zero on A.C. with probe internal. (Note an offset voltage of approximately 0.07V is deliberately introduced upon the A.C. ranges (see p. 9).	1. Input leads not shorted.  2. Incorrect setting of A.C. zero control. 3. Probe diode faulty. 4. Circuit fault.	1. Short leads together.  2. Reset A.C. zero control. (See p. 17.) 3. Replace diode (see p. 14). 4. Return instrument to manufacturer.

**SERVICE NOTES AND ADJUSTMENTS**  
(Continued)

<i>Symptoms</i>	<i>Possible Fault</i>	<i>Procedure</i>
1. As above but with probe external.	<ol style="list-style-type: none"> <li>1. Probe terminal marked "C" not shorted to probe case terminal.</li> <li>2. A connection to the probe terminal marked "D."</li> <li>3. Fault in extension cable for probe.</li> </ol>	<ol style="list-style-type: none"> <li>1. Short probe marked "C" and probe case terminals.</li> <li>2. Remove.</li> <li>3. Check probe lead and sockets.</li> </ol>
1. Failure to obtain a deflection on D.C. ranges when endeavouring to make a measurement.	<ol style="list-style-type: none"> <li>1. Faulty measuring leads.</li> <li>2. Internal circuit fault.</li> </ol>	<ol style="list-style-type: none"> <li>1. Check leads.</li> <li>2. Return instrument to manufacturer.</li> </ol>
1. Failure to obtain a deflection on A.C. ranges when endeavouring to make a measurement (probe internal) and assuming that instrument works correctly on D.C. ranges.	<ol style="list-style-type: none"> <li>1. Faulty measuring leads.</li> <li>2. Flying lead in probe box normally connected to terminal marked "D" on probe, either disconnect or connected to terminal marked "C" on probe.</li> <li>3. Faulty probe diode valve.</li> </ol>	<ol style="list-style-type: none"> <li>1. Check leads.</li> <li>2. Check connection.</li> <li>3. Replace probe diode.</li> </ol>
1. Random needle deflection usually accompanied by excessive brilliance of lamps.	1. Arc in series with mains supply to instruments.	<ol style="list-style-type: none"> <li>1. Check input lead and connections to 3-pin plug.</li> <li>2. Check mains switch for bad make and break.</li> </ol>

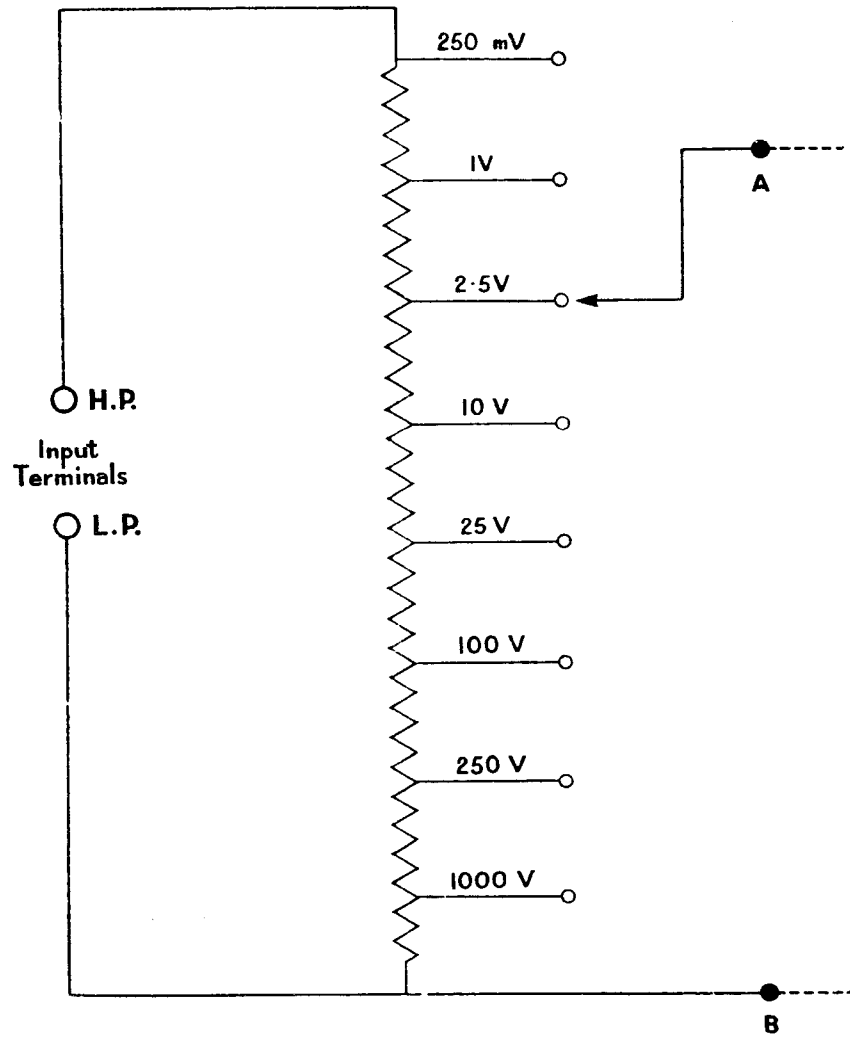
**Return of Instrument to Manufacturer**

If, after having studied the foregoing notes, it is quite clear that the instrument should be returned to the manufacturer for attention it should be accompanied with a clear and concise report of the fault(s) which have been found. The instrument should be adequately packed to ensure that it is not damaged in transit.

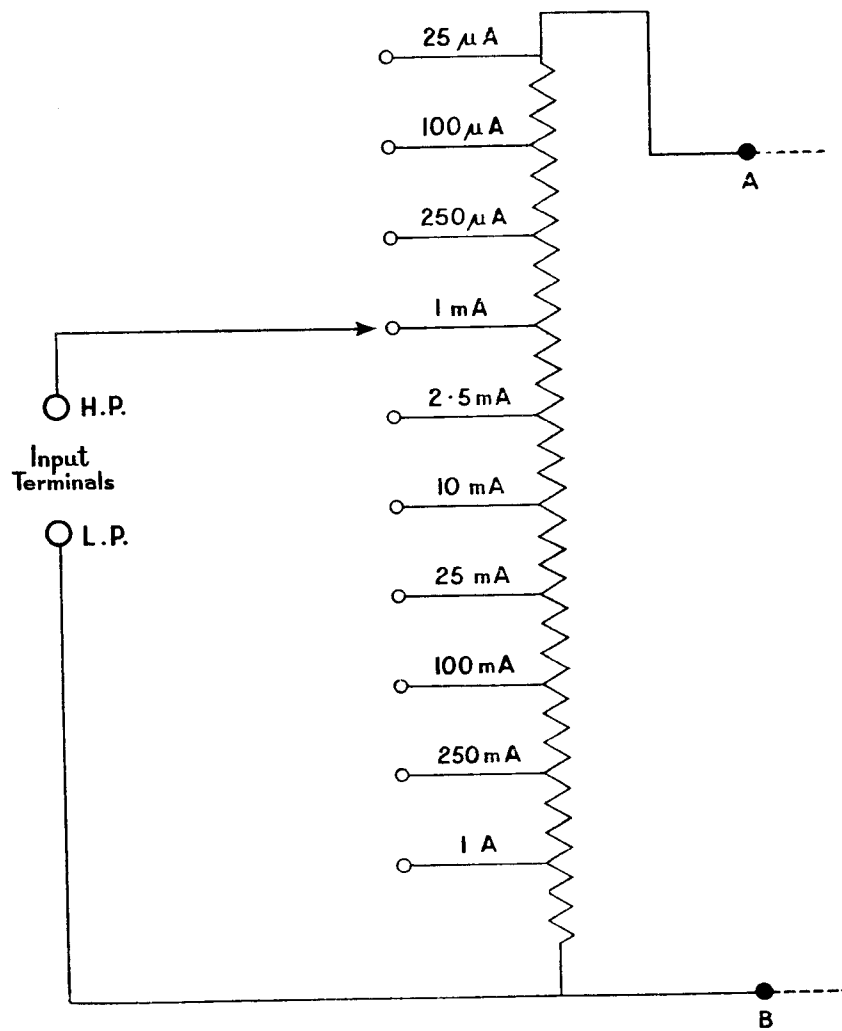
**TABLE OF RANGES**

Type of Measurement to be made.	Scale Reading.	Multiplier Switch Setting.	Range Switch Setting.	Load Switch Setting.
<i>D.C. Volts.</i> Using H.P. and L.P. Terminals (Input Resistance 11M $\Omega$ )	250-0mV full scale	250-0mV D.C.	Volts D.C.	
	1-0V " "	1-0V	" "	
	2-5V " "	2-5V	" "	
	10-0V " "	10-0V	" "	
	25-0V " "	25-0V	" "	
	100-0V " "	100-0V	" "	
	250-0V " "	250-0V	" "	
	1000-0V " "	1000-0V D.C.	" "	
<i>D.C. Volts</i> Using L.P. Terminal with External Multiplier plugged into X10 Socket (Input Resistance 110M $\Omega$ )	2-5V full scale	250-0mV D.C.	Volts D.C.	
	10-0V " "	1-0V	" "	
	25-0V " "	2-5V	" "	
	100-0V " "	10-0V	" "	
	250-0V " "	25-0V	" "	
	1000-0V " "	100-0V	" "	
	2500-0V " "	250-0V	" "	
	10,000-0V " "	1000-0V D.C.	" "	
<i>A.C. Volts</i> Using L.P. and H.P. Terminals with Probe Internal	1-0V R.M.S. full scale	1-0V	Volts A.C.	
	2-5V " " "	2-5V	" "	
	10-0V " " "	10-0V	" "	
	25-0V " " "	25-0V	" "	
	100-0V " " "	100-0V	" "	
	250-0V " " "	250-0V	" "	
Measuring between Probe Terminal marked "C" and Earth Clip with Probe External (See page 10 for notes on Voltage Limitation at High Frequencies.)	1-0V R.M.S. full scale	1-0V	Volts A.C.	
	2-5V " " "	2-5V	" "	
	10-0V " " "	10-0V	" "	
	25-0V " " "	25-0V	" "	
	100-0V " " "	100-0V	" "	
	250-0V " " "	250-0V	" "	
<i>A.C. Volts</i> Using L.P. Terminal with Probe Internal and High Potential Lead Plugged into X10 Socket	10-0V R.M.S. full scale	1-0V	Volts A.C.	
	25-0V " " "	2-5V	" "	
	100-0V " " "	10-0V	" "	
	250-0V " " "	25-0V	" "	
	1000-0V " " "	100-0V	" "	
	2500-0V " " "	250-0V	" "	

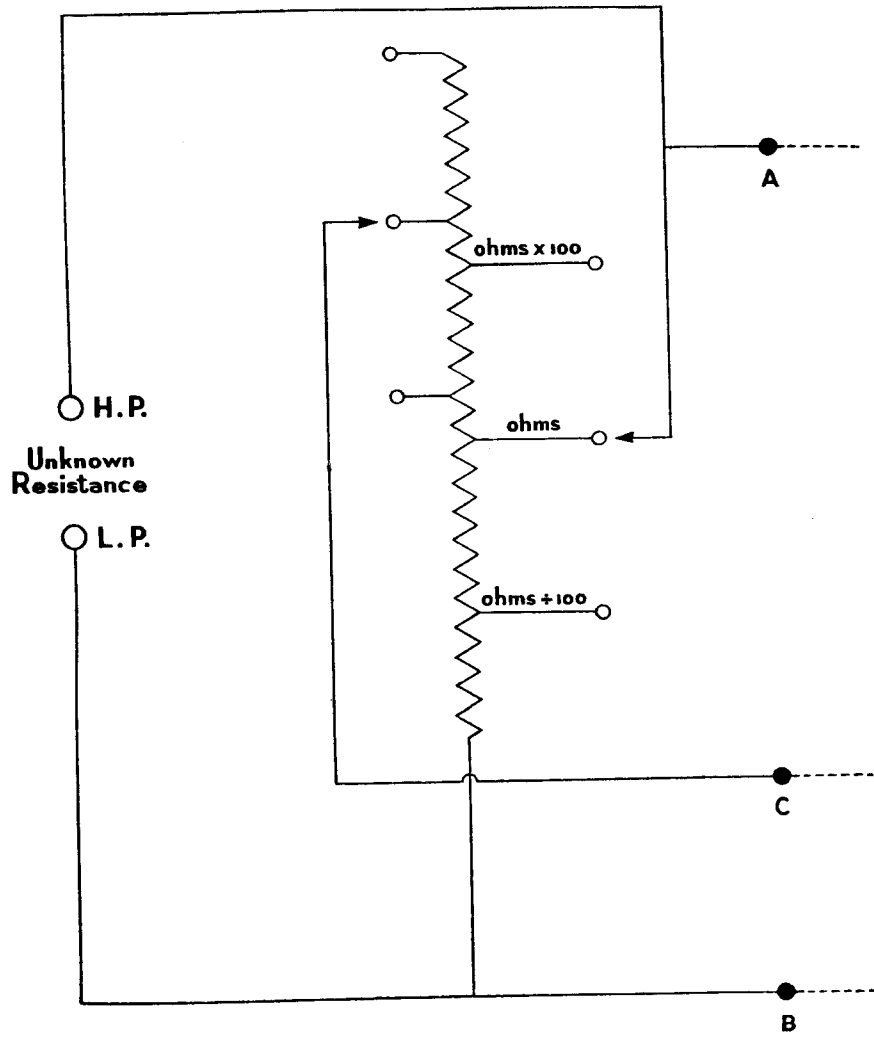
Type of Measurement to be made.	Scale Reading.	Multiplier Switch Setting.	Range Switch Setting.	Load Switch Setting.
<i>D.C. Current</i> 250mV Drop at Full Scale on all Ranges. Using L.P. and H.P. Terminals	25 $\mu$ A full scale 100 $\mu$ A „ „ 250 $\mu$ A „ „ 1mA „ „ 10mA „ „ 25mA „ „ 100mA „ „ 250mA „ „ 1A „ „	25 $\mu$ A 100 $\mu$ A 250 $\mu$ A 1mA 10mA 25mA 100mA 250mA 1A	Amps. D.C. „ „ „ „ „ „ „ „ „ „ „ „ „ „ „ „	
<i>Decibels</i> (Reference level of 50mW)	-10 to +10db add 10db to scale reading	—	50mW 5 Watts	5 $\Omega$ 600 $\Omega$ 10 $\Omega$ 2000 $\Omega$ 25 $\Omega$ 5000 $\Omega$ Select any load above as required
<i>A.C. Power Output</i>	500mV full scale 5.0W „ „	—	500mW 5 Watts	5 $\Omega$ 600 $\Omega$ 10 $\Omega$ 2000 $\Omega$ 25 $\Omega$ 5000 $\Omega$ Select any load above as required
<i>Capacitance</i> —	·0001 $\mu$ F—0.5 $\mu$ F ·01 $\mu$ F— 50 $\mu$ F	—	$\mu$ F $\mu$ F $\times$ 100	
<i>Resistance</i> —	0.2 $\Omega$ —1000 $\Omega$ 20 $\Omega$ —100,000 $\Omega$ 2000 $\Omega$ —10M $\Omega$	—	$\Omega \div 100$ $\Omega$ $\Omega \times 100$	
<i>Insulation</i> —	0.1M $\Omega$ —1000M $\Omega$	—	M $\Omega$	See notes on p. 13, re test voltage



