AVO
VALVE CHARACTERISTIC METER
MARK IV

SERVICE MANUAL

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CONTENTS

CHAPTER 1

MAINTENANCE INFORMATION

CONTENTS

NOTE: On receipt of an instrument for repair, the setting of the Coarse Mains Voltage Control should be noted and set to the same position prior to return to the customer.

SECTION 1 – TEST EQUIPMENT REQUIRED

(a) AVO Electronic Testmeter (or equivalent dc mean valve voltmeter).

(b) Valve CV491 (Standardised for Mutual Conductance at 16mA anode current).

(c) Model 7 or Model 8 AvoMeters (3).

(d) Power Valve capable of passing 100mA anode current (KT33C).

(e) Power Rectifier type U52 or similar.

(f) Resistor 1MΩ ±5%

SECTION 2 – FAULT FINDING AND SERVICING NOTES

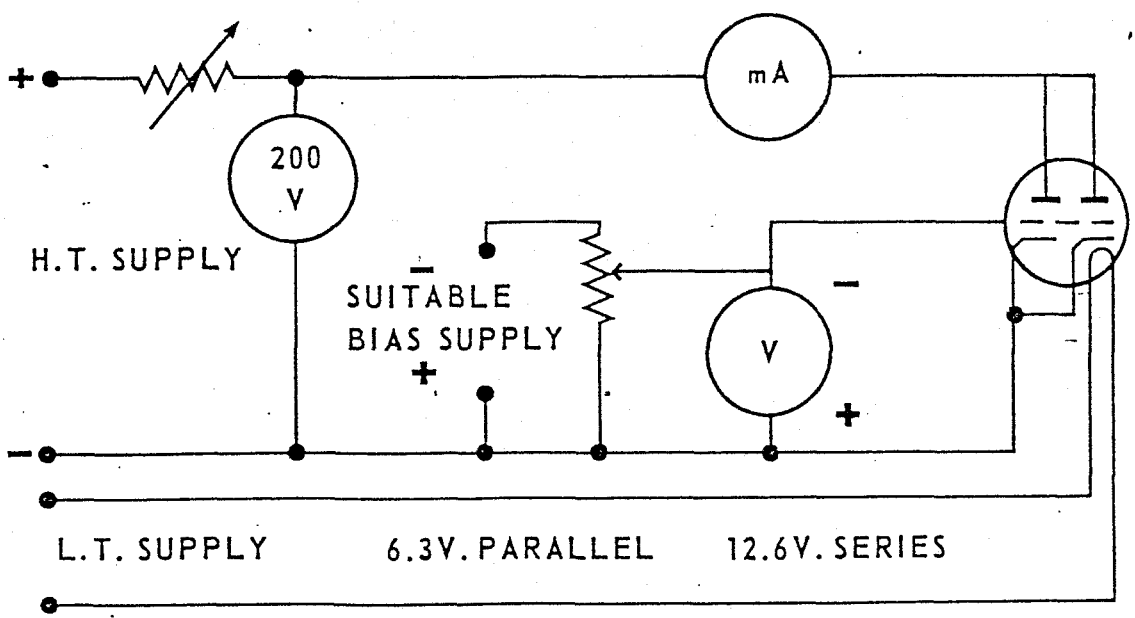
(See WARNING on page 2)

NOTE: All measurements and tolerances stated do not include those of the testing instrument, and where necessary, these should be ascertained, particularly before commencement of the calibration procedure. Where possible the recommended instruments should be employed.

If, at any time, it is necessary to displace wiring within the instrument, great care must be taken to ensure that it is replaced in its original position.

To Obtain Standard Figures for a Valve Using dc Supplies

Using the recommended AvoMeters, the valve should be connected as shown below:–



If unable to use the recommended meters ensure that those used are of sub-standard accuracy, the current meter having a maximum voltage drop of 100mV and preferably scaled 0–25mA and the voltmeters a sensitivity of 1000Ω/V. If rectified ac is used for the ht supply, it is essential that steps are taken to ensure that the supply circuit is adequately smoothed (the Solartron Varipack is a suitable source). The bias supply should be obtained from a suitable battery (note polarity of connection). The heater supply for the valve may be ac or dc, but must be within ±5% of the rated voltage.

(a) Set the grid bias until voltmeter reads 9V and note anode current.

(b) Adjust the ht supply to 200V, then by means of successive adjustments of the bias and ht voltage controls, set the anode current at 16mA (the anode voltmeter must read 200V). Note the new grid bias reading.

(c) The Standardised slope for the valve can now be obtained from:– The difference between the two anode current readings (i.e. 1mA) over the difference between the two grid voltage readings:–

$$\frac{Ia_2 - Ia_1}{Vg_1 - Vg_2}$$

The result will generally be between 4 and 5mA/V. For greater accuracy it is suggested that readings of grid voltage be plotted against values of anode current between 10 and 20mA and the slope taken from the curve at 16mA.
The valve should now be labelled as follows:–

Va	=	200V dc
Ia	=	16mA dc
Vg	=	.....
Slope	=	mA/V
Date	=	.....
		CV491

The valve should be re-standardised daily when in use.

To Check the Accuracy of Instrument

(a) With Circuit Selector switch set to check Cold, Leakage switch to ~ position, and Meter switch to a current range (Ia)*, connect instrument to suitable 50 c/s supply of good wave form and with coarse mains tapping appropriately set, adjust Set ~ control until meter needle reads in the Set ~ zone.

(b) The unloaded rms heater volts are not critical and are arranged approximately to compensate for the voltage drop due to the heater current likely to flow and will normally be slightly higher than the reading of the heater voltage switch. For example a nominal 5V heater voltage would read between say 5.3 and 5.7 volts on open circuit.

**WARNING:– If Meter Switch is set to mA/V positions or D/R positions 180 or 120mA a false setting of all instrument voltages will result.*

(c) The unloaded anode volts measured with a standardised Model 8 or Model 7 AvoMeter should be such that the r.m.s. reading on the Meter equals half the calibration on the panel of the Instrument +6 −2%. −IV (+6 −3% −IV on instruments using two diodes in series.

(d) The screen voltages should be the same as the anode voltages.

(e) The grid voltage should be such that when measured with a standardised Electronic Testmeter, or other standard d.c. mean Valve Voltmeter, the voltage measured between grid and cathode (this measurement must be made with the link open and the meter switch set to 100mA) should be such that the mean d.c. voltage equals the calibrated voltage on the panel of the instrument x 0.52 i.e. 101V negative bias should read, (with the link open) 52.5V mean d.c.

(f) With fixed grid voltage control set to 0-5, the incremental grid voltage control to −IV and the mA/V on 1-10 range, switch the meter selector switch to the 2.5mA position. The voltage measured between grid and cathode should be 0.52V ±2% ±0.1V. On rotating the meter switch to the mA/V position, this reading should fall to zero ±20mV. Close link.

(g) With the Instrument working under the above normal tolerances with the grid link closed, and presuming that a valve has been standardised on d.c., then with the anode screen and negative grid voltages set to correspond to the equivalent of a d.c. voltage, the anode current of the valve should match to within ±10%, the absolute anode current measured with pure d.c. anode, screen and grid voltages and an a.c. heater voltage.

(h) The mutual conductance of the valve should also compare with the mutual conductance obtained from the curve of a valve suitably standardised. Set the anode and/or screen voltages of the instrument to correspond to the voltages used when standardising the valve, then at any anode current the mutual conductances should compare to within ±5%. This tolerance may widen slightly on very high slope short grid base valves.

(j) For an additional check on anode current, the anode current as read on the meter of the instrument may be compared with the d.c. current indicated on a standardised AvoMeter set to a suitable d.c. range inserted in a series in the anode link. The anode current read on the movement of the instrument should then be equal to twice the anode current read on the external d.c. AvoMeter ±5%.

(k) With the instrument set for testing a pentode and a suitable output pentode (KT.33C) inserted and controls adjusted for an anode current of 80mA, the valve should not show any signs of oscillation.

(m) With the instrument set up for electrode insulation and a 1 megohm resistor connected across H/C and A/C, then with the requisite settings for H/C insulation (hot) and A/G insulation (cold), the meter should indicate 1 megohm ±10%.

Removal of the Instrument from its Case (See WARNING on page 2)

To facilitate servicing or calibration of the instrument, it is necessary to remove the back and side plates from the instrument case. This is accomplished by the removal of four instrument headed screws from the side plates and six round-headed screws from the back plate. The valve panel is then readily accessable.