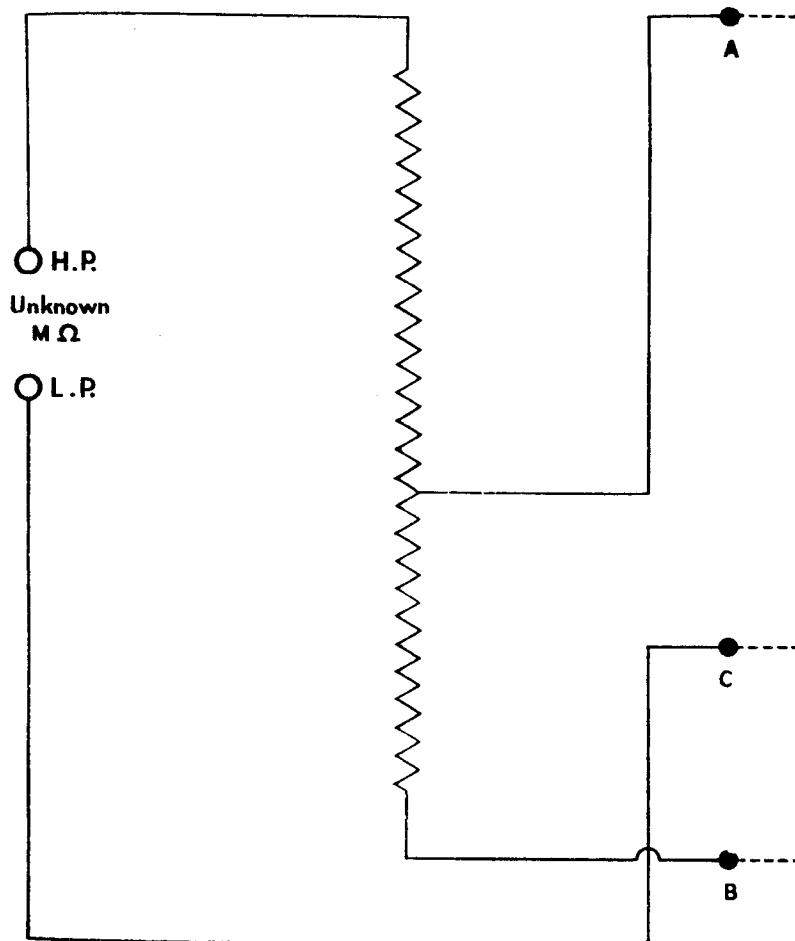
**D.C. VOLTS MEASURING CIRCUIT**



**D.C. CURRENT MEASURING CIRCUIT**

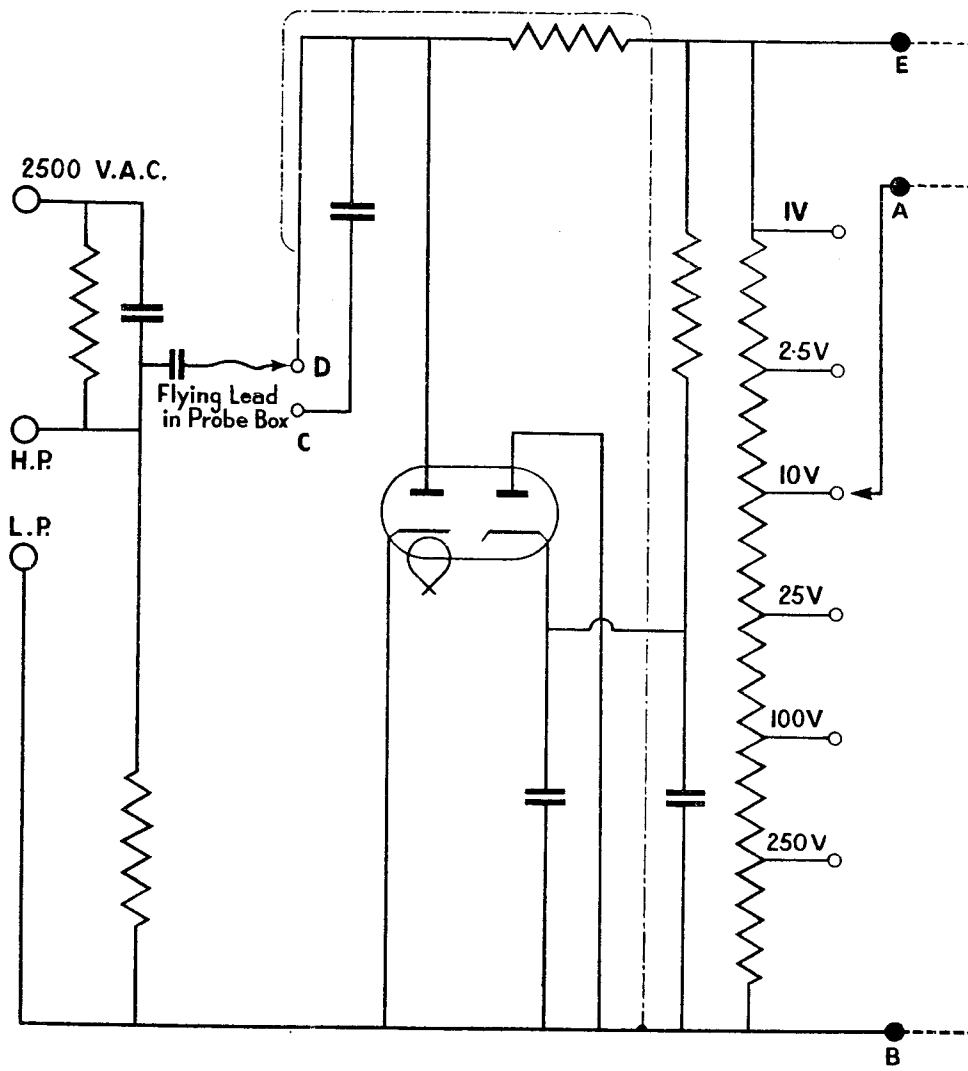


**OHMS MEASURING CIRCUIT**

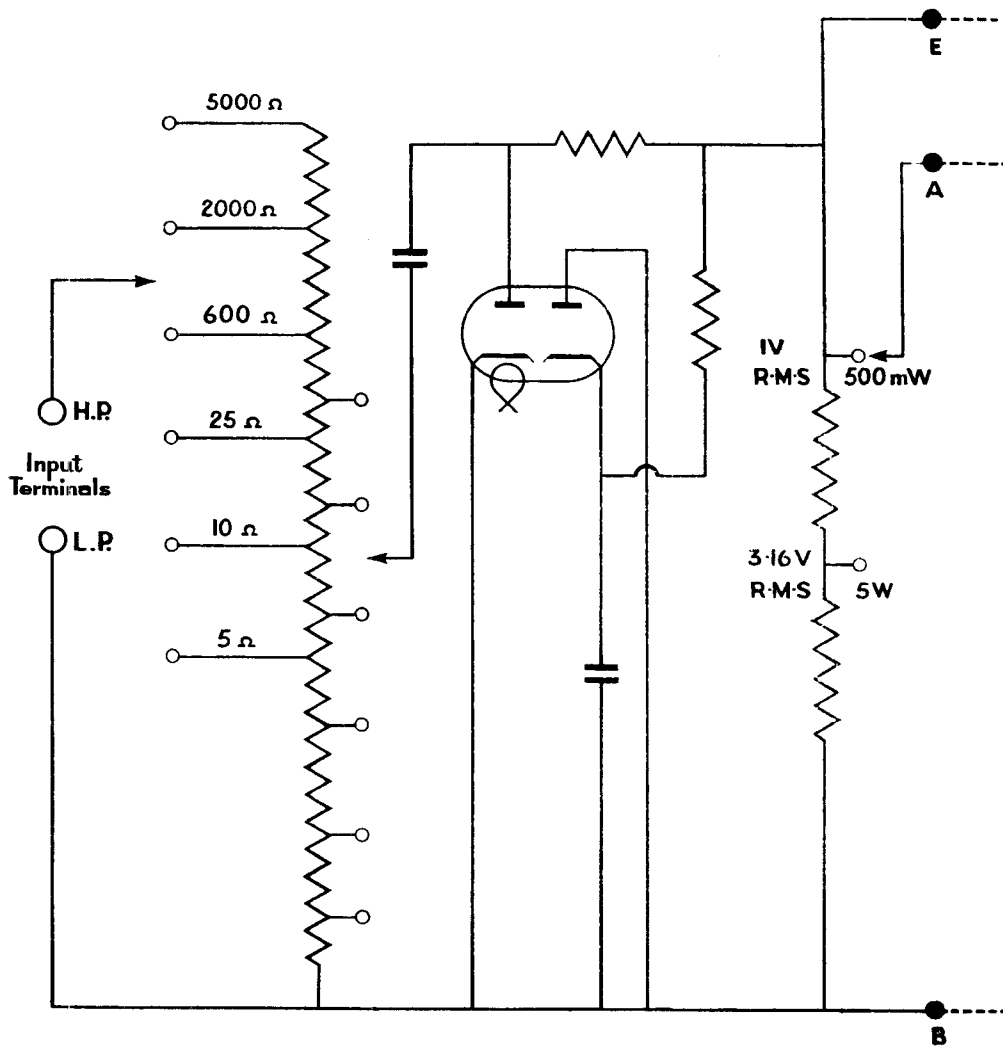


**MEGOHMS MEASURING CIRCUIT**

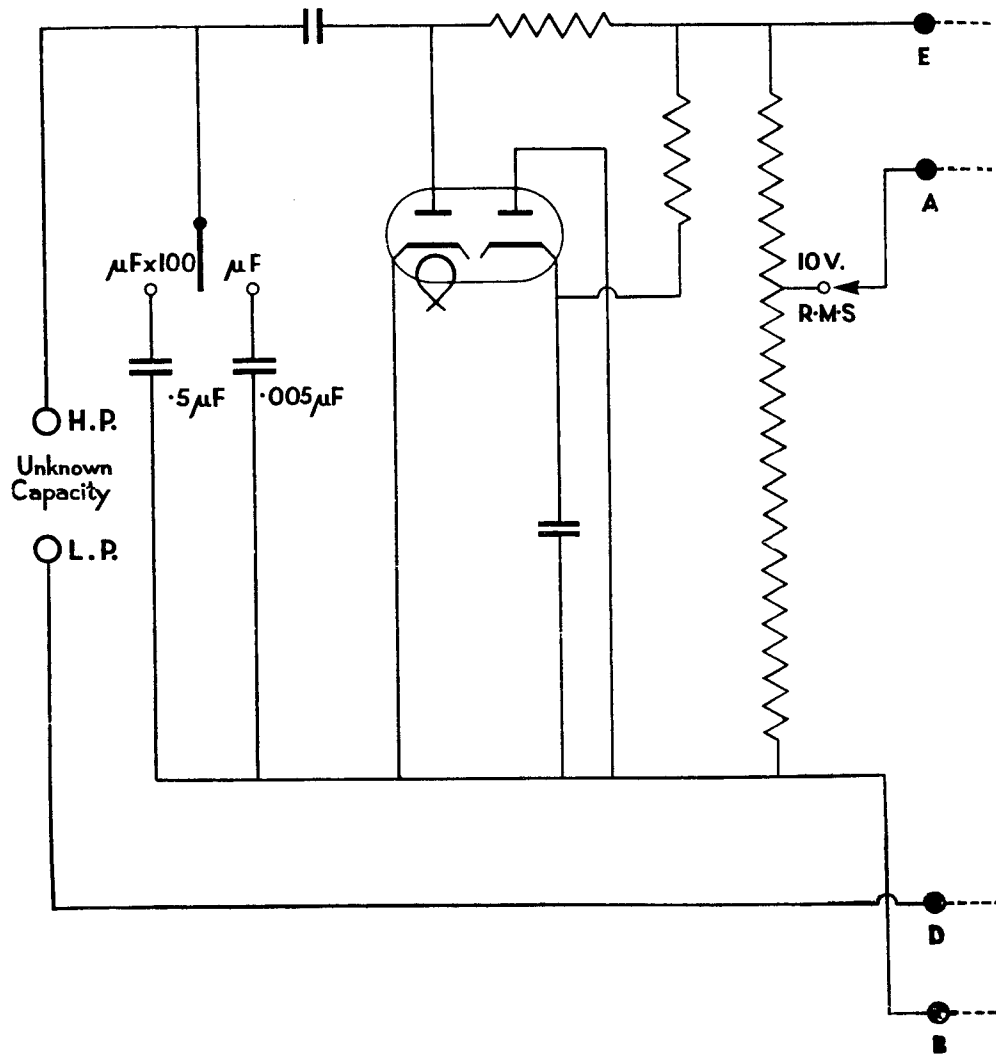




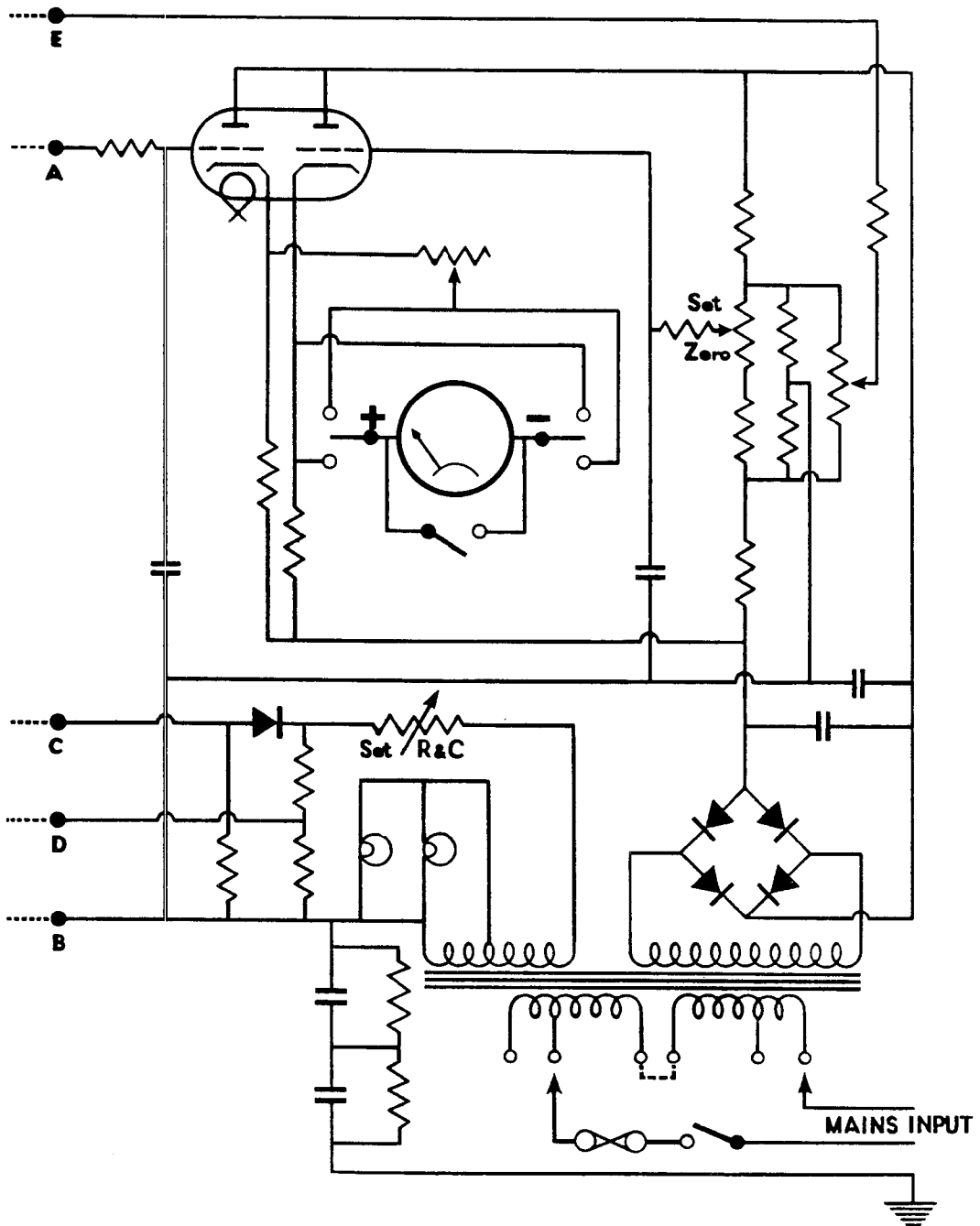
A.C. VOLTS MEASURING CIRCUIT



**WATTS MEASURING CIRCUIT**

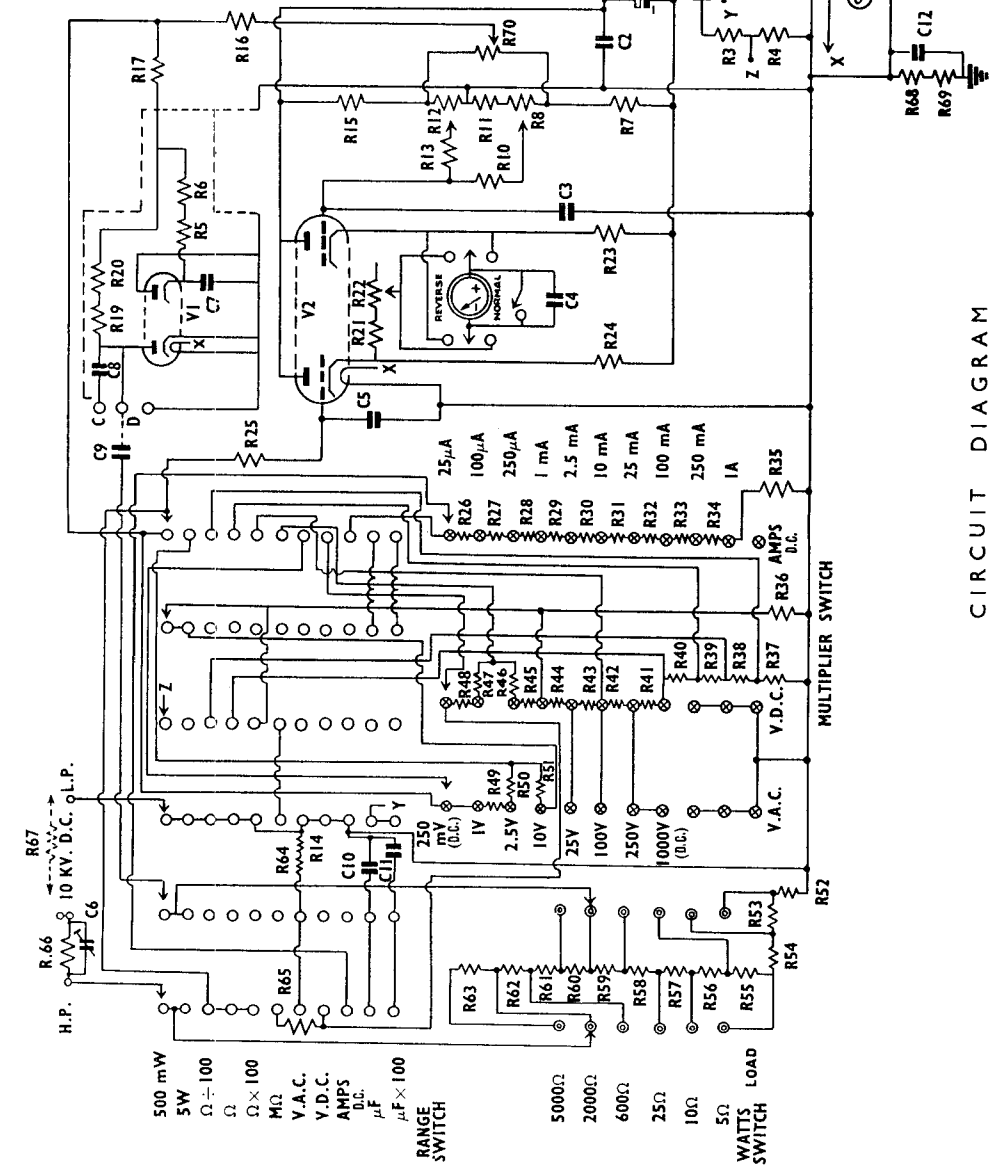


CAPACITY MEASURING CIRCUIT



BASIC D.C. MILLIVOLTMETER DIAGRAM

REF.	VALUE	TOL.	REF.	VALUE	TOL.	REF.	VALUE	TOL.	REF.	VALUE	TOL.
R1	15Ω		POT.	1.5KΩ	±1%	C1	16μF				
R2	75Ω		R39	1.5KΩ	±1%	C2	16μF				
R3	150Ω		R40	1.5KΩ	±1%	C3	16μF				
R4	180Ω		R41	1.5KΩ	±1%	C4	16μF				
R5	2 resistors to 7.5Ω		R42	100KΩ	±1%	C5	0.4μF				
R6	matched to 7.5Ω		R43	500KΩ	±1%	C6	0.4μF				
R7	BOXΩ		R44	1MΩ	±1%	C7	3.5μF				
R8	100Ω		R45	815KΩ	±1%	C8	470μF				
R9	100Ω		R46	500KΩ	±1%	C9	470μF				
R10	100Ω		R47	1.5KΩ	±1%	C10	0.5μF				
R11	450Ω		R48	1.5KΩ	±1%	C11	0.5μF				
R12	50KΩ		R49	1.5KΩ	±1%	C12	1μF				
R13	50KΩ		R50	250KΩ	±1%						
R14	SUPP.		R51	615KΩ	±1%						
R15	50KΩ		R52	3.16Ω	±1%						
R16	50KΩ		R53	5Ω	±1%						
R17	50KΩ		R54	5Ω	±1%						
R18	50KΩ		R55	2.07Ω	±1%						
R19	2 resistors to 7.5Ω		R56	2.07Ω	±1%						
R20	matched to 7.5Ω		R57	15Ω	±1%						
R21	750Ω		R58	9.6Ω	±1%						
R22	750Ω		R59	28.8Ω	±1%						
R23	500KΩ		R60	500Ω	±1%						
R24	500KΩ		R61	500Ω	±1%						
R25	9.1KΩ		R62	1.4KΩ	±1%	L1	6.3V 2A				
R26	7.5KΩ		R63	3KΩ	±1%	L2	2.5V 2A				
R27	1.5KΩ		R64	823KΩ	±1%						
R28	200Ω		R65	54Ω	±1%						
R29	200Ω		R66	54Ω	±1%						
R30	75Ω		R67	54Ω	±1%						
R31	15Ω		R68	54Ω	±1%						
R32	7.5Ω		R69	54Ω	±1%						
R33	1.5Ω		R70	54Ω	±1%						
R34	1.5Ω										
R35	25Ω										
R36	310KΩ										
R37	16.4Ω										
R38	150Ω										



CIRCUIT DIAGRAM  
 THE "AVO" ELECTRONIC TESTMETER  
 Mk. IV

Instruments made to this circuit commence at Serial Number 101. See label on probe box cover.

ROS RADIO/TV-SERVICE

# ELECTRONIC TESTMETER MK. IV

## SERVICE MANUAL



**AVO LTD**

"AVOCET HOUSE," 92-96 VAUXHALL BRIDGE ROAD, LONDON, S.W.1, ENGLAND

Telephone: VICTORIA 3404 (12 lines)

Telegrams: AVOCET, LONDON SW1

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# INTRODUCTION

Throughout the past decade, the AvoMeter has built for itself an unrivalled reputation for reliability and service. It is, however, inevitable that instruments fail from time to time, mainly due to accidental misuse, and, when they do, we are most anxious to ensure that they are repaired to the highest possible standard. We have, therefore, produced this booklet primarily to aid our friends and associates overseas, and we hope that it will form a useful guide to the *trained engineer* who has the task of servicing our products.

## Procedure for Ordering Spare Parts

If you will kindly follow the procedure set out below, delays will not occur due to the exchange of unnecessary correspondence:—

- (1) Study this manual carefully, and identify the part(s) required from the illustrations.
- (2) State the Serial Number of your instrument, if known. This will be found on a label on the exterior of the instrument.
- (3) When ordering spare parts for the movement assembly, in addition to the instrument serial number, the serial number of the movement should also be stated.

Overseas users of our instruments should send their requirements to our Representatives on their territory. If the parts are required in Great Britain, application should be made direct to the manufacturers in London.



# THE AVO ELECTRONIC TESTMETER Mk IV SERVICE MANUAL

## 1. Suggested Repair Procedure

When the instrument arrives for repair, examine it carefully, and note any signs of damage which might have been caused whilst the instrument was in course of transit to you (we assume here that the instrument has not been brought to you by hand). Do not proceed with any repairs apart from internal inspection until (a) you have received your customer's observations regarding the failure of the instrument, and (b) you are quite sure that the instrument has not suffered damage since it left your customer. Severe transit shocks can sometimes damage instruments internally, although externally they appear to be perfect. Always give your customer full details of any suspected transit damage, particularly when the damage to the instrument is more serious than that reported by him. Your customer may wish to claim financial damages from the carrier who shipped the instrument, and in order to assist him you should retain the packing materials in which the instrument arrived. It is also most important that the carriers should be informed of the damage without delay.

If your customer has not told you specifically to go ahead with the repair, irrespective of your charge, we strongly advise that you should examine the instrument and submit a quotation before any work is carried out. (Do not overlook the condition of the leads and clips when quoting.) This procedure, and the acceptance of your quotation, will safeguard you against disputes arising over your charge for the work, after the necessary repairs have been completed.

## 2. The Supply of Interchangeable Parts.

Reference to the parts lists facing the illustrations will show that the instrument has been 'broken down' in such a manner that all parts which may suffer electrical or physical damage can be replaced. We have not shown every small component, pillar, nut, and bolt, for such items seldom suffer damage.

*If you have not all the necessary apparatus at your disposal to carry out repairs to the movement assembly, replace the whole unit.* We cannot stress too strongly the advisability of using factory set-up assemblies, and we do in

particular urge you to replace a faulty movement with a new one, for so many difficulties can arise if you are not fully equipped and skilled in this delicate work. The factory employs special jigs, fixtures and tools for the assembly of the movement, and without their aid, some repair tasks become most difficult.

Spare hairsprings and pivots can be supplied if required, but we would stress that both these items are difficult to fit, and such work should not be attempted unless adequate facilities, tools, jigs, fixtures and the necessary skill are all available. The moving coil complete with hairsprings and pivots can also be supplied, but the replacement of such a unit in the movement will demand adjustment of sensitivity to  $32\mu\text{A}$ — $34\mu\text{A}$ .

*In view of the difficulties set out above the desirability of fitting a complete replacement movement is self-apparent. When a movement is changed, always ensure that the serial number (if any) marked on its scale plate is transferred to the scale plate of the replacement movement.*

*Be most careful to ensure that ferrous objects such as screwdrivers are not allowed to touch the magnetic system, which also must never be knocked or tapped. Failure to observe these precautions may result in a loss of magnetic flux.*

Due to modifications in movement design it will now be necessary in some circumstances to return the complete assembly to Avo, Ltd., for overhaul.

Movements in this category can be identified by the letter 'T' incorporated in the serial number on the scale-plate.

**UNDER NO CIRCUMSTANCES SHOULD ANY ATTEMPT BE MADE TO SERVICE BASIC MOVEMENT ASSEMBLIES OF THIS TYPE AS IT IS NOT POSSIBLE WITHOUT SPECIALISED EQUIPMENT.**

The spare parts shown in this Service Manual on page 26 items 4—6 are therefore not applicable to 'T' type movements.

# USEFUL SERVICING INFORMATION

## 1. Adjustment of Instrument for Operation upon Various Power Supplies.

The instrument is suitable for connection to a.c. mains voltages between 100–130 volts, 50–60 c/s and 200–260 volts 50–60 c/s. Should it be necessary to alter the mains voltage tapping from the normal 220–240 volt mains for which the instrument is initially adjusted, *remove the rear case, thus exposing to view the tap changing board and fuse.*

The mains voltage connections for different values of voltages are then made as in the table below.

When connecting a plug to the mains cable, the green or yellow lead should be connected to the earthing pin of the plug or, if there is no earthing pin, to any earth point.

The instrument will read in the correct direction when measuring a.c. quantities, regardless of whether the L.P. terminal is connected to the 'earthy' side of the circuit under test, or to the 'live' side. The meter reverse switch should be in the 'Normal' position. It is important, however, to ensure that when measuring mains supplies the L.P. terminal is connected to the 'Neutral' side of the supply. When measurements of d.c. voltage are being made, the L.P. terminal should be normally connected to the point in the circuit under test, which is nearest to earth. Depending on the nature of the circuit under test, this may result in the H.P. terminal being connected to a +ve or -ve potential, resulting in a change of direction in the meter reading. This is taken care of by the meter reversing switch.

For measurements on a.c./d.c. equipment do not disconnect the earth connection on the Electronic Testmeter, but operate the equipment under test from an isolating transformer.

**MAINS VOLTAGE CONNECTIONS**

Operating Voltage	Connect H to	Connect G to	Link
100/110V	B & D	C & E	—
110/130V	A & D	C & F	—
200/220V	B	E	C & D
220/240V	A	E	C & D
240/260V	A	F	C & D

## 2. Moving Coil Will Not Move

If the instrument is subjected to most severe shock, it sometimes happens that the moving coil is thrown completely out of its jewels. When this happens, the instrument must be opened, the movement removed, and the pivots and jewels examined for possible damage.

## 3. The Movement Needle Tends to Stick at One Point on the Scale

This symptom usually indicates that a small piece of iron or some other foreign body has found its way into the magnetic gap, and is fouling the moving coil former. The movement should be withdrawn from the meter, examined in a good light against a white background, and any non-metallic bodies removed with a small non-magnetic pin, or iron dust carefully drawn out by means of a thin steel needle. Iron dust in the gap will adhere to the needle, and with a little patient effort, an iron particle can usually be withdrawn.

This 'stick' can also be due to the pointer fouling the scale plate. In such instances, the pointer should be bent away from the scale-plate to give it adequate clearance.

## 4. The Movement Needle Tends to Stick to All Points Across the Scale.

However well an instrument is constructed, there will always be some measure of friction between its pivots and jewels. If this friction is increased by damage due to impact, it may assume noticeable proportions, and it sometimes happens that an instrument will give slightly different consecutive readings upon the same test, although tapping the glass makes all readings more or less agree. Such a suspected fault can be found by carrying out the following procedure:—

- (a) Pass a known current through the instrument, and note its reading.
- (b) Reduce the current considerably, and then bring it slowly back to its original value and take a second reading.

- (c) Increase the current well beyond its original value, and then slowly reduce it to the value fixed under item (a).

If the differences between the readings are too great to be ignored, the movement will require attention. The trouble is usually due to increased friction in the movement bearings caused by dirt, a blunted pivot or a damaged jewel. Dirt can be removed by cleaning the pivots with pith, and gently inserting the sharp point of a small stick of orange wood into jewel recesses, or by washing the jewel screws in Genklene. A damaged jewel or pivot should always be replaced.

## 5. Replacement of Diode in Probe

When this diode fails it must be replaced by an Osram D77 or American type 6AL5 valve. Valves taken from stock will generally be found to be perfectly satisfactory after having been aged for a period of 50–100 hours to reduce the initial instability of contact potential within the valve. It is, however, preferable that a specially selected valve should be obtained from Avo Ltd., upon payment of the list price of the valve plus a very small charge for the selection and ageing work involved. When replacing this component some slight adjustment of the 1V a.c. Zero setting may be necessary. (See notes on p. 11.)

To open the probe, remove two screws from the rear of probe case and withdraw plate. The outer case of the probe can then be withdrawn to enable the valve to be replaced.

## 6. Replacement of Bridge Valve and Lamps

The instrument should be opened by placing it carefully upon its face and removing the four self-tapping screws around the side of the casing. The six screws around the perimeter of the back of the instrument should be withdrawn, the probe removed from its box and the rear half of the

casing lifted off, taking care not to damage the probe box which fits into two slots on the inner side of this half of the casing.

**Note.** — When replacing the back of the instrument, ensure that the probe lead is correctly positioned in the slot in the probe box, and check that the probe box is correctly retained by the brackets inside the instrument casing. Replace the six screws upon the back of the instrument, the five self-tapping screws around the sides of the case and replace probe.

On a few models this procedure will have to be slightly modified owing to a variation in the construction in the casing.

Having thus opened the instrument, it is now possible to remove and replace the valve and lamps. Only lamps of the following (or equivalent) suggested type should be used: GEC 6.3V 0.3 amp. radio panel lamps.

The bridge valve 12AU7 or 13D8 will be found mounted on a rubber suspension. The valve is removed in the normal way with the exception that the base must be held whilst the cover and valve are being handled.

Valves giving rise to the following defects should not be used.

#### (a) Loose Electrode Assembly

This will cause a shift of zero when the instrument is subjected to either knocking or jolting.

#### (b) Gas Current

This will cause a shift of zero when, with the instrument leads open circuited, the range switch is changed from 25 microamps d.c. to 250mV d.c. The change of zero should not exceed one division, that is, 2 per cent. of full scale.

It may be necessary to try several valves in order to obtain the best results, and it should be noted that valves having gas current will improve considerably after having been aged in

the instrument continuously for a period of approximately 48 hours.

If required, Avo Ltd. can supply selected and aged valves at the list price of the valve, plus a small charge for the selection and ageing work involved.

## 7. The Appearance of the Repaired Instrument

Having ensured that the instrument is perfect electrically and mechanically, do not be content to return it to the customer in a dirty condition. Thoroughly clean the components, and wipe out the inside of the case, taking particular care that no small particles of iron or other foreign substances are left within the instrument.

## SERVICE NOTES AND ADJUSTMENTS

Symptoms	Possible Cause
Lamps not illuminated	Faulty Mains Lead. Open Circuit fuses. Lamp failure. Faulty Mains Transformer.
No meter indication	Faulty Valve. Movement Open Circuit. Potentiometers RV2 and RV3 and associated circuit faulty. Dirty contacts on the Reverse Toggle Switch. No ht supply.
Meter fails to zero correctly when H.P. and L.P. terminals are shorted with the probe internal and with the function switch set to d.c. 'amps' or 'volts'.	Faulty Valve. Faulty Potentiometers RV2 and RV3 and associated components. Dirty contacts on the Reverse Toggle Switch. Incorrect setting of Coarse Zero Control (RV2). Open circuit movement.
Slight zero fluctuations when operating the Multiplier Switch on 'amps' or d.c. volts.	Gassy Double Triode.
Instrument zeros satisfactorily on d.c. ranges, but fails to zero correctly on a.c. ranges with the probe internal (an offset voltage of 0.07 is introduced on all a.c. ranges).	H.P. and L.T. terminals not shorted. Incorrect setting of the a.c. zero control. Faulty probe diode. Loose probe spacers causing a poor heater circuit. Dry joint between the spring clip and the Diode Valve Heater.
As above but with the probe external.	Probe Terminal Marked 'C' not shorted to the Terminal on the Probe Case. A fault in the Lead between the Probe and the main instrument.
Failure to obtain a deflection on a.c. ranges when making measurements with the probe internal. (Assuming that the instrument is satisfactory on d.c. ranges.)	The Flying Lead in the Probe Box which is normally connected to the Terminal Marked 'D' has either become disconnected or incorrectly connected to the Terminal Marked 'C'. Faulty Probe Diode or associated circuit.
Incorrect readings on a.c. when using the times ten terminal.	Faulty Internal Multiplier or R39.
Large zero fluctuations which progressively decrease on switching the higher ranges.	Open circuit resistor in the multiplier chain.