Simple Faults

SYMPTOMS	POSSIBLE FAULT	ACTION
(a) No dial light indication.	No mains input. Dial light bulb burnt out.	Check mains connector. Replace LP1
(b) No dial light indication or meter deflection on set ~ setting of Circuit Selector	Fuse blown	Check mains voltage selector and replace fuse
(c) No indication of meter current	No anode volts at valve pin.	Check that links A_1 and A_2 are tight and making firm contact.
(d) No indication of meter current and protective relay operates when testing tetrodes or pentodes.	No anode volts at valve pin but screen volts present.	Check that links A_1 and A_2 are tight and making firm contact.

Adjustment of Protective Relay

The relay should seldom require attention, but if for any reason parts are replaced, the adjustment is simple, it only being necessary to position two 4BA screws. It should be noted that the mains voltage appears on these screws, therefore great care should be exercised when making any adjustments. The bobbins if replaced, should be mounted such, that the flux which they produce is additive.

Operational limits are as follows:—

(a) Anode overload—Relay should operate on 100V short circuit.

(b) Screen overload—Relay should operate on 100V short circuit

(c) The relay should not operate when checking a 180mA rectifier.

Faulty action of relay may be due to a damaged Rectifier. This usually results in the relay buzzing.

Servicing the Valve Holder Panel

The Valve Holder Panel is connected electrically to the control panel by means of a 10-way tagboard.

The wiring of the valve holders on the panel is in the form of nine separate loops, all pins comprising a loop and linking in roller 1 of the Roller Selector Switch. This form of loop connec-

tion is used likewise for pins 2-9, all nine circuits approximating in length and following a similar route around the panel. These loops are loaded with beads of Ferroxcube which sufficiently damp the loop to prevent the valve under test breaking into parasitic oscillation. Ferroxcube is also used on leads feeding the Roller Selector Switch as a further precaution against oscillation. Plate 4 shows the route followed by the wiring, also the position of the Ferroxcube beads.

Where it is necessary to replace valve holders, those fitted to the panel with nuts and bolts are easily removable. When removing riveted valve holders, care should be taken to ensure that rivets are drilled out from the underside of the panel. All wire must be replaced in its original position.

Removal and Replacement of Knobs and Setting of Knob Skirts

To remove any knob, remove 6BA screw and spring washer. To remove knob spindle and skirt, release locking pin. The switch nut is now accessible. Reverse procedure to replace. To adjust skirt, slacken lock nut, rotate skirt to desired position and re-tighten lock nut.

SECTION 3 – MOVEMENT SERVICING

Reference to the parts lists facing the illustration will show that the movement 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 replacing 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 to a sensitivity of 22.2μA at the 1mA/V position.

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.

NOTE: 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 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 plate 5 items 1–6 are therefore not applicable to 'T' type movements.

Moving Coil Will Not Move

If the instrument is subjected to the 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.

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 scale plate should be bent away from the pointer to give it adequate clearance.

The Movement Needle Tends to Stick at 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 (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 must always be replaced.

NOTE: The two connections to the meter movement should always be shorted out when the movement is removed from the instrument for repair or return to the manufacturer. This damps the movement and reduces the risk of further damage.

SECTION 4 - VOLTAGE CHECKS WITH NO VALVE UNDER TEST

Connect the instrument, correctly* set up as detailed in Chapter 2 to a known 220/230V

*See Warning on Page 5.

50 c/s supply, ensuring that the mains 'ON/OFF' switch is in the 'OFF' position. Switch on and adjust coarse mains tapping and/or 'SET~' switch until meter reads in the centre of the ~ zone. Set the Circuit Selector to TEST and proceed to check the relevant electrode voltages as follows:–

Heater Voltages

(a) Connect the AvoMeter, switched to its ac voltage ranges, between H+ and H– sockets on top cap connector panel.

(b) Switch on and rotate the Heater Voltage switch through the full range of values, the external meter being set to the appropriate voltage range as required.

(c) The heater voltage reading on the meter should conform to the voltage limits shown in the following table.

Due allowance must be made for the limits of accuracy of the measuring instrument for each particular reading:–

NOMINAL VOLTS	ACTUAL AC VOLTS	LIMITS	
		MIN.	MAX.
2	2.3	2.2	2.4
5	5.5	5.3	5.7
10	10.3	10.0	10.6
20	20.6	20.0	21.1
40	41.2	40.4	42
117.5	121.4	118.7	124.1

(d) Switch off and remove meter.

Anode Voltages

(a) Set the mains 'ON/OFF' switch to the 'OFF' position and connect the AvoMeter, set to its dc voltage range, between A_1 and C sockets on the top cap selector panel.

(b) Switch on and rotate the 'Anode Voltage' switch through successive positions, the meter being set to the appropriate range as required.

(c) The meter readings should be 0.5 x the voltage indicated by the 'Anode Voltage' switch –2 +6% +0 –IV (–3 +6% +0 –IV on instruments using two diodes in series).

Due allowance must be made for the limits of accuracy of the measuring instrument for each particular reading

(d) Switch off and remove the meter.

Screen Voltages

(a) Connect the AvoMeter set to its dc voltage range, between S and C on the top cap selector panel ensuring that the mains 'ON/OFF' switch is in the 'OFF' position.

(b) Switch on and rotate the screen voltage switch through successive positions, the external meter being set to the appropriate range as required.

(c) The meter readings obtained should be 0.5 x the voltage indicated by the 'Screen Voltage' switch –2 +6% +0 –IV (–3 +6% +0 –IV on instruments employing two diodes in series).

Due allowance must be made for the limits of accuracy of the measuring instrument for each particular reading.

(d) Switch off and remove the meter.

CIRCUIT CHANGES

Due to production changes and the availability of rectifiers etc., a number of changes have been made to the Valve Characteristic Meter Mk. IV. Plate 11 shows the circuit diagram of the latest instrument and it is recommended that instruments are modified to this circuit. The Table of component changes lists all modifications which have been incorporated.

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.

CHAPTER 2

SETTING-UP PROCEDURE

CONTENTS

SECTION 1 – TEST EQUIPMENT REQUIRED

(a) Avo Electronic Testmeter (or equivalent dc mean Valve Voltmeter).

(b) AC Voltmeter (not greater than 200Ω/V) standardised at 220V.

NOTE: The Electronic Testmeter should be standardised at the appropriate voltages before making any adjustment mentioned in the following paragraphs.

WARNING

It is wise to ensure that the mains voltage does not change during the following test. A stabilised supply is not recommended due to 3rd and 5th harmonic waveform distortion.

SECTION 2 – SETTING-UP DETAILS

(a) With suitable mains voltage applied, carry out preliminary check for the presence of Anode, Screen, Grid and Heater voltages, ensure that they are of the right order of magnitude and follow the switch settings.

(b) Open anode current link, insert moving coil dc milliameter in link. Obtain anode current from suitable valve under test and check each anode current range in turn; ensure that the reading on the external milliameter is 0.5 x the anode current indicated by the panel meter ±5%. Remove valve and close Anode Current Link.

(c) Set the coarse mains tapping on the instrument to approximate mains input voltage. Connect the ac Voltmeter between ac side of MR5 (Plate 11) and cathode of a valveholder. Set anode voltage switch to 200V and vary Set ~ switch until a reading of 220V r.m.s. ±2% is obtained.

(d) Set the additive grid volt selector control to 0–20+80, the variable grid potentiometer to maximum and the Meter Switch to 100mA. Then, with the grid circuit link open, and the dc Valve Voltmeter between grid and cathode, adjust the grid voltage pre-set potentiometer (RV4) until the reading on the Valve Voltmeter equals 52.5V (101 x 0.52 ±2% ±0.1V). Adjust dial on grid voltage control (by loosening screw at the bottom of the rear of the potentiometer assembly and potentiometer spindle nut which then allows the quadrant controlling the potentiometer and dial to be adjusted with respect to the hair line). With incremental grid switch set at 0-5 rotate grid potentiometer until meter reads 0.52V ±2% ±0.1V (1 x 0.52), tighten grid control quadrant so that, with this effective grid voltage the dial reads 1V on the scale.

(e) Set Grid Voltage control to zero. Adjust dial on Set mA/V control, (by loosening screw at the bottom of the rear of the potentiometer assembly and potentiometer spindle nut, this then

allows the quadrant controlling the potentiometer and dial to be adjusted with respect to the hair line) until with range switch set to 1–10 the voltage between grid and cathode is 104mV (0.2V x 0.52) the 5mA/V mark should then correspond with the hair line. Retighten quadrant screw and spindle nut. Close link.

It is wise to monitor the 200 anode volts tapping during b, c, d and e, to ensure that the mains voltage has not altered. A stabilised supply is not generally suitable because of 3rd and 5th harmonic wave-form distortion.

N.B. operations d & e should only be carried out if absolutely necessary. These dials have been set accurately at the Works to minimise the errors over the whole range.

(f) With circuit selector and leakage switches set at the Set Mains condition and anode current switch set to 100mA, adjust RV6 until pointer reads on the Set ~ mark.