Symptoms	Possible Cause
Inaccurate readings on current ranges.	Faulty Bobbins. Faulty Components in the d.c. current chain. Dirty Switch Contacts, etc.
Unable to set full-scale deflection on ohms ranges.	Faulty Rectifier (MR.2), or faulty R and C zero control (RV.5).
Inaccuracy on ohms ranges.	Resistors R.3, R.4 and R.5 faulty.
Unable to set full-scale deflection on the Megohm range.	Resistor R.40 faulty.
Unable to set full-scale deflection on capacitance ranges, but functions on ohms ranges.	Incorrect balance between R.47 and R.48. Mains tapping incorrectly set for the main supply voltage available.
Inaccuracy on capacitance ranges.	C.7 and C.8 leaky.
High readings on times ten a.c. ranges.	Poor insulation in capacitor C.1.
Pointer fluctuation when making a reading on a.c. ranges.	Loose spacers in the probe or a dry joint between the Spring Clip and the Valve Holder causing poor heater connections. A soft araldite connector block which has become distorted causing an intermittent short circuit between the connections and the Probe Case.
No readings on d.c. voltage ranges.	Faulty test leads or Range Switch. Readings on d.c. voltage range incorrect (either high or low). Grid capacitor C.5 leaky or R.19 to R.25 faulty.
Inaccurate readings on times ten d.c. voltage range only.	External multiplier or Internal multiplier R.1 faulty.

## RETURN OF INSTRUMENT TO MANUFACTURER

If, after having studied the foregoing notes, it is quite clear that the instrument should be returned to the manufacturer for attention, it should be accompanied with a clear and concise report of the fault(s) which have been found. The instrument should be adequately packed to ensure that it is not damaged in transit.

## SETTING UP AND TEST PROCEDURE

- (1) Check instrument mains input and adjust to match mains voltage.
- (2) With instrument switched on but *not connected to mains*, check movement mechanical zero, balance, etc. When the mains switch is in the 'Off' position, check that movement is heavily 'damped' (mains switch in 'Off' position applies a short circuit to movement).
- (3) Connect to mains: Switch on and allow 15–30 minutes to warm up.
- (4) Switch to lowest d.c. current range ( $25\mu\text{A}$ ).

Set instrument zero potentiometer to its mid-position. Using the '*Coarse Zero Potentiometer*', bring the movement pointer to zero. With the '*Meter Reverse Switch*' in the normal position, turn the '*Instrument Zero Control*' fully anti-clock-wise; the pointer should take up a position of 10–20% of full-scale deflection. On turning the '*Instrument Zero Control*' in a clock-wise direction, the pointer should move smoothly to zero, and, on switching the '*Meter Reverse Switch*' to reverse, and continuing to rotate '*Instrument Zero Control*' in clock-wise direction, the pointer should move up from zero and assume the same position on the scale as was obtained in the normal position with the '*Instrument Zero Control*' fully anti-clock-wise, i.e., the '*Instrument Zero Control*' should give you approximately equal scope of adjustment in either position of '*Meter Reverse Switch*'.

- (5) Check for range to range zero shift by changing from lowest current range to lowest dc voltage range with the terminals open and *no leads attached*. This should not exceed  $\pm 1$  per cent.
- (6) With the '*Meter Reverse Switch*' in the 'Normal' position, adjust Sensitivity Potentiometer on the lowest dc current Range until 250mV applied should give f.s.d.
- (7) Check dc current range tolerance, which should be  $\pm 2$  per cent at f.s.d.

- (8) Check dc Voltage Range at f.s.d. tolerance, which should be  $\pm 2$  per cent. Transpose the meter input and check at least one dc voltage range with *Meter Reverse Switch* in 'Reverse' position.

### (9) A.C. Zero Set-Up

With the *Meter Reverse Switch* in the 'Normal' position, set instrument to 1V dc Range and short out the H.P. and L.P. terminals. Rotate *Range Switch* to 'A.C. Volts' position (Multiplier switch is automatically at 1V ac now), and adjust the *AC Zero Potentiometer* so that 0.07V (3.5 divisions) is registered. This 0.07V zero shift is proportional on all ac volt ranges, and will disappear as *Multiplier Switch* is switched to higher voltages.

Check ac volts tolerance is within  $\pm 3$  per cent at f.s.d.

Switch to 25V a.c. range and apply 250V between LP and X10 Terminals. The instrument should then read f.s.d.  $\pm 3\%$ .

### (10) Check Watts Ranges

Note that 0.07V bias will be observed on these ranges:

Apply 50V ac with switch set to 500mW x  $5k\Omega$  the meter should then indicate f.s.d.  $\pm 20\%$ .

Apply 7.07V ac with switch set to 5W x  $10\Omega$  the meter should then indicate f.s.d.  $\pm 20\%$ .

### (11) Check Ohms Ranges

Short leads together. Adjust '*Instrument Zero Potentiometer*' to zero. Open leads and adjust the *R/C Zero Potentiometer* for f.s.d. Slight readjustment of *R/C Zero Potentiometer* is normal changing from any of these ranges.

Check that Readings at mid-scale on all ranges are within  $\pm 5\%$ .

**Note.** – If minimum reading of *R/C Zero Potentiometer* is less than approximately 65, the Rectifier (MR2) is usually suspect. This should be made with the instrument switched to the  $\Omega$  100 range. (Check on  $\Omega$  100 for this minimum reading.)

(12) Check MΩ Ranges

Open leads to adjust *Instrument Zero Potentiometer* at 0 on 0–100 scale, close leads and adjust *R/C Zero Potentiometer* for f.s.d. Check that at 25MΩ readings are within ± 5 per cent.

Close leads and adjust *R/C Zero Potentiometer* for f.s.d. Check readings. Tolerance ± 5 per cent (at mid-Scale).

(13) Check Capacitance Ranges

Open leads and adjust *Instrument Zero Potentiometer* for zero on 0–100 scale.

(14) Check Instrument Insulation

Check High Voltage (up to 1kV) for insulation between L.P. and case and chassis, taking into consideration the 10MΩ bleeder across the 0.1μF capacitor between these points in most instruments.

### TYPICAL VOLTAGES TAKEN WITH MODEL 8 AVOMETER

Circuit Position	Voltage	Range
H.T. output of transformer . . . . .	170 V approx . . . . .	250 V a.c.
L.T. output from transformer	5.6 V approx . . . . .	10 V a.c.
Across R51 & RV5 . . . . .	11V approx . . . . .	25 V a.c.
H.T. (d.c.) across C10 . . . . .	220 V approx . . . . .	250 V d.c.
Across R45 (80Ω) . . . . .	170 V approx . . . . .	250 V d.c.
Across R43 (20Ω) . . . . .	40 V approx . . . . .	100 V d.c.
H.T. to L.P. Terminals . . . . .	40-45 V . . . . .	100 V d.c.
L.P. Terminal to junction of R31) R42) C9 )	+ 0.25 V to -0.25 V approx . . . . .	2.5 V d.c.
Across R35 or R37 . . . . .	170 V approx. . . . .	250 V d.c.
Potentiometer Coarse Zero RV2	1 V approx. . . . .	2.5 V d.c.
Across Zero RV3 . . . . .	0.2 V approx. . . . .	2.5 V d.c.
Across R47 & R48 . . . . .	-2.2 to -3.7 V approx. . . . .	10 V d.c.
Across R51 . . . . .	7.5 to 10 V approx. . . . .	25 V a.c.
Across RV4 . . . . .	2 V approx. . . . .	2.5 a.c.



# ACCESSORIES

NOT ILLUSTRATED

<i>Item No.</i>	<i>Description</i>	<i>Part No.</i>
1	Leather Case . . . . .	40404-A
2	Instruction Book . . . . .	10072-289
3	Multiplier (10kV) . . . . .	20396-A
4	Multiplier Lead for Item 3 (Instrument to Multiplier) . .	20406-A
5	Multiplier Lead for Item 3 (Multiplier to eht) . . . . .	20406-B
6	Multiplier (25kV) (95M $\Omega$ $\pm$ 1% Total) . . . . .	40512-A
7	Multiplier Lead for Item 6 (Multiplier to eht) . . . . .	20974-A
8	Multiplier Lead for Item 6 (Multiplier to Instrument) . .	20974-B
9	Test Lead (Red) . . . . .	12218-A
10	Test Lead (Black) . . . . .	12218-B
11	Crocodile Clip . . . . .	12381-B
12	Prod Assembly (Red) . . . . .	11588-A
13	Prod Assembly (Black) . . . . .	11588-B

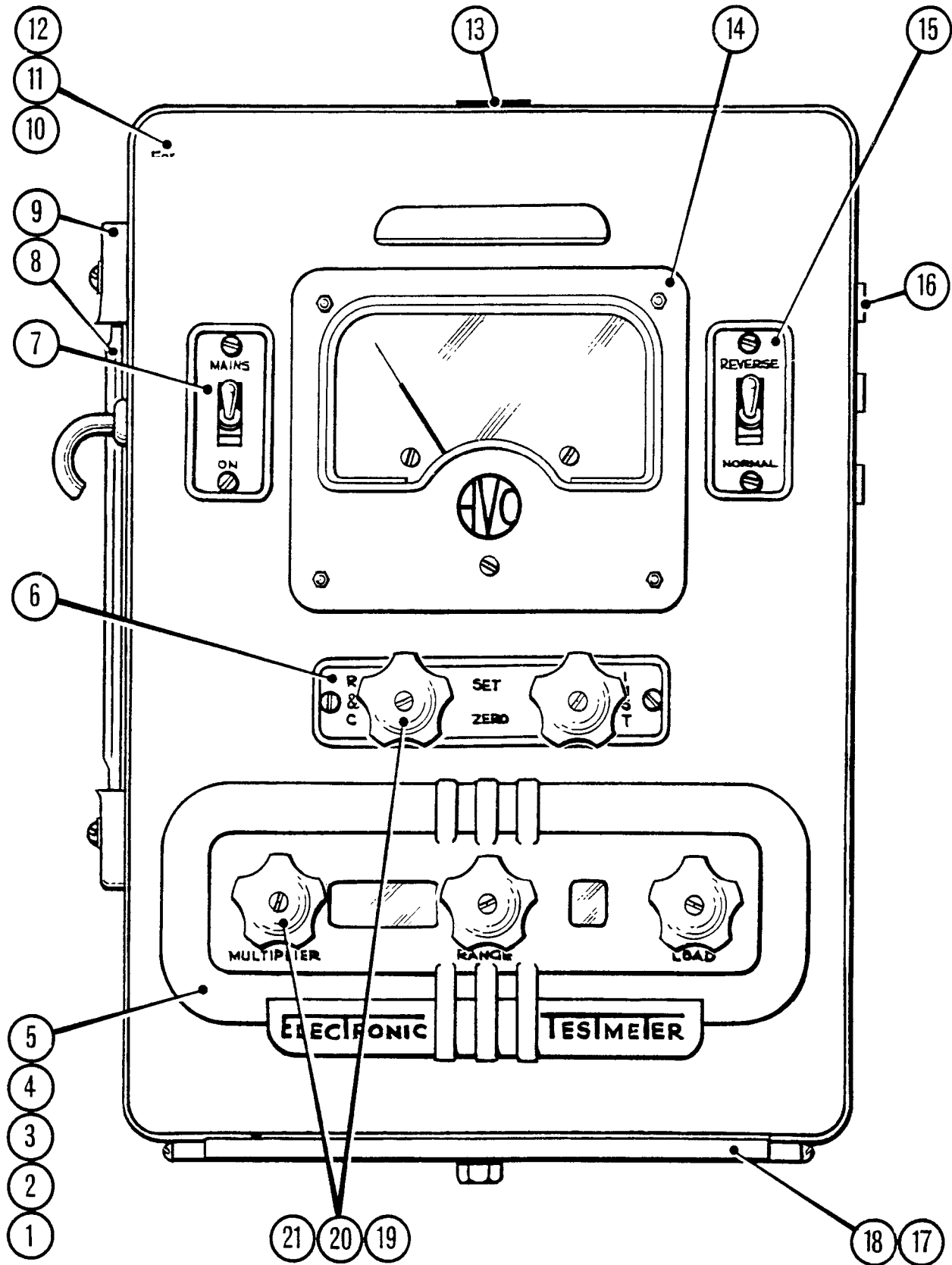
# PLATE 1

# MAIN ASSEMBLY

<i>Item No.</i>	<i>Description</i>	<i>Circuit Ref.</i>	<i>Part No.</i>
1	Window (Large) . . . . .		10712-2
2	Window (Small) . . . . .		10712-1
3	Clamp (Large) . . . . .		20098-2
4	Clamp (Small) . . . . .		20097-2
5	Range Escutcheon . . . . .		40049-A
6	Zero Escutcheon. . . . .		13221-1
7	On/Off Escutcheon . . . . .		13223-1
8	Handle Assembly . . . . .		11727-A
9	End Cap . . . . .		11727-4
10	Top Case . . . . .		40268-B
11	Bottom Case . . . . .		40515-B
12	Top and Bottom Case Assembly . . . . .		40268-D
13	Name Plate (Avo Limited) . . . . .		12231-5
14	Movement Assembly (32-34 $\mu$ A, 2800 $\Omega$ ) See P.26 . . . . .	M1	20698-F
15	Reverse Escutcheon . . . . .		13222-1
16	Plugs . . . . .		10962-1
17	Probe Box and Probe Assembly. See page 20 for details. . . . .		20984-A
18	Probe Lid Assembly . . . . .		20958-B
19	Sprung Dowel . . . . .		20245-52
20	Knob . . . . .		14267-1
21	Knob Carrier . . . . .		14670-2
22	Stand Assembly (Not Illustrated) . . . . .		20338-B
23	Clip for Item 22 (Not Illustrated) . . . . .		12353-2
24	Rubber Foot (Not Illustrated) . . . . .		11596-1
25	Plugs. Similar to Item 16. . . . .		14797-1
26	Label (Mains Connections) (Not Illustrated) . . . . .		15367-19
27	Special Screw for Item 20 . . . . .		S745