(g) Set Relay:

With Electrode Selector set to A1, and the anode voltage switch set to 100V the relay should operate when A1 is shorted to cathode. Repeat with the anode switch set to 200V The above procedure should be repeated with the Electrode Selector set to A2. The relay should operate when A2 is shorted to cathode. With the Electrode Selector set to 'S' and the screen voltage set to 100V the relay should break when the cathode is shorted to screen. The relay contacts should break cleanly and stay open until the instrument is switched off and then switched on again. Faulty action of the relay is generally due to a damaged rectifier and usually results in the relay buzzing.

Using the normal test procedure for checking a valve type U52 except that the roller switch should be set to read 020 808 030 and the meter selector switch set to 180mA. Reduce the meter selector switch reading to 60mA and check that the relay has not operated.

WARNING

Do not prolong this test or the load resistors may be damaged.

CHAPTER 3

FINAL TEST PROCEDURE

CONTENTS

SECTION 1 – TEST EQUIPMENT REQUIRED

(a) Avo Electronic Testmeter (or equivalent mean dc Valve Voltmeter).

(b) Model 7 or Model 8 AvoMeter.

(c) Valves CV491 – KT33C – HL23–U52 or similar types.

(d) Resistance 1 megohm ±1%.

SECTION 2 – FINAL TEST DETAIL – INSTRUMENT

(a) Apply 500V megger tester between mains leads and frame.

(b) Check that the earth lead is connected to frame.

(c) Switch on–adjust 'Set Mains' control so that the meter pointer is as near as possible to the ~ mark on the scale plate.

(d) Check the Check (C), Check (H) and C/H INS. positions of the Circuit Selector Switch using a 1 megohm resistance. Indication on the meter should be 1 megohm ±10%.

(e) With the anode and screen voltages set to 100, check the operation of the overload cut-out by applying first an Anode/Cathode short. With the Anode/Screen shorted with a milliameter, check that no current flows when either the Anode or Screen voltages are increased.

(f) Check Anode and Screen voltages. Values read on an external meter should correspond to half the voltages indicated on the front panel +6% −2% +0 −IV (+6% −3% +0 −IV on instruments employing two diodes in series).

(g) Check the following unloaded heater voltages:

NOMINAL VOLTS	ACTUAL AC VOLTS	LIMITS	
		MIN.	MAX.
2	2.3	2.2	2.4
5	5.5	5.3	5.7
10	10.3	10.0	10.6
20	20.6	20.0	21.1
40	41.2	40.4	42
117.5	121.4	118.7	124.1

(h) Insert a KT 33c valve and set up the instrument to obtain the following condition:

Va = 200, Vg2 = 150, Ia = 100mA.*

*Adjust grid voltage until this is obtained

Check that the valve does not oscillate. With the Circuit Selector Switch in the 'Gas' position, check that there is no backward indication on the meter.

(j) Using the KT 33c as a source of current, check the accuracy of the meter on the anode current ranges, i.e. 2.5mA, 10mA, 25mA and 100mA ranges against an external standard. The external standard should read half of the indication of the V.C.M. meter ±5%.

(k) Check grid voltage at 2, 4, 9, 14, 19, 24, 30, 50, 70 and 90V. Limits ±2% ±0.1V.

(m) Check 'Slope' voltages on 1–10mA/V range at 1mA/V (1V) 2mA/V (.5V) 5mA/V (.2V) 8mA/V (.125V) and on 8–60 range at 10mA/V (0.3V) 40mA/V (0.075V) tolerance ±3% ±5mV.

NOTE: Voltages quoted in paragraphs (K) and (M) are effective, and should correspond to a multiplying factor of 0.52.

Using standardised valves check that for given anode currents the bias is within ±5% ±0.5V and slope in within ±10% of the standardised value. (Use valves giving approximate slope readings of 3mA/V on 1–10mA/V range and 12mA/V on 8–60mA/V range.)

(n) Check the 'GAS' position of Circuit Selector Switch. Insert a 1 megohm resistance between G and cathode. Adjust bias for full scale deflection on the movement, Bias reading should be 40–60V.

With the instrument set up to check a valve type 12 AT7 and switched to GAS position there should be no reverse deflection of the pointer for any bias more negative than 3V. Small reverse deflections are permissible. With the instrument set up to check rectifiers and diodes use an external meter to check that when nominal currents are flowing the pointer is approximately in the centre of the 'good' scale. Check on all diode and rectifier ranges. (Make these tests on the D1 position, and repeat any one of them in the D2 position.

(p) Check a valve type HL23 (or similar type) to ensure the correct phasing of the h.t. and l.t. transformers, incorrect phasing being indicated by an excessive anode current.

(q) Check that all valve pins of the same number are connected together.

(r) Check there is no negative reading in the 'Gas' position with a valve whose grid voltage is .1V or below.

SECTION 3 – FINAL TEST DETAIL – MOVEMENT

(a) Ensure that the zero adjuster gives an approximately equal swing on either side of the zero ±2% f.s.d. Check that the panel adjuster and movement adjuster are correctly meshed. Set the adjuster such that a clockwise rotation causes a positive or forward movement of the pointer. The instrument zero should be within one width of the pointer at the end of the arc line.

THE FOLLOWING TESTS SHOULD BE CARRIED OUT WITH THE INSTRUMENT AT AN ANGLE OF 60° TO THE HORIZONTAL.

(b) Check that the balance is within ±1% in the vertical plane. Balance should be within ± one width of the pointer from its zero position over 180° arc in the vertical plane.

(c) The movement resistance should be 3250 ohms ±1%. Total resistance of the moving coil should not exceed 1600 ohms. Current at 1mA/V position to be 22.2mA.

(d) The positive connection to the coil must be well clear of the pole-piece and any flying leads to the movement must be clear of the case edges.

(e) The scale shape linearity should be within ±1% of full scale current between the 100 and 30 marks on the scale and ±2% between the 25 and 10 markings.

(f) The top cover should not bear on the end stops.

(g) Check for sticks in all positions over the whole scale length. (Rolling stick ±1% f.s.d, Pivot stick ±2% f.s.d).

(h) Flash test complete assembly at 1000V dc to exposed metal parts. (Terminal Studs shorted).

APPENDIX 1

SCHEDULE OF SPARE PARTS

FOR

AVO VALVE CHARACTERISTIC METER

MARK IV

PROCEDURE FOR ORDERING SPARES

By following the procedure set out below, delays will not occur due to unnecessary correspondence.

1. State the part number of the items required, also the quantity.
2. State the serial number of the instrument. This will be found on the rear panel.,
3. When ordering spare parts for the movement assembly, the serial number on the scaleplate should also be quoted.

Overseas users of our instruments should send their requirements to our representative on their territory.

If parts are required in Great Britain application should be made direct to AVO Ltd.

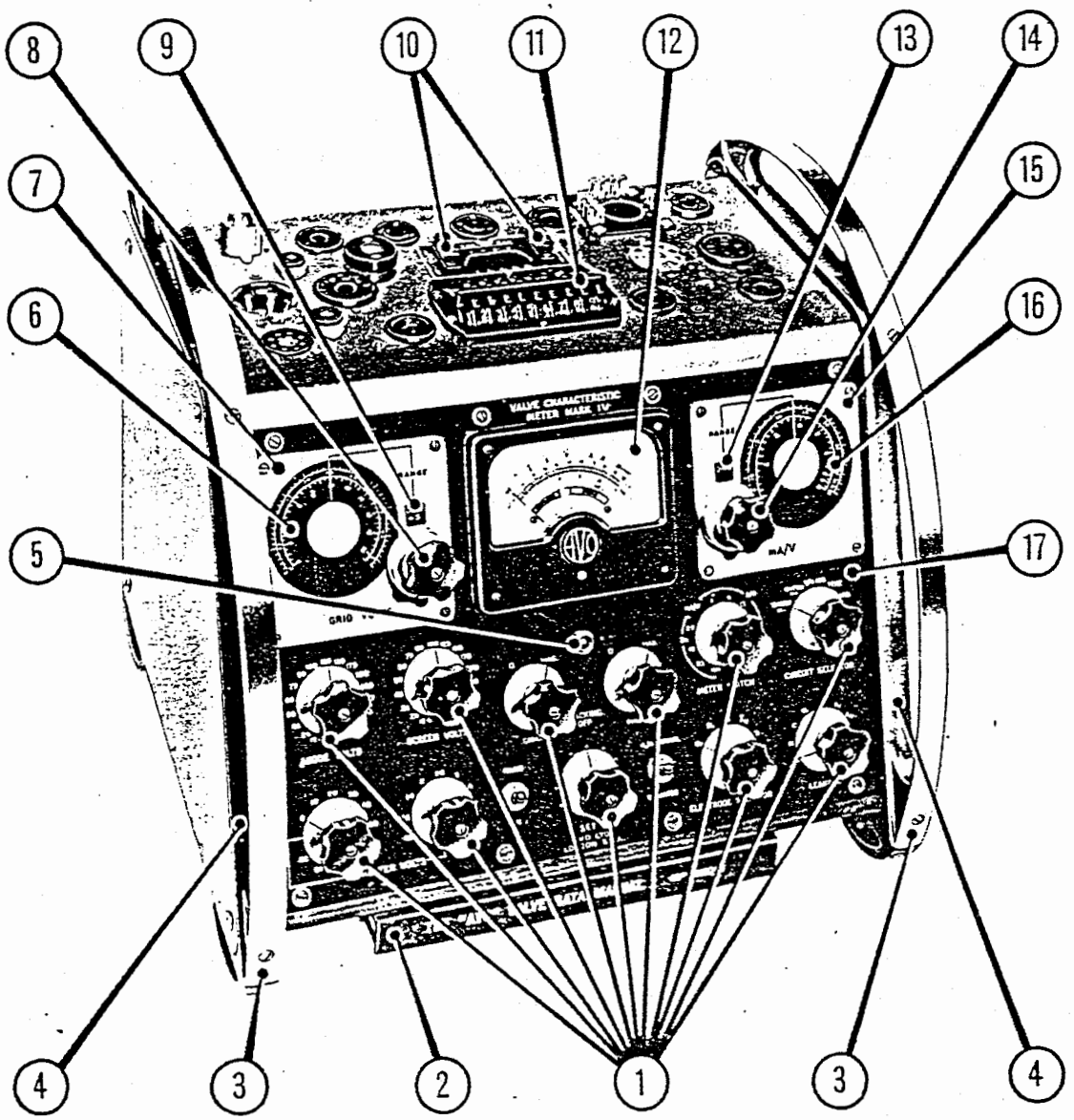
PLATE 1 FRONT PANEL

Item No.	*Description*	*Circuit Ref.*	*Part No.*
1	Knob Assembly Complete With Skirt		15220-A
2	Valve Data Manual		—
3	Handle		40533-2
4	End Frame		40530-3
5	Indicating lamp holder		14812-1
	Bulb 6.5V 0.3A	LP1	50010-14
6	Dial for Grid Voltage Control		21204-1
7	Grid Voltage Name Plate		21202-2
8	Knob for Grid Voltage and mA/V Controls		15220-E
9	Dial for Grid Volts Switch		21203-2
10	Anode Link Terminals		13834-A
11	Roller Selector Switch Escutcheon		40166-2
‡12	Meter Movement Complete (for details see plate 5)		40650-F
13	Dial for Mutual Conductance Switch		21203-1
14	Drive Collar for Grid Volts and mA/V Controls		15624-2
15	Mutual Conductance Name-Plate		21202-3
16	Dial for mA/V Control		21204-2
17	Front Panel		40696-1
18	Knob for Items 1 and 8		14267-1
†19	Valve Board Lid Assembly		40137-D
†20	Top Cap Lead		11237-G

‡See Notes on page 8.

†Not Illustrated.

PLATE 1 FRONT PANEL



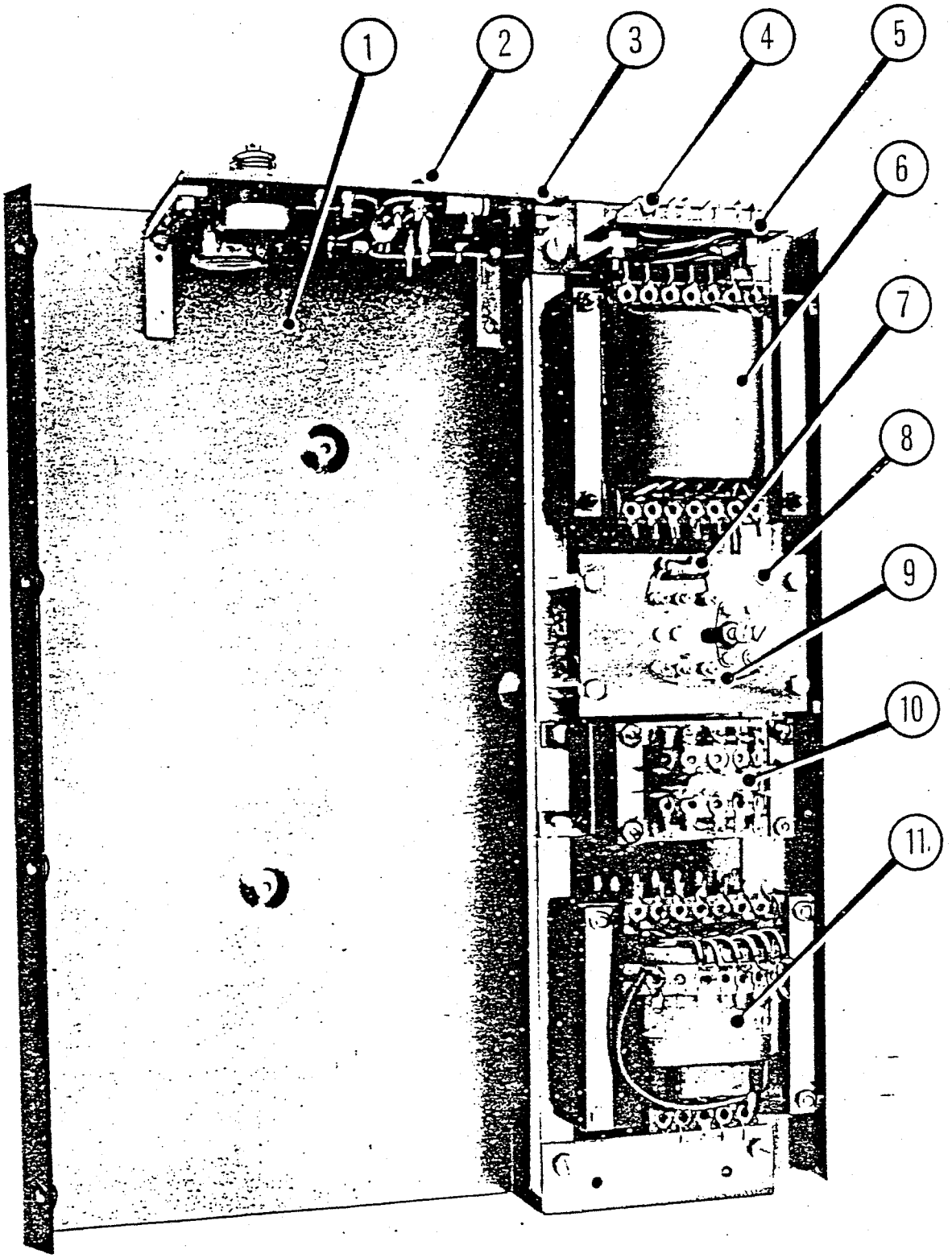
For Service Manuals Contact
MAURITRON TECHNICAL SERVICES
8 Cherry Tree Rd, Chinnor
Oxon OX9 4QY
Tel:- 01844-351694 Fax:- 01844-352554
Email:- enquiries@mauritron.co.uk

PLATE 2 POWER SUPPLY PANEL

Item	Description	Circuit Ref.	Part No.
1	Base Plate		40070-B
2	Heater Current Link Terminal		14657-2
3	Component Board Assembly (for details see plate 6)		21205-A
4	Fuse (3A)	FS1	12239-3
5	Fuse Panel Assembly		12239-7
6	H.T. Transformer Assembly	~~T1~~ T3	21002-D
7	Resistor 2.2kΩ ±5% Vitreous	R44	12049-473
8	Relay Assembly Complete	RL1	40466-B
‡ 9	Rectifier Type 10DE8	MR2	15581-60
10	Grid Transformer Assembly	T2	20129-D
11	L.T. Transformer Assembly	~~T3~~ T1	21005-B

‡See Table of Component Changes (page 38)

PLATE 2 POWER SUPPLY PANEL



For Service Manuals Contact
MAURITRON TECHNICAL SERVICES
8 Cherry Tree Rd, Chinnor
Oxon OX9 4QY
Tel:- 01844-351694 Fax:- 01844-352554
Email:- enquiries@mauritron.co.uk