# MAIN ASSEMBLY

# PLATE 1



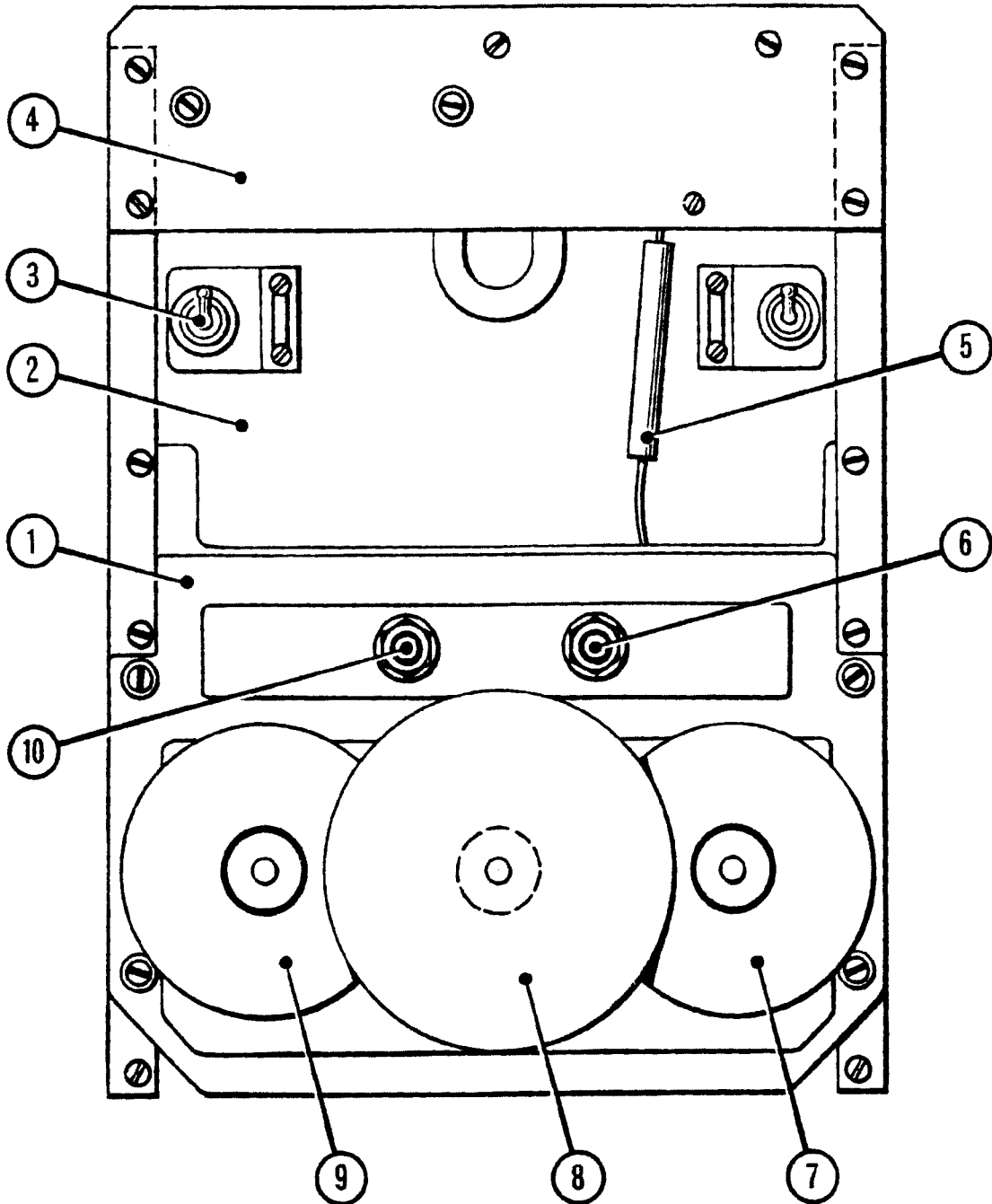
# PLATE 2

# CHASSIS ASSEMBLY – FRONT

<i>Item No.</i>	<i>Description</i>	<i>Circuit Ref.</i>	<i>Part No.</i>
1	Switch Board Assembly. See page 24 for details . .		40517–A
2	Component Board Assembly. See page 22 for details		40514–B
3	Toggle Switch (2 off) . . . . .	SA1, SA2	13657–1
4	Transformer Board . . . . .		20979–1
5	Resistor 5M $\Omega$ total (matched pair) . . . . .	R49, R50	12049–213
6	Potentiometer 100 $\Omega$ (Mounted on Switch Board Assembly)	RV3	10770–16
7	Load Dial . . . . .		10717–1
8	Range Dial . . . . .		20103–1
9	Multiplier Dial . . . . .		20105–1
10	Potentiometer 15 $\Omega$ (Mounted on Switch Board Assembly)	RV5	10770–15

# CHASSIS ASSEMBLY - FRONT

PLATE 2



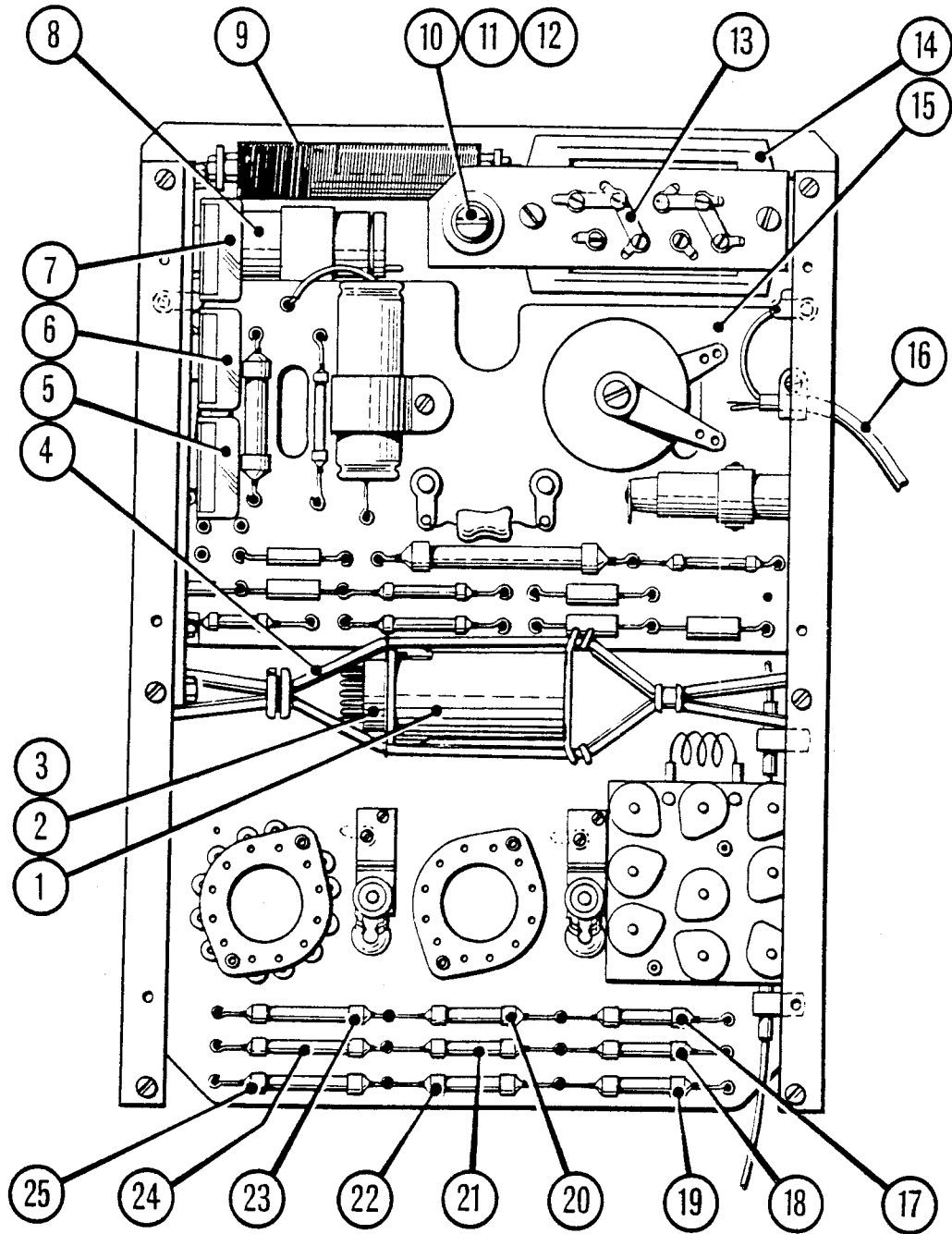
# PLATE 3

# CHASSIS ASSEMBLY REAR

<i>Item No.</i>	<i>Description</i>	<i>Circuit Ref.</i>	<i>Part No.</i>
1	Valve Can . . . . .		14779-A
2	Valve 13 D 8 (12AU7) . . . . .	V2	12241-39
3	Valve Holder . . . . .		13737-2
4	Valve Retaining Rubber . . . . .		11670-1
5	Potentiometer 25k $\Omega$ (a.c. Zero) . . . . .	RV4	10770-10
6	Potentiometer 500 $\Omega$ (Coarse Zero) . . . . .	RV2	10770-13
7	Potentiometer 1000 $\Omega$ (Sensitivity) . . . . .	RV1	10770-14
8	Capacitor 16 $\mu$ F Electrolytic 350V . . . . .	C10	12049-410
9	Rectifier ( $\frac{1}{2}$ A) . . . . .	MR2	11173-1
10	Fuse (1 A) . . . . .	FS1	12239-2
11	Fuse Body . . . . .		12049-89
12	Fuse Cap . . . . .		12049-88
13	Transformer Links . . . . .		13061-2
14	Mains Transformer . . . . .	T1	20705-B
15	Component Board Assembly See Page 22 for details . . . . .		40514-B
16	Mains Lead 6 ft. 6 ins. . . . .		PVC 21
17	Resistor 825k $\Omega$ $\pm$ 1% HSC . . . . .	R39	12049-169
18	Resistor 15k $\Omega$ $\pm$ 1% . . . . .	R2	12049-170
19	Resistor 1.5k $\Omega$ $\pm$ 1% . . . . .	R3	40062-23
20	Resistor 1M $\Omega$ $\pm$ 1% . . . . .	R21	40062-17
21	Resistor 50k $\Omega$ $\pm$ 1% HSC . . . . .	R7	40062-20
22	Resistor 150 $\Omega$ $\pm$ 1% HSC . . . . .	R4	40062-24
23	Resistor 500k $\Omega$ $\pm$ 1% HSC . . . . .	R20	40062-18
24	Resistor 100k $\Omega$ $\pm$ 1% HSC . . . . .	R8	40062-19
25	Resistor 16.6 $\Omega$ $\pm$ 1% HSC . . . . .	R5	12049-405
26	Valve Retaining Rubber . . . . .		11670-1

# CHASSIS ASSEMBLY REAR

# PLATE 3



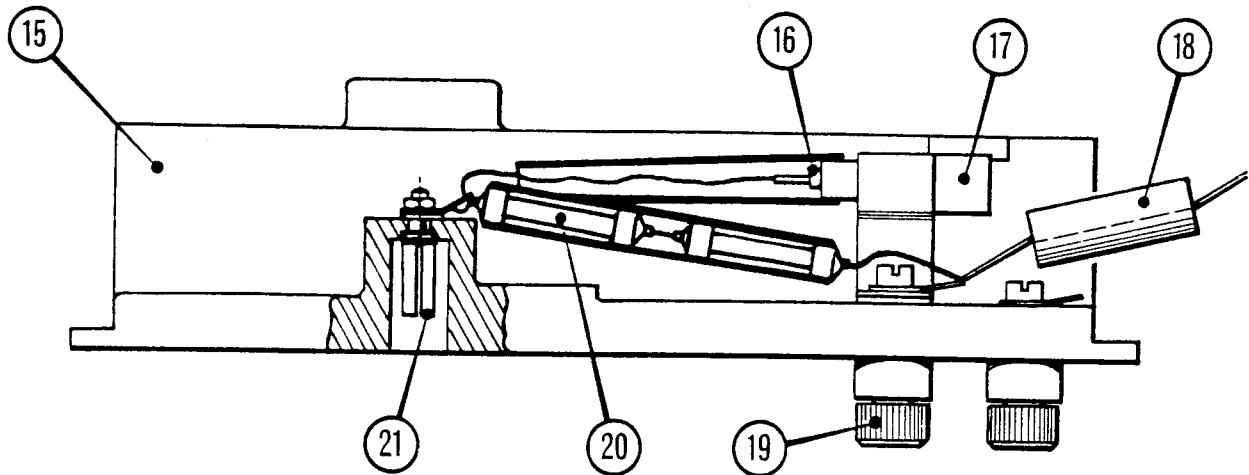
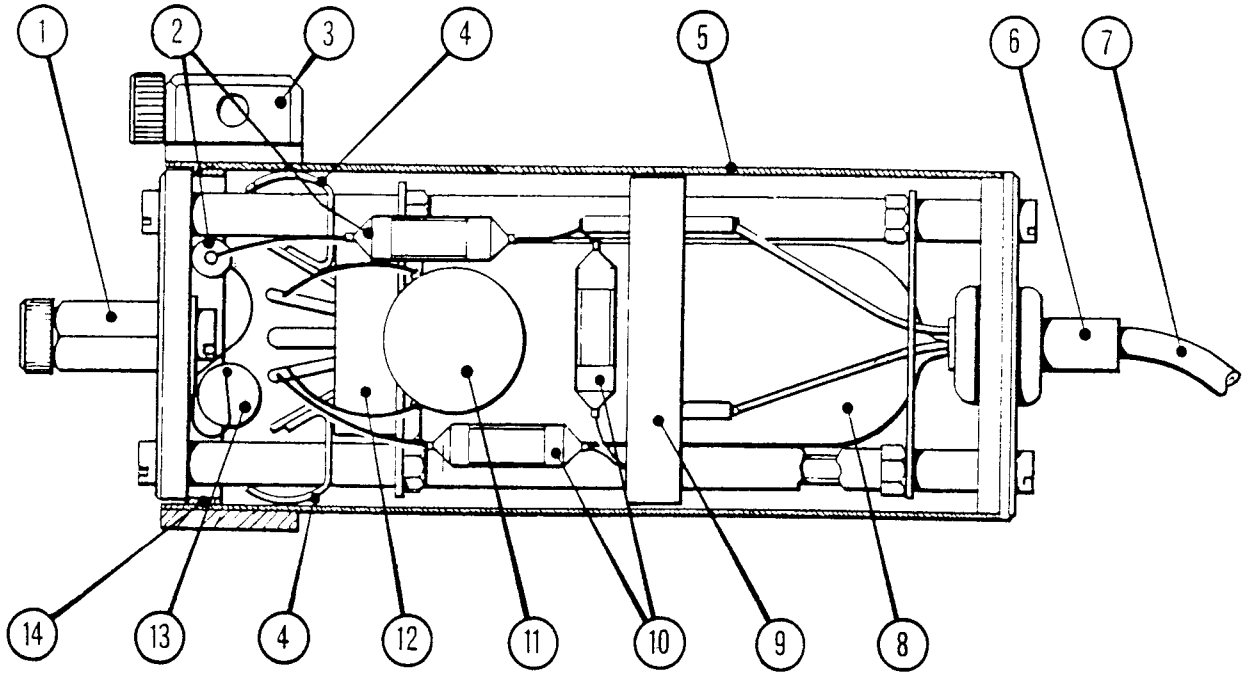
# PLATE 4 PROBE AND PROBE BOX ASSEMBLY

<i>Item No.</i>	<i>Description</i>	<i>Circuit Ref.</i>	<i>Part No.</i>
1	Terminal Block . . . . .		10507-3
2	Resistors (Matched Pair) Total $7M\Omega \pm 2\%$ HSC . .	R29 R30	12049-414
3	Contact Assembly . . . . .		10513-B
4	Spring Clip . . . . .		14777-2
5	Case . . . . .		14767-2
6	Rubber Sleeve . . . . .		10042-1
7	Lead . . . . .		PVC105
8	Valve Type D77 or 6AL5 . . . . .	V1	12241-5
9	Connection Block . . . . .		14771-A
10	Resistors (Matched Pair) Total $7.5M\Omega \pm 2\%$ HSC . . . . .	R31 R32	12049-413
11	Capacitor $0.01\mu F + 80\% - 20\%$ . . . . .	C4	12049-415
12	Valve Holder . . . . .		13738-3
13	Capacitor 470 pf . . . . .	C3	40030-4
14	Housing . . . . .		14766-2
15	Probe Box . . . . .		40045-B
16	Plug . . . . .		14782-2
17	Capacitor 3-5pf . . . . .	C1	14781-A
18	Capacitor $0.05\mu F/500V$ . . . . .	C2	12049-557
19	Terminal Screw . . . . .		10686-A
20	Resistor $5.2M\Omega \pm 1\%$ (Matched Pair) . . . . .	R1	12049-417
21	Socket . . . . .		11121-2



# PROBE AND PROBE BOX ASSEMBLY

PLATE 4



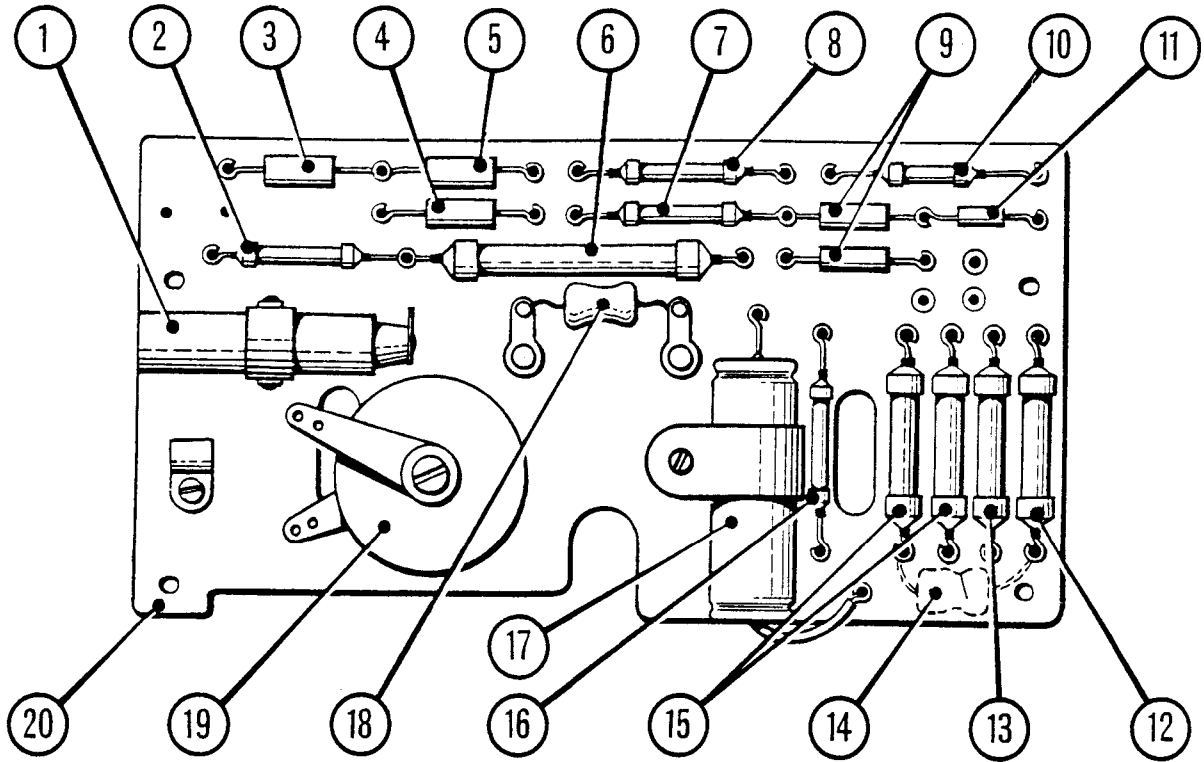
# PLATE 5

# COMPONENT BOARD ASSEMBLY

<i>Item No.</i>	<i>Description</i>	<i>Circuit Ref.</i>	<i>Part No.</i>
1	Capacitor 0.5 $\mu$ F .. .. .	C8	12049-144
2	Resistor (Supp.) 50k $\Omega$ to 250k $\Omega$ HSC (Selected on Test) ..	R33	
3	Resistor 3 $\Omega$ $\pm$ 5% VIT .. .. .	R47	12049-406
4	Resistor 75 $\Omega$ $\pm$ 5% VIT .. .. .	R51	12049-408
5	Resistor 18 $\Omega$ $\pm$ 5% VIT .. .. .	R48	12049-407
6	Resistor 15M $\Omega$ $\pm$ 2% HSC .. .. .	R46	12049-211
7	Resistor 450 $\Omega$ $\pm$ 5% HSC .. .. .	R44	12049-409
8	Resistor 100k $\Omega$ $\pm$ 1% HSC .. .. .	R42	12049-314
9	Capacitor 0.04 $\mu$ F 200V .. .. .	C9 C5	12049-402
10	Resistor 50k $\Omega$ $\pm$ 1% HSC .. .. .	R41	12049-315
11	Resistor 9.1k $\Omega$ $\pm$ 5% Insulated .. .. .	R34	12049-192
12	Resistor 20k $\Omega$ $\pm$ 1% HSC .. .. .	R43	30019-10
13	Resistor 80k $\Omega$ $\pm$ 1% HSC .. .. .	R45	12049-416
14	Capacitor 0.1 $\mu$ F 250V Supplementary. .. .. .		40071-9
15	Resistor 500k $\Omega$ $\pm$ 1% HSC .. .. .	R35 R37	12049-210
16	Resistor 750 $\Omega$ $\pm$ 10% .. .. .	R36	12049-532
17	Capacitor 0.1 $\mu$ F .. .. .	C11	12049-343
18	Capacitor 0.1 $\mu$ F 250V .. .. .	C 6	40071-9
19	Rectifier .. .. .	MR1	13697-1
20	Component Board (Bare) .. .. .		20978-A

# COMPONENT BOARD ASSEMBLY

PLATE 5



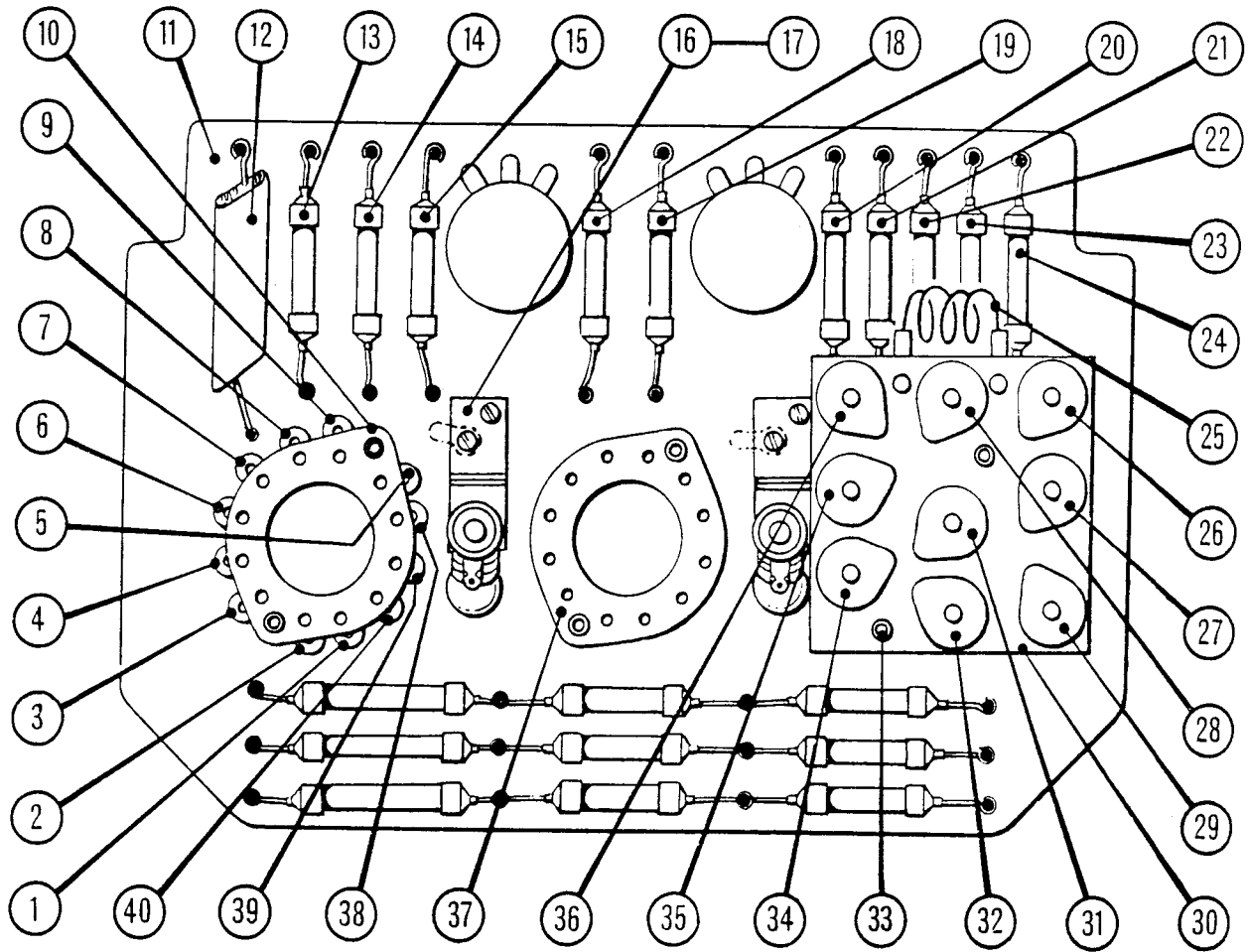
# PLATE 6

# SWITCH BOARD ASSEMBLY

<i>Item No.</i>	<i>Description</i>	<i>Circuit Ref.</i>	<i>Part No.</i>
1	Resistor 1.4kΩ ± 2.5% VIT	R53	20104-2
2	Resistor 3kΩ ± 2.5% VIT	R52	20104-3
3	Resistor 3.16Ω ± 2.5% VIT	R63	20104-4
4	Resistor 1.31Ω ± 2.5% VIT	R62	20104-5
5	Resistor 2.93Ω ± 2.5% VIT	R59	20104-9
6	Resistor 2.07Ω ± 2.5% VIT	R60	20104-6
7	Resistor 9.6Ω ± 2.5% VIT	R57	20104-13
8	Resistor 28.6Ω ± 2.5% VIT	R56	20104-12
9	Resistor 36.8Ω ± 2.5% VIT	R55	20104-11
10	Load Switch	SE	10714-3
11	Switch Board (Tagged)		20977-A
12	Capacitor 4000pF 350V	C7	12049-629
13	Resistor 330kΩ ± 1% HSC	R19	12049-173
14	Resistor 825kΩ ± 1% HSC	R22 R39	12049-169
15	Resistor 25kΩ to 100kΩ HSC Supplementary	R38	-
16	Panel Lamp 6.3V 0.3A	ILP1 ILP2	50010-14
17	Lampholder		40071-11
18	Resistor 5MΩ ± 1% HSC	R40	50010-27
19	Resistor 8.25MΩ ± 1% HSC	R25	12049-174
20	Resistor 1.1MΩ ± 1% HSC	R24	12049-167
21	Resistor 550kΩ ± 1% HSC	R23	12049-168
22	Resistor 1.93MΩ ± 1% HSC	R28	12049-164
23	Resistor 250kΩ ± 1% HSC	R27	12049-165
24	Resistor 615kΩ ± 1% HSC	R26	12049-166
25	Wound Resistance 0.25Ω	R9	10725-2
26	Wound Bobbin 7.5kΩ ± 0.5%	R18	30006-FE
27	Wound Bobbin 750Ω ± 0.5%	R16	30006-GE
28	Wound Bobbin 1.5kΩ ± 0.5%	R17	30006-GD
29	Wound Bobbin 75Ω ± 0.5%	R14	30006-MC
30	Bobbin Board (Bare)		10718-2
31	Wound Bobbin 150Ω ± 0.5%	R15	30006-M
32	Wound Bobbin 15Ω ± 0.5%	R13	30006-Q
33	Multiplier Switch (Located below Bobbin Board)	SC	10713-3
34	Wound Bobbin 7.5Ω ± 0.5%	R12	30006-KC
35	Wound Bobbin 1.5Ω ± 0.5%	R11	30006-JD
36	Wound Bobbin 0.75Ω ± 0.5%	R10	30006-HE
37	Range Switch	SD	20099-3
38	Resistor 0.53Ω ± 2.5% VIT	R61	20104-10
39	Resistor 15Ω ± 2.5% VIT	R58	20104-8
40	Resistor 500Ω ± 2.5 VIT	R54	20104-7

# SWITCH BOARD ASSEMBLY

PLATE 6



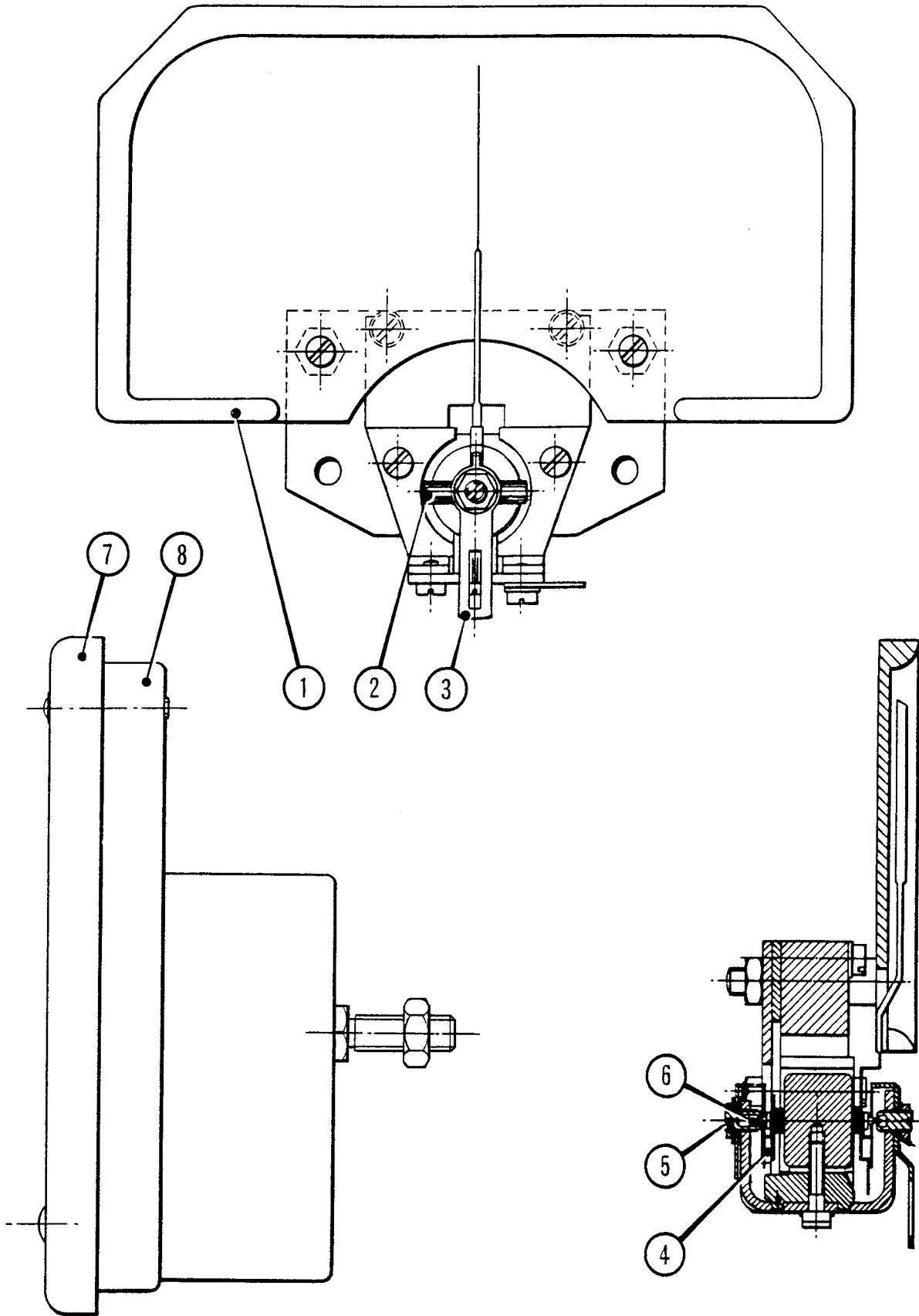
# PLATE 7

# MOVEMENT ASSEMBLY

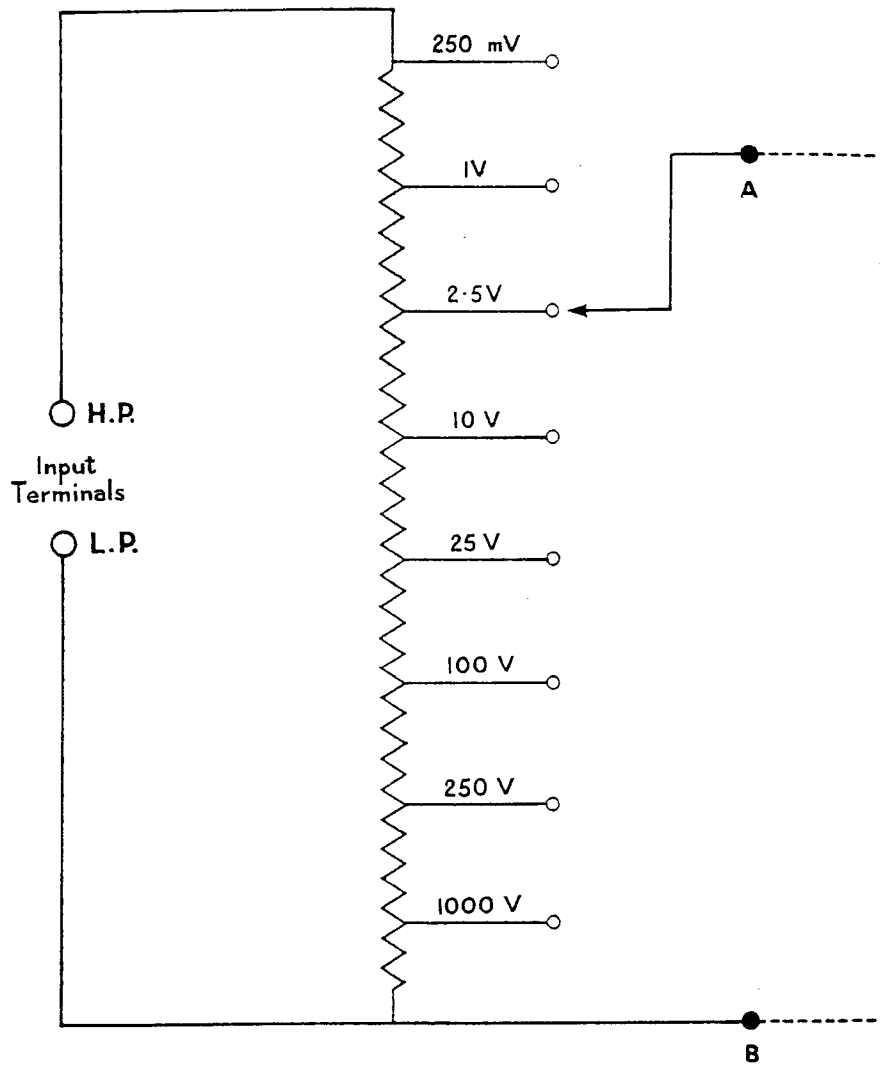
<i>Item No.</i>	<i>Description</i>	<i>Part No.</i>
1	Scale Plate . . . . .	14824-2
2	Moving Coil Assembly . . . . .	21124-D
3	Zero Adjuster . . . . .	15436-1
4	Hair Springs (2 off) . . . . .	10076-16
5	Sprung Jewel Assembly (2 off) . . . . .	10184-A
6	Pivots (2 off) . . . . .	10158-4
7	Case Front (Not Illustrated) . . . . .	40537-2
8	Rear Case (Not Illustrated) . . . . .	40538-B
9	Movement Mounting Pillars (Not Illustrated) . . . . .	10077-4
10	Movement Glass (Not Illustrated) . . . . .	12730-2