PLATE 3 CONTROL PANEL

Item	Description	Circuit Ref.	Part No.
1	Toggle Switch (A1.A2 limited/unlimited)	SM	13657-1
2	Electrode Selector Switch	SB	20996-1
3	Leakage Switch	SE	20992-1
‡ 4	Resistor 1kΩ ±1%	R39	12049-464
5	Circuit Selector Switch (for details see plate 8)	SA	20991-1
6	Meter Switch (for details see plate 7)	SC	20997-1
7	Potentiometer 10kΩ Linear (set mA/V)	RV5	14558-9
8	Mutual Conductance Switch (for details see plate 9)	SK	21027-17
9	Meter Movement Complete (for details see plate 5)	M1	40650-F
10	Movement Board Assembly		14810-4
11	Negative grid voltage switch (for details see plate 10)	SD	21207-16
12	Resistor 3.54kΩ ±1%	R15	12049-427
13	Potentiometer 10kΩ Linear (neg. grid volts)	RV3	14558-9
14	Resistor 470kΩ ±10%	R45	12049-250
15	Anode voltage switch	SJ	14822-4
16	Screen voltage switch	SH	14822-4
17	Heater voltage switch (coarse)	SF	20993-1
18	Heater voltage switch (fine)	SG	20994-1
19	Coarse backing-off Potentiometer 250Ω linear	RV2	14558-5
20	Switch (on/off)	SL	13657-1
21	Set ~ Switch	SN	20994-1
22	Fine backing-off control 25Ω	RV1	14558-4
‡ †23	Capacitor 8μF 12V REV. (Located on item 10)	C3	12049-731

†Not Illustrated

‡See Table of Component Changes (page 38)

PLATE 3 CONTROL PANEL

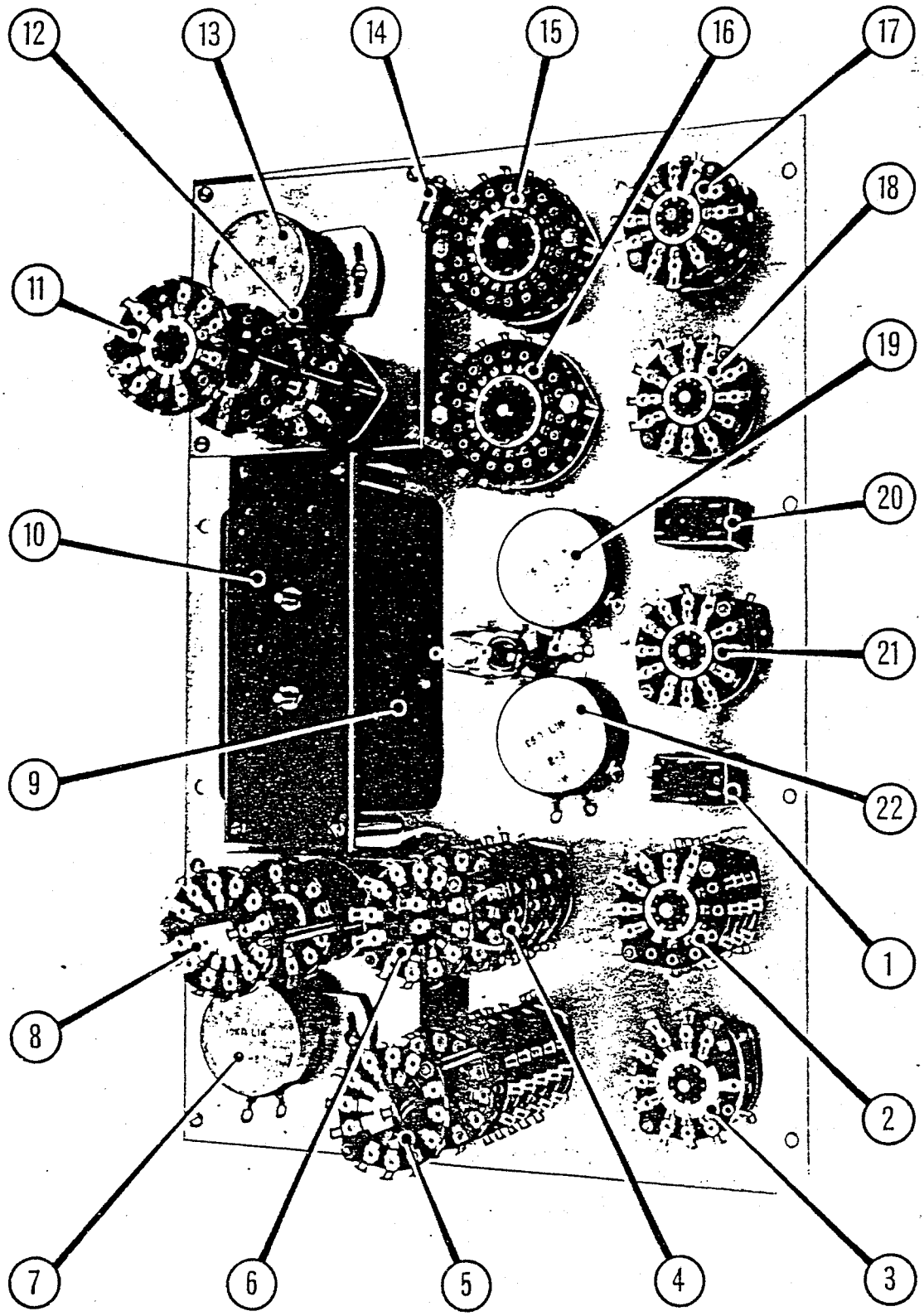


PLATE 4 VALVE HOLDER PANEL

Item No.	Description	Circuit Ref.	Part No.
1	Roller Selector Switch Assembly		40157-B
2	Valve Holder UX4		40140-4
3	Valve Holder B9G		10281-1
4	Valve Holder International Octal		40140-8
5	Valve Holder B8D		40140-22
6	Valve Holder B7		40140-2
7	Valve Holder UX6		40140-9
8	Valve Holder (Flying Lead) (3 off)		21199-A
9	Rubber Bush for Item 8		14555-1
10	Valve Holder UX7 American 7 Pin (Large)		40140-3
11	Valve Holder SM7 American 7 Pin (Small)		40140-20
12	Top Cap Escutcheon Assembly		20903-A
†13	Tag Board Assembly		11996-A
14	Valve Holder UX5		40140-6
15	Valve Holder B3G		10509-1
16	Valve Holder MO8 (Mazda Octal)		40140-7
17	Valve Holder B8A		40140-11
18	Valve Holder B7G		40140-14
19	Valve Holder 8SC (P Type Base)		40140-10
20	Valve Holder B8G		40140-16
21	Valve Holder B9A		40140-19
22	Valve Holder B9		40140-1
23	Ferroxcube Bead		14747-1
24	Valve Holder B4/5		40140-5
25	Panel only		40692-B
†26	Cable for Item 8		15617-2_
†27	Cable for Item 12		20919-2_

†Not Illustrated

PLATE 4 VALVE HOLDER PANEL

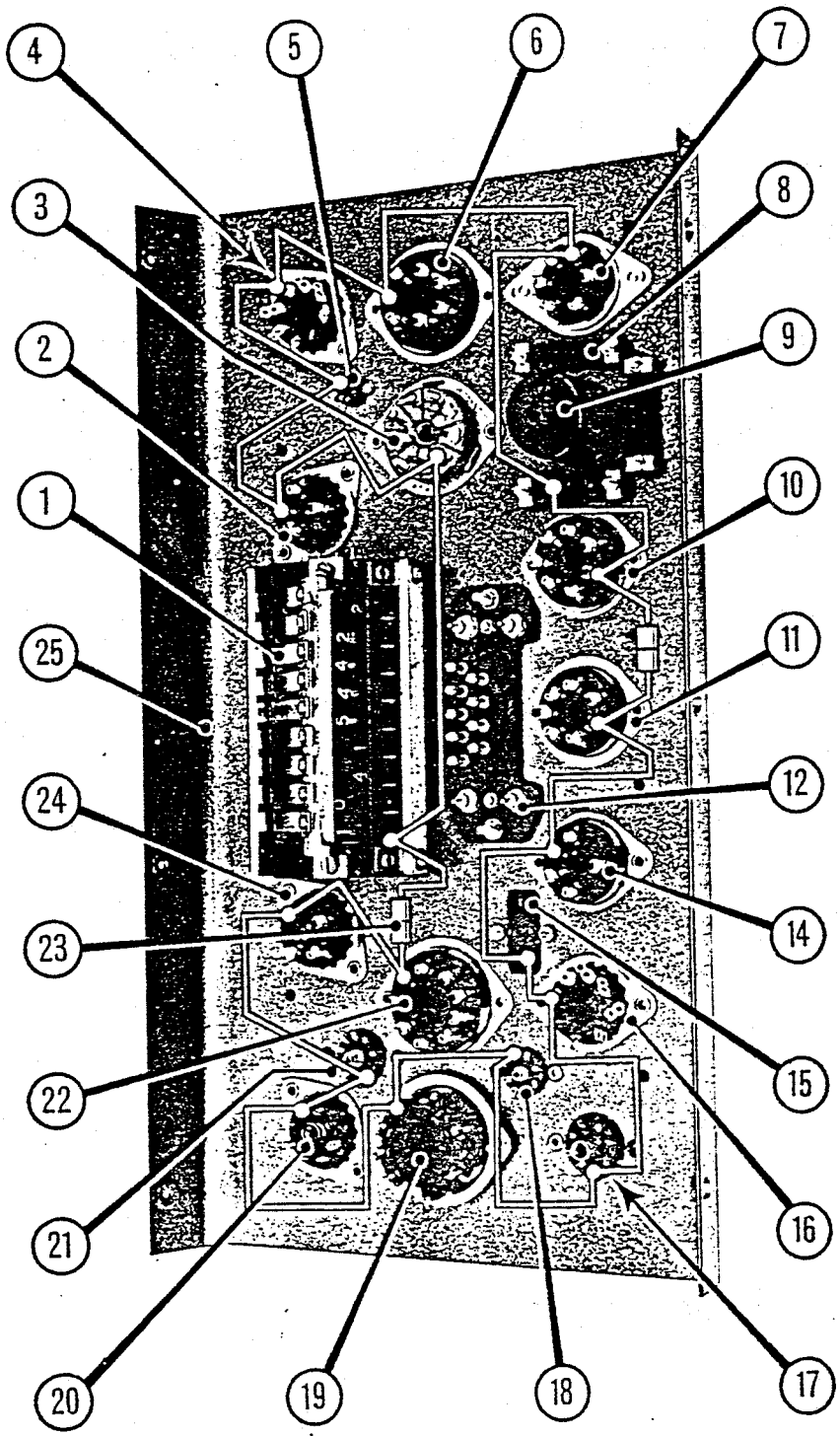


PLATE 5 MOVEMENT ASSEMBLY

Item No.	*Description*	*Part No.*
‡ 1	Scaleplate	(14824-4)
‡ 2	Moving coil assembly	21124-D
‡ 3	Zero Adjustor	15436-1
‡ 4	Hairsprings	10075-16
‡ 5	Sprung Jewel Assembly	10184-B
‡ 6	Pivots	10158-4
7	Movement Case Front	40537-2
8	Movement Case Rear	40538-B
†9	Window Glass	12730-2

†Not illustrated

‡See Note on page 8

PLATE 5 MOVEMENT ASSEMBLY

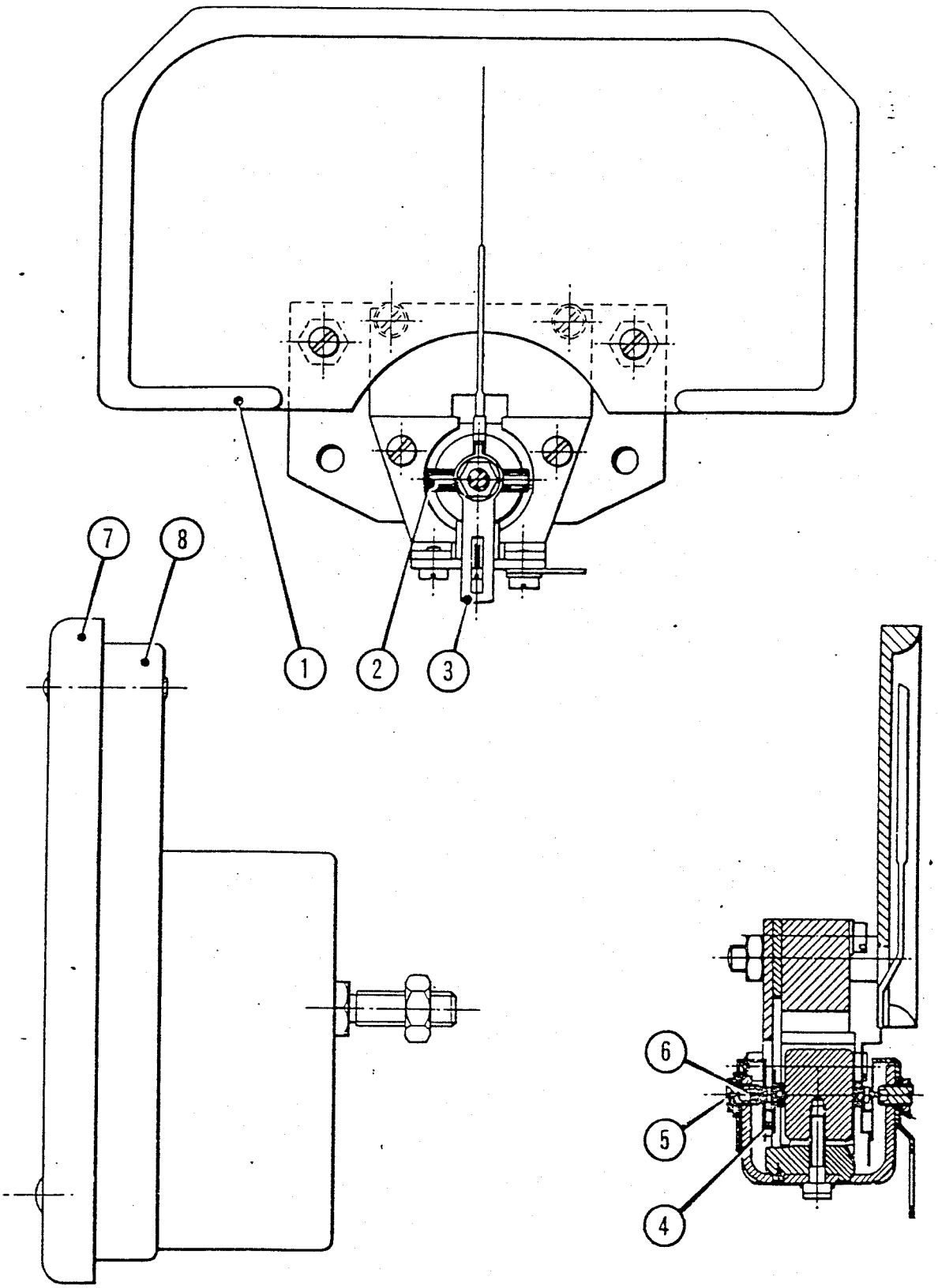


PLATE 6 COMPONENT BOARD ASSEMBLY

Item	Description	Circuit Ref.	Part No.
1	Potentiometer 5,000Ω Linear (Set ~)	RV6	10070-32
‡ 2	Rectifier Type 10DE8	MR4	15581-60
‡ 3	Rectifier Type SD94	MR1	15581-11
4	Resistor 100kΩ ±10%	R1	12049-244
‡ 5	Rectifier Type 10DE8	MR6	15581-60
‡ 6	Rectifier Type 10DE8	MR5	15581-60
‡ 7	Resistor 100kΩ ±10%	R40	12049-244
‡ 8	Rectifier Type 10DE8	MR3	15581-60
9	Potentiometer 5,000Ω Linear (Set Vg)	RV4	10070-32
10	Component Board (bare)		21200-3

‡See Table of Component Changes (page 38)