# MOVEMENT ASSEMBLY

PLATE 7



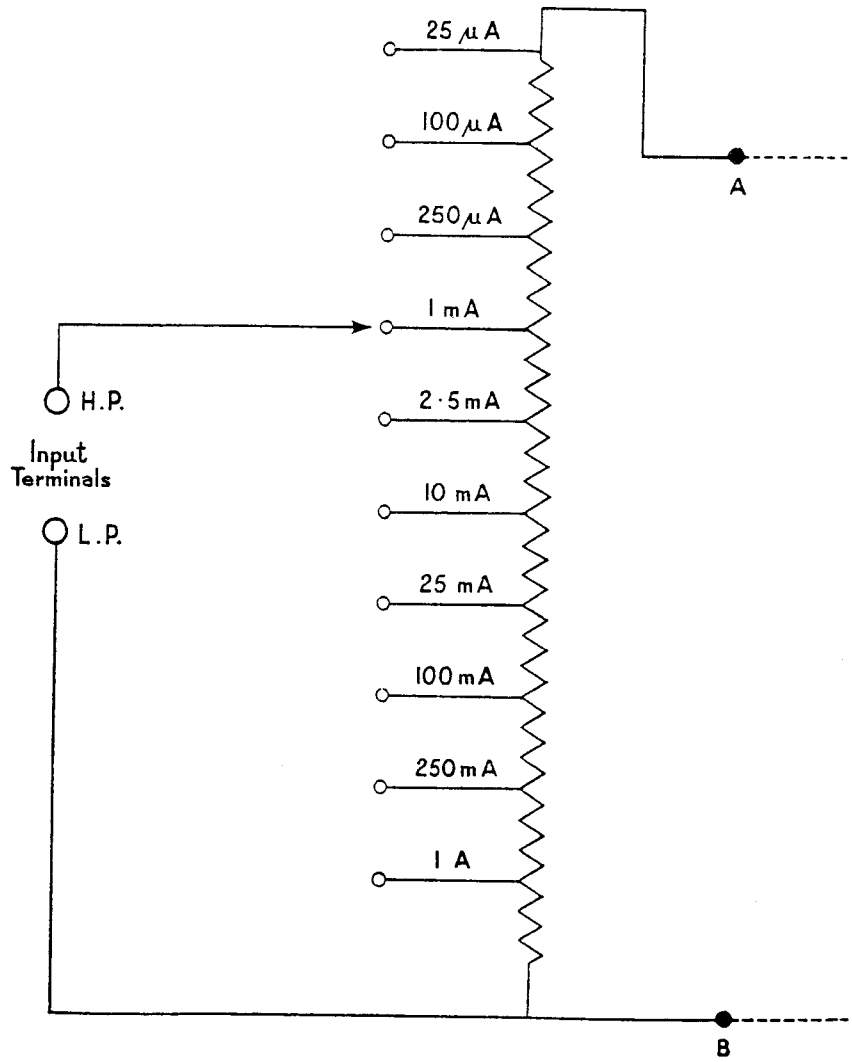
# PLATE 8



D.C. VOLTAGE MEASURING CIRCUIT

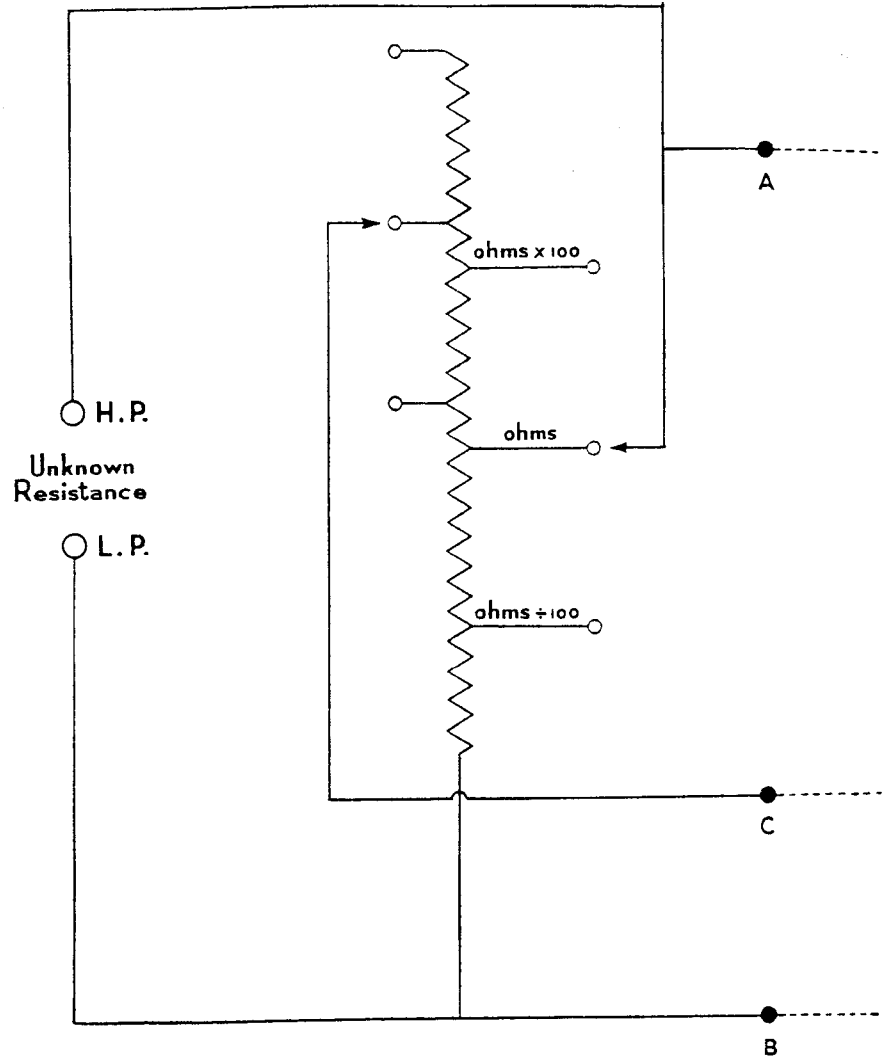


# PLATE 9



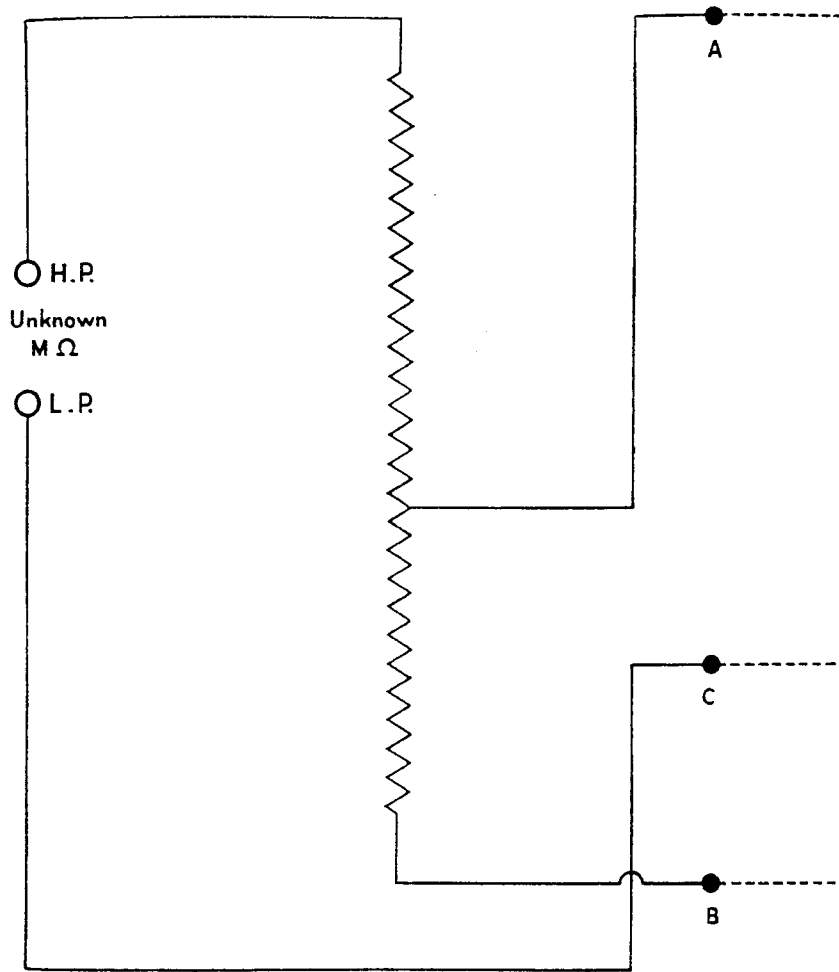
D.C. CURRENT MEASURING CIRCUIT

# PLATE 10



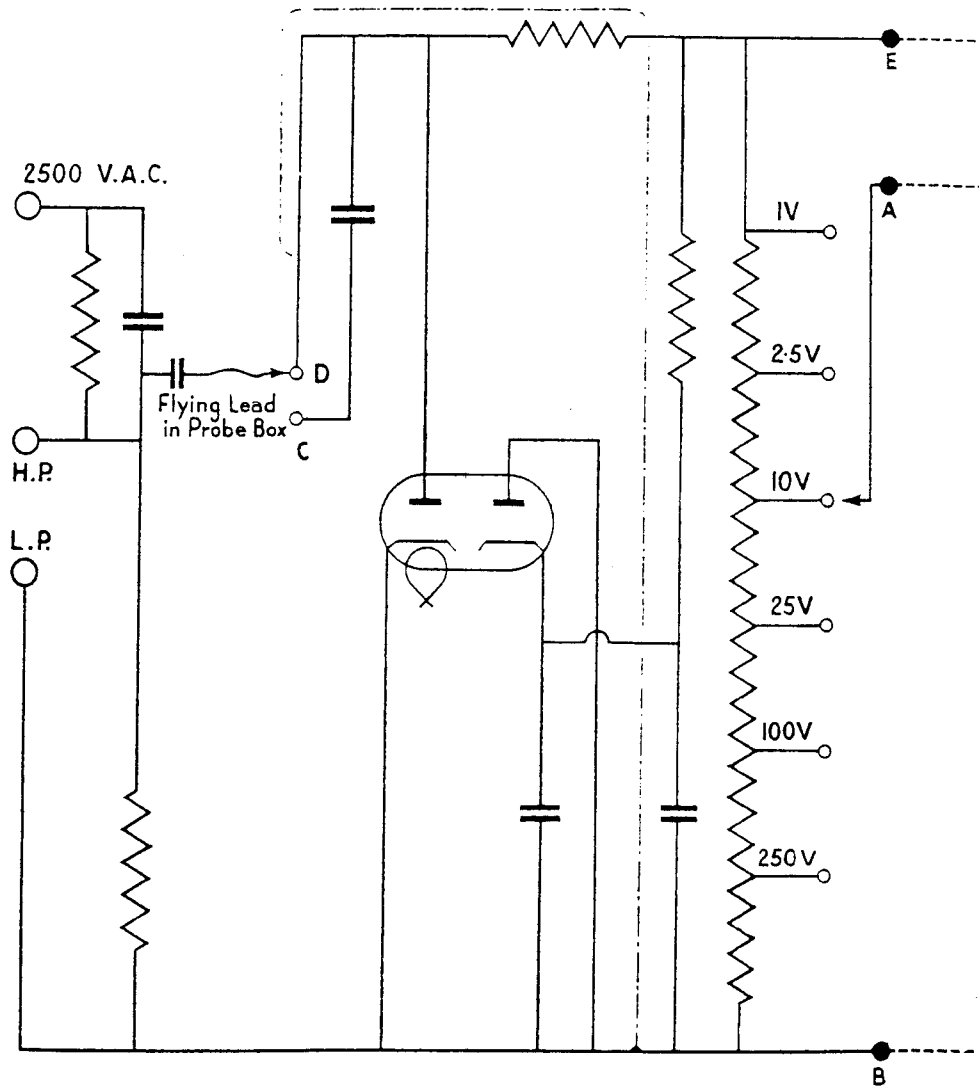
OHMS MEASURING CIRCUIT

# PLATE 11



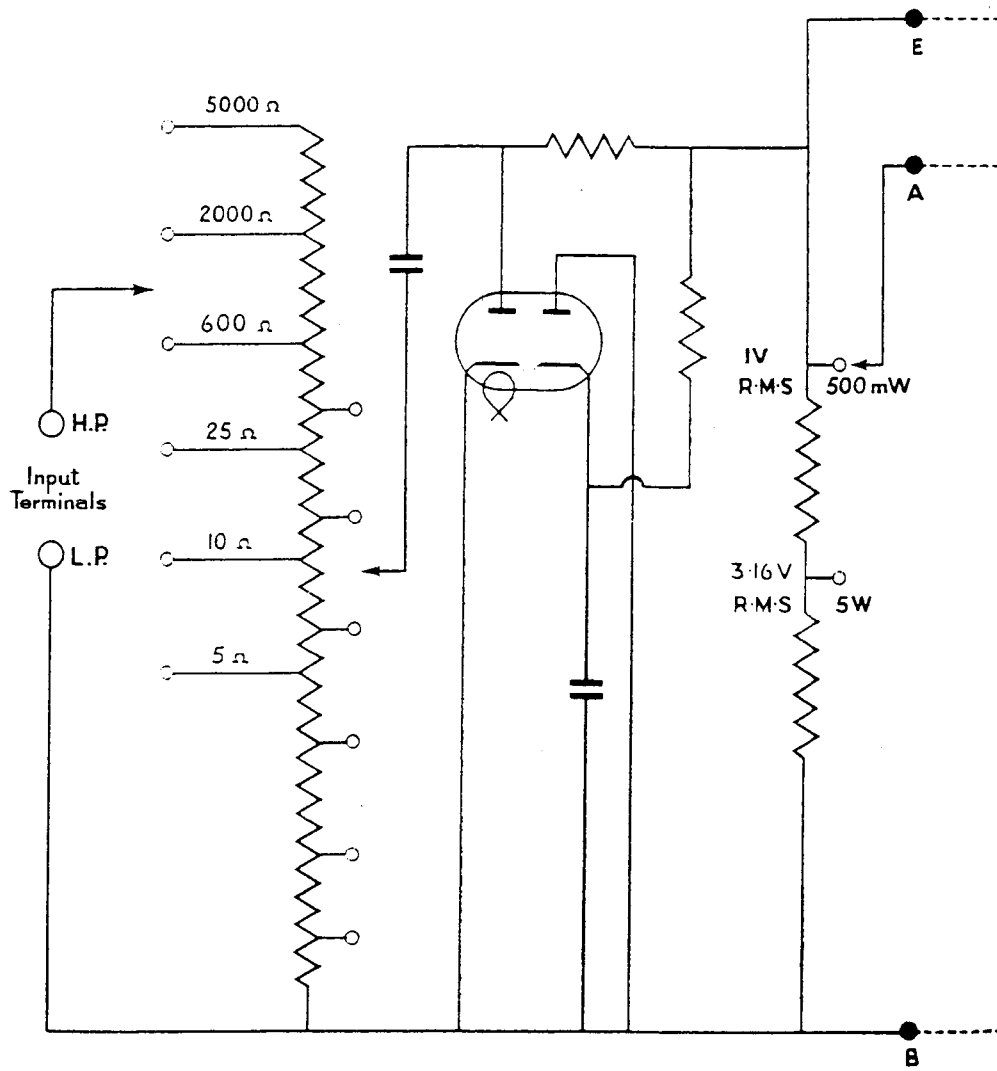
MEGOHMS MEASURING CIRCUIT

# PLATE 12



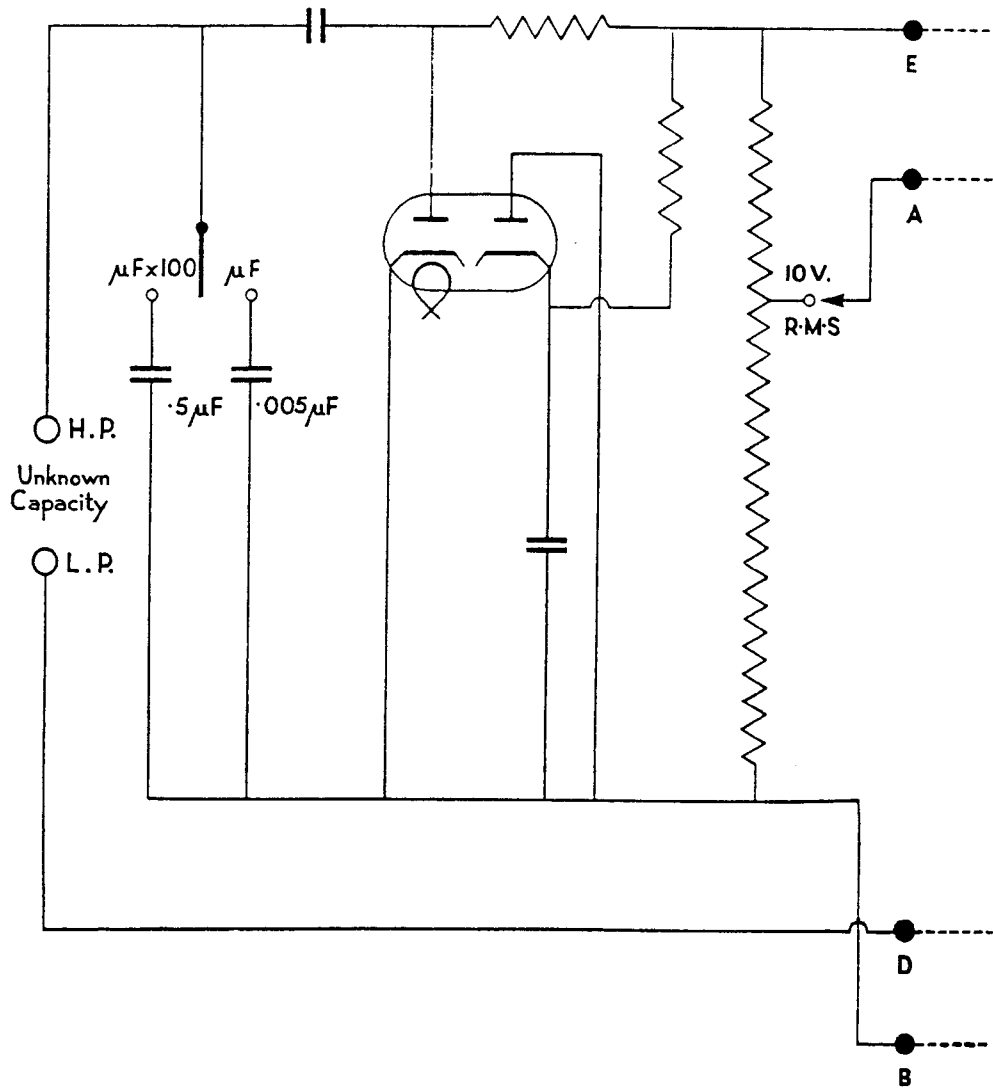
A.C. VOLTAGE MEASURING CIRCUIT

# PLATE 13



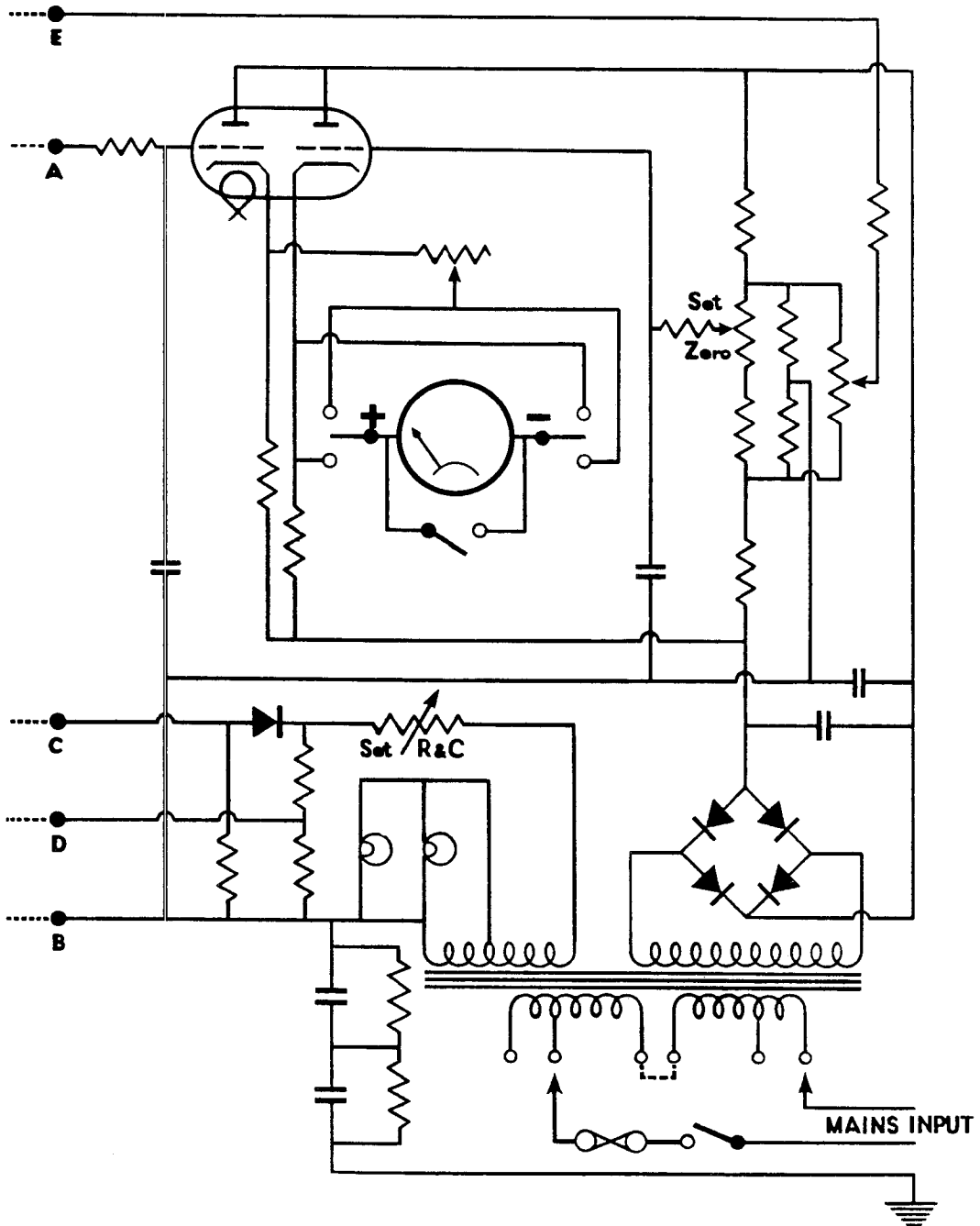
WATTAGE MEASURING CIRCUIT

# PLATE 14



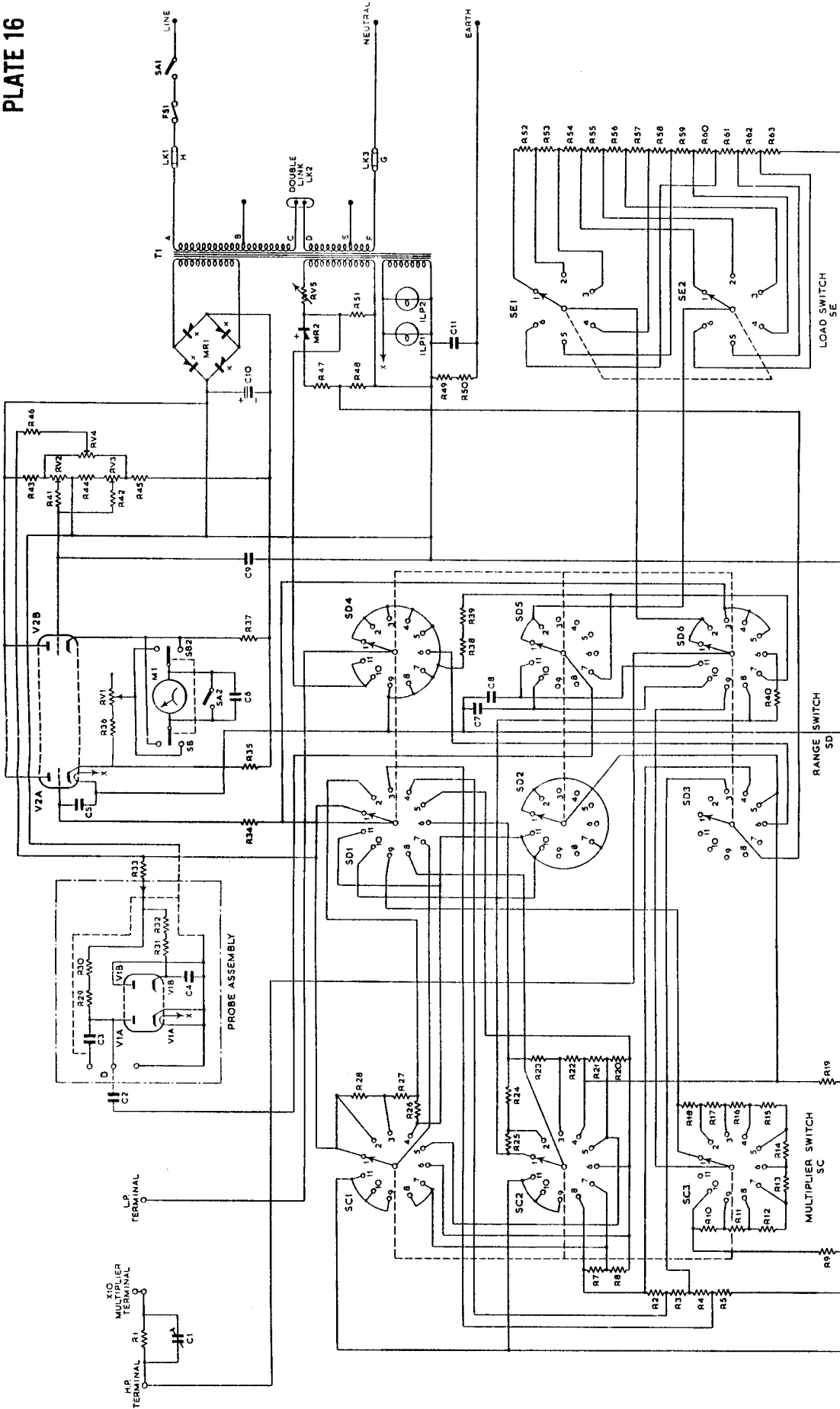
CAPACITANCE MEASURING CIRCUIT

# PLATE 15



BASIC D.C. MILLIVOLTMETER DIAGRAM

PLATE 16



CIRCUIT DIAGRAM COMPLETE INSTRUMENT



# TABLE OF COMPONENTS

Circuit Reference	Description	Remarks	Circuit Reference	Description	Remarks
R1	5.2M $\Omega$	$\pm 1\%$	R49	5M $\Omega$	$\pm 20\%$
R2	15k $\Omega$	$\pm 1\%$	R50	5M $\Omega$	$\pm 20\%$
R3	1.5k $\Omega$	$\pm 1\%$	R51	75 $\Omega$	$\pm 5\%$
R4	150 $\Omega$	$\pm 1\%$	R52	3k $\Omega$	$\pm 2.5\%$
R5	16.6 $\Omega$	$\pm 1\%$	R53	1.4k $\Omega$	$\pm 2.5\%$
R6	NOT USED		R54	500 $\Omega$	$\pm 2.5\%$
R7	50k $\Omega$	$\pm 1\%$	R55	36.8 $\Omega$	$\pm 2.5\%$
R8	100k $\Omega$	$\pm 1\%$	R56	28.6 $\Omega$	$\pm 2.5\%$
R9	0.25 $\Omega$	$\pm 0.5\%$	R57	9.6 $\Omega$	$\pm 2.5\%$
R10	0.75 $\Omega$	$\pm 0.5\%$	R58	15 $\Omega$	$\pm 2.5\%$
R11	1.5 $\Omega$	$\pm 0.5\%$	R59	2.93 $\Omega$	$\pm 2.5\%$
R12	7.5 $\Omega$	$\pm 0.5\%$	R60	2.07 $\Omega$	$\pm 2.5\%$
R13	15 $\Omega$	$\pm 0.5\%$	R61	0.53 $\Omega$	$\pm 2.5\%$
R14	75 $\Omega$	$\pm 0.5\%$	R62	1.31 $\Omega$	$\pm 2.5\%$
R15	150 $\Omega$	$\pm 0.5\%$	R63	3.16 $\Omega$	$\pm 2.5\%$
R16	750 $\Omega$	$\pm 0.5\%$			
R17	1.5k $\Omega$	$\pm 0.5\%$			
R18	7.5k $\Omega$	$\pm 0.5\%$			
R19	330k $\Omega$	$\pm 1\%$	C1	3-5pF	Preset