PLATE 6 COMPONENT BOARD ASSEMBLY

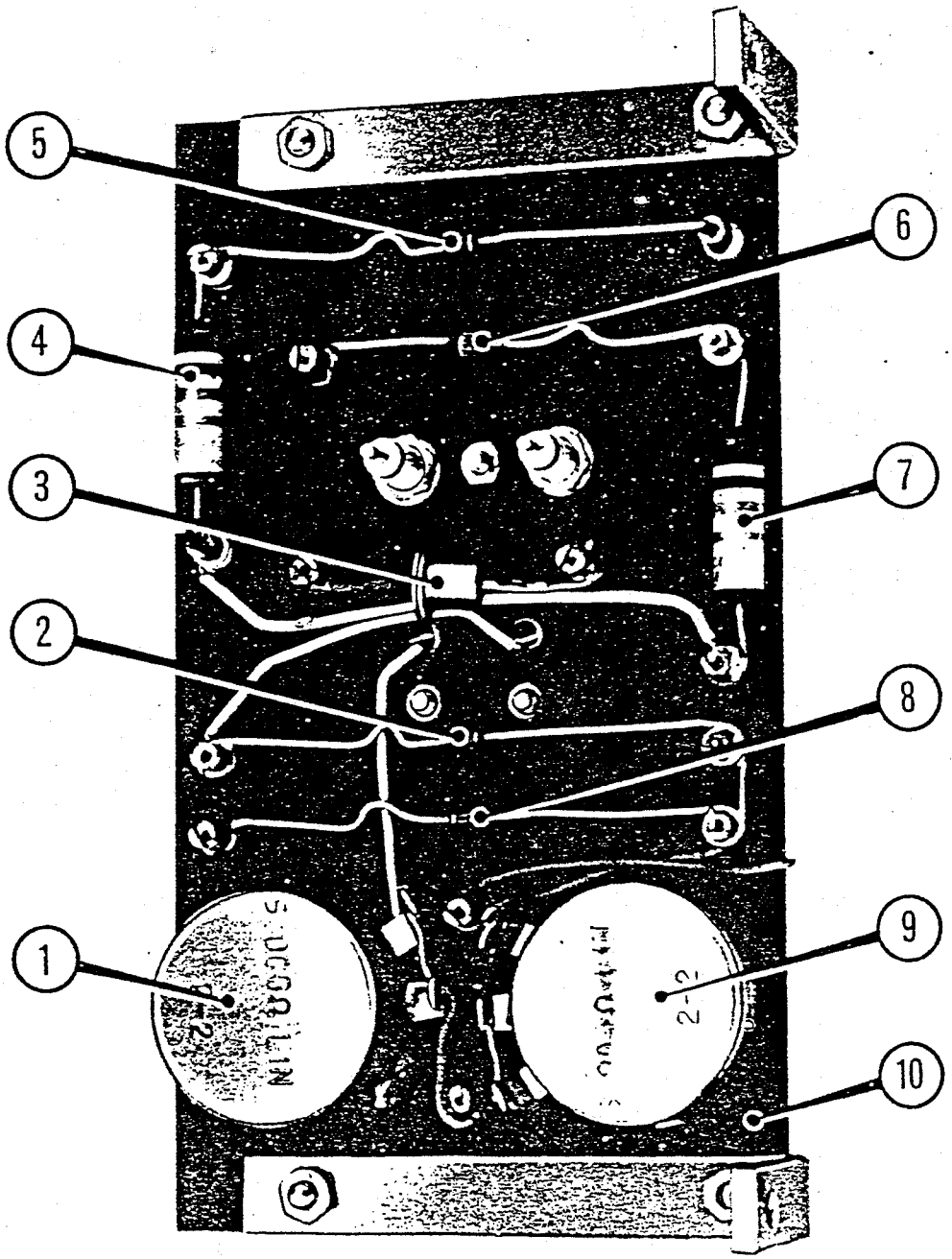
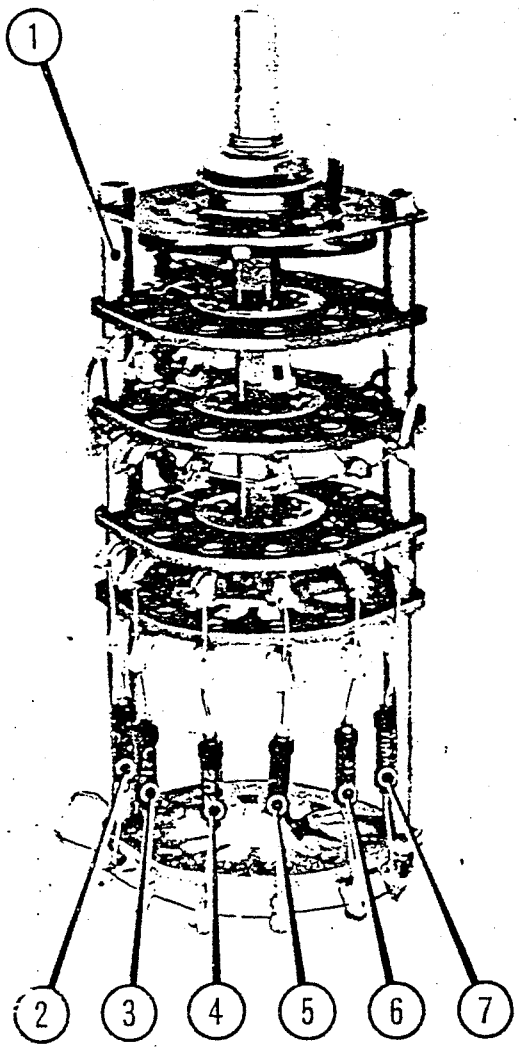


PLATE 7 METER SWITCH ASSEMBLY

Item	*Description*	*Circuit Ref.*	*Part No.*
1	Meter Switch	SC	20997-1
2	Resistor 814kΩ ±2%	R22	12049-392
3	Resistor 406kΩ ±2%	R23	12049-393
4	Resistor 202kΩ±2%	R24	12049-394
5	Resistor 100kΩ ±2%	R25	12049-395
6	Resistor 31.5kΩ ±2%	R26	12049-396
7	Resistor 4.35kΩ ±2%	R27	12049-397
8	Resistor 6.8kΩ ±1%	R32	12049-428
9	Resistor 2.9kΩ ±1%	R31	12049-426
10	Resistor 21.8kΩ ±1%	R30	12049-429
11	Resistor 59.6kΩ ±1%	R29	12049-430
12	Resistor 249kΩ ±1%	R28	12049-431
13	Resistor 1.22MΩ ±2%	R21	12049-432

PLATE 7 METER SWITCH ASSEMBLY



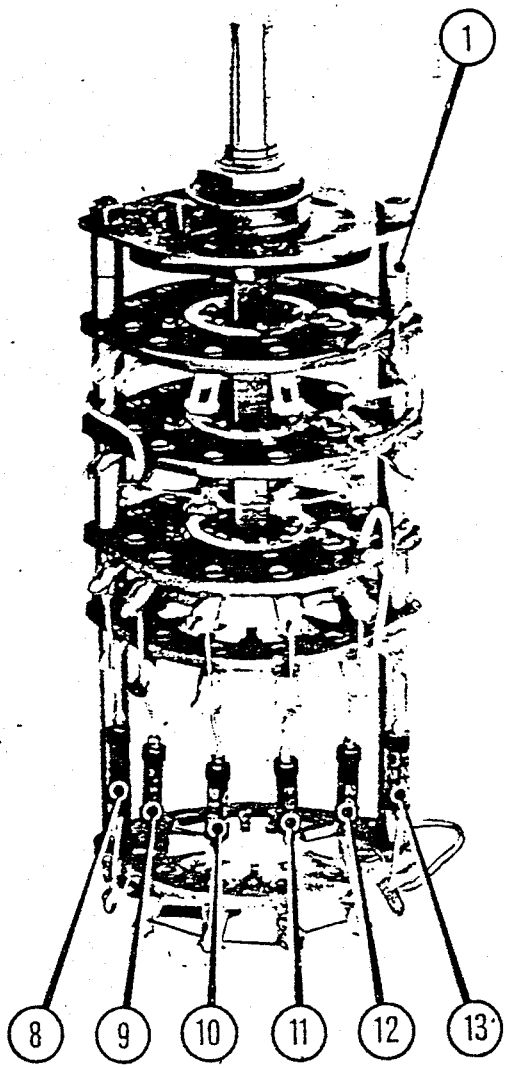
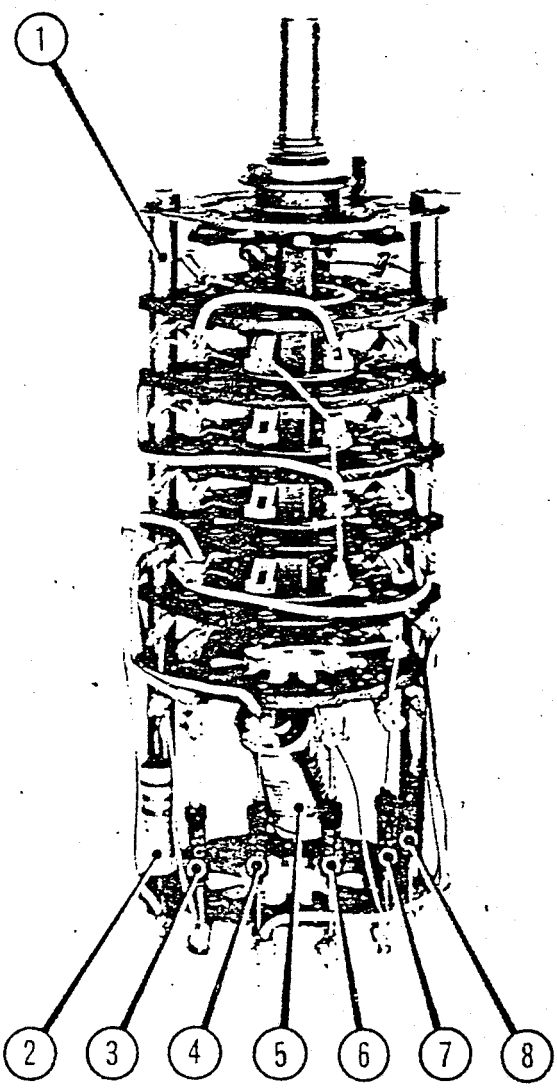


PLATE 8 CIRCUIT SELECTOR SWITCH ASSEMBLY

Item	Description	Circuit Ref.	Part No.
1	Circuit Selector Switch	SE	20991-1
‡ 2	Resistor 56kΩ ±10%	R33	12049-241
3	Resistor 10kΩ ±2%	R34	12049-632
4	Resistor 10kΩ ±1%	R35	12049-386
5	Capacitor 8μF ± % 12V Rev.	C1	12049-404
6	Resistor 1.48MΩ ±1%) Matched pair	R19	12049-433
7	Resistor 1.48MΩ ±1%)		
8	Resistor 15kΩ ±2%	R16	12049-391
9	Resistor 3kΩ ±2%	R17	12049-390
10	Resistor 600Ω ±2%	R18	12049-389
‡11	Rectifier SD91	MR7	15581-12
‡12	Rectifier SD91	MR8	15581-12
13	Resistor 300Ω ±1%	R5	12049-421
14	Resistor 1.86kΩ ±1%	R4	12049-423
15	Resistor 2kΩ ±1%	R3	12049-424

‡See Table of Component Changes (page 38)

PLATE 8 CIRCUIT SELECTOR SWITCH ASSEMBLY



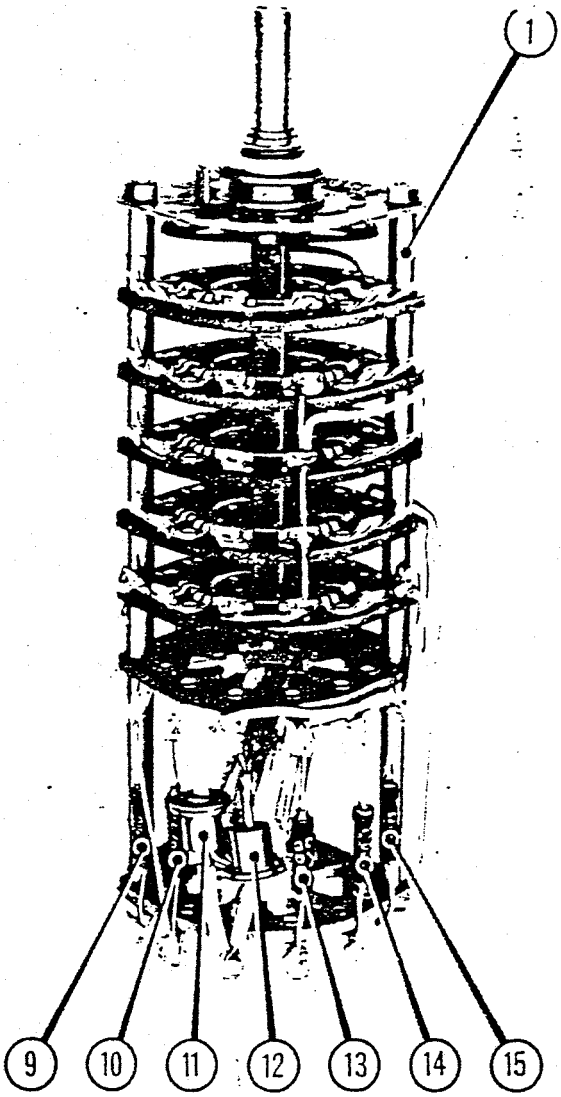
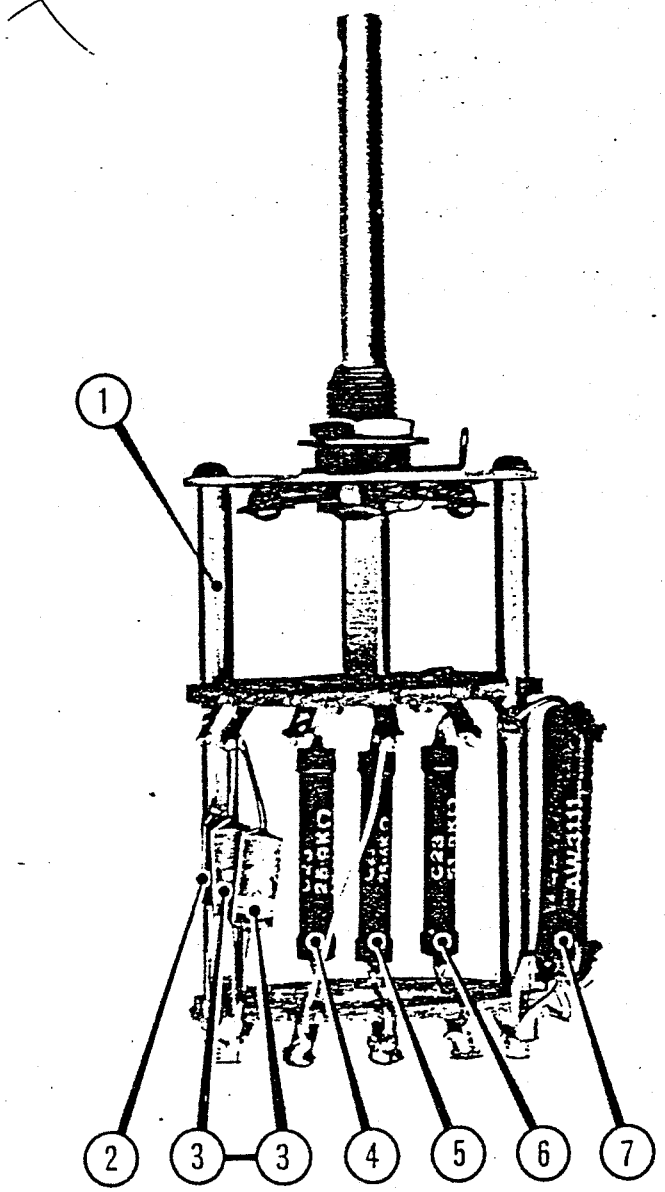


PLATE 9 MUTUAL CONDUCTANCE SWITCH

Item	*Description*	*Circuit Ref.*	*Part No.*
1	mA/V Switch	SC	21027-17
2	Resistor 10kΩ ±2%	R46	12049-632
3	Resistor 3.9Ω ±20% (2 off)	R47	12049-434
4	Resistor 25.9kΩ ±1%	R43	12049-703
5	Resistor 25.6kΩ ±1%	R6	12049-420
6	Resistor 51.8kΩ ±1%	R20	12049-700
‡ 7	Resistor 1kΩ ±2.5%	R48	12049-754
‡ 8	Resistor 1kΩ ±2.5%	R37	12049-754
9	Resistor 24kΩ ±10% 6W	R38	12049-95
10	Resistor 200Ω ±0.5%	R36	14709-B
11	Resistor 760Ω ±2%	R2	12049-422

‡See Table of Component Changes (page 38)

PLATE 9 MUTUAL CONDUCTANCE SWITCH



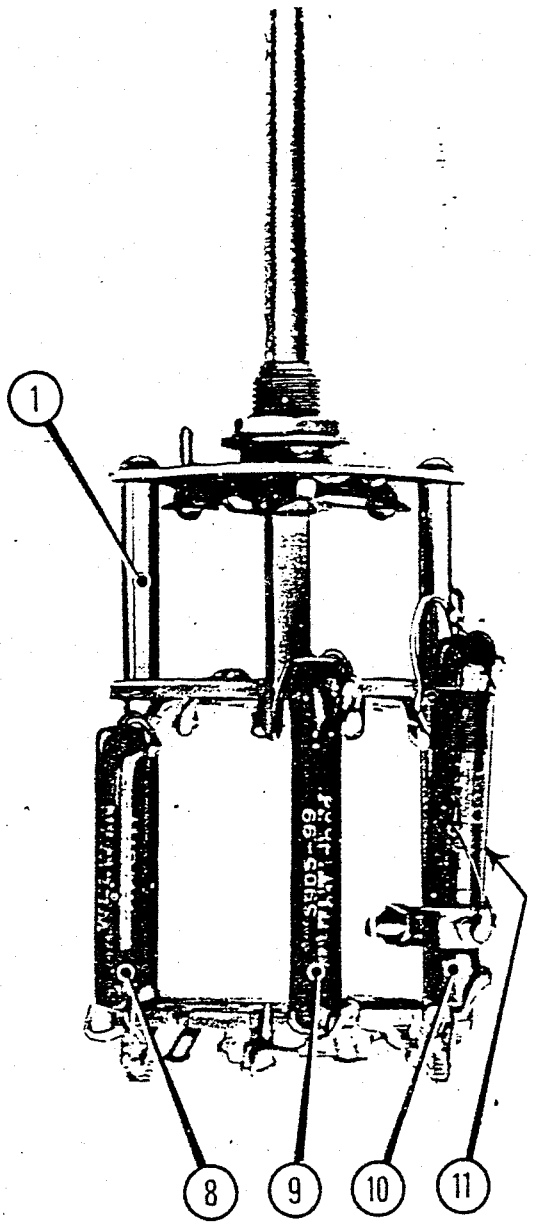