R20	500k $\Omega$	$\pm 1\%$	C2	0.05 $\mu$ F	500V
R21	1M $\Omega$	$\pm 1\%$	C3	470pf	
R22	825k $\Omega$	$\pm 1\%$	C4	0.01 $\mu$ F	Disc
R23	550k $\Omega$	$\pm 1\%$	C5	0.04 $\mu$ F	200V
R24	1.1M $\Omega$	$\pm 1\%$	C6	0.1 $\mu$ F	250V
R25	8.25M $\Omega$	$\pm 1\%$	C7	4000pf	350V
R26	615k $\Omega$	$\pm 1\%$	C8	0.5 $\mu$ F	
R27	250k $\Omega$	$\pm 1\%$	C9	0.04 $\mu$ F	200V
R28	1.93M $\Omega$	$\pm 1\%$	C10	16 $\mu$ F	350V
R29	7M $\Omega$ total	$\pm 2\%$	C11	0.1 $\mu$ F	1000V
R30			V1	D77 or 6AL5	
R31	7.5M $\Omega$ total	$\pm 2\%$	V2	13D7 or 12 AU7	
R32			ILP1	6.3V	
R33	50k $\Omega$ -250k $\Omega$		ILP2	6.3V	
R34	9.1k $\Omega$	$\pm 5\%$	MR1	F.W. Bridge	
R35	500k $\Omega$	$\pm 1\%$	MR2	1/6 A	
R36	750 $\Omega$	$\pm 10\%$	M1	32-34 $\mu$ A 2,800 $\Omega$ approx.	
R37	500k $\Omega$	$\pm 1\%$	T1	Mains Transformer	
R38	25k-100k		RV1	1k $\Omega$ (sensitivity)	
R39	825k $\Omega$	$\pm 1\%$	RV2	500 $\Omega$ (coarse zero)	
R40	5M $\Omega$	$\pm 1\%$	RV3	100 $\Omega$ (instrument zero)	
R41	50k $\Omega$	$\pm 1\%$	RV4	25k $\Omega$ (AC zero)	
R42	100k $\Omega$	$\pm 1\%$	RV5	15 $\Omega$	
R43	20k $\Omega$	$\pm 1\%$	FS1	1A	
R44	450 $\Omega$	$\pm 5\%$	SA	On/Off	
R45	80k $\Omega$	$\pm 1\%$	SB	Reverse/Normal	
R46	15M $\Omega$	$\pm 2\%$	SC	Multiplier switch	
R47	3 $\Omega$	$\pm 5\%$	SD	Range Switch	
R48	18 $\Omega$	$\pm 5\%$	SE	Load Switch	

## RANGE SWITCH

Position	Range
1	500mW
2	5W
3	$\Omega \pm 100$
4	$\Omega$
5	$\Omega \times 100$
6	M $\Omega$
7	V a.c.
8	V d.c.
9	Amps d.c.
10	$\mu$ F
11	$\mu$ F $\times 100$

## MULTIPLIER SWITCH

Position	Range
1	250mV/25 $\mu$ A
2	1V ac/dc and 100 $\mu$ A d.c.
3	2.5V ac/dc 250 $\mu$ A d.c.
4	10V ac/dc 1mA d.c.
5	25V ac/dc 2.5mA d.c.
6	100V ac/dc 10mA d.c.
7	250V ac/dc 25mA d.c.
8	1000V dc 100mA dc
9	250mA dc
10	1A dc
11	Blank

## LOAD SWITCH

Position	Range
1	5000 $\Omega$
2	2000 $\Omega$
3	600 $\Omega$
4	25 $\Omega$
5	10 $\Omega$
6	5 $\Omega$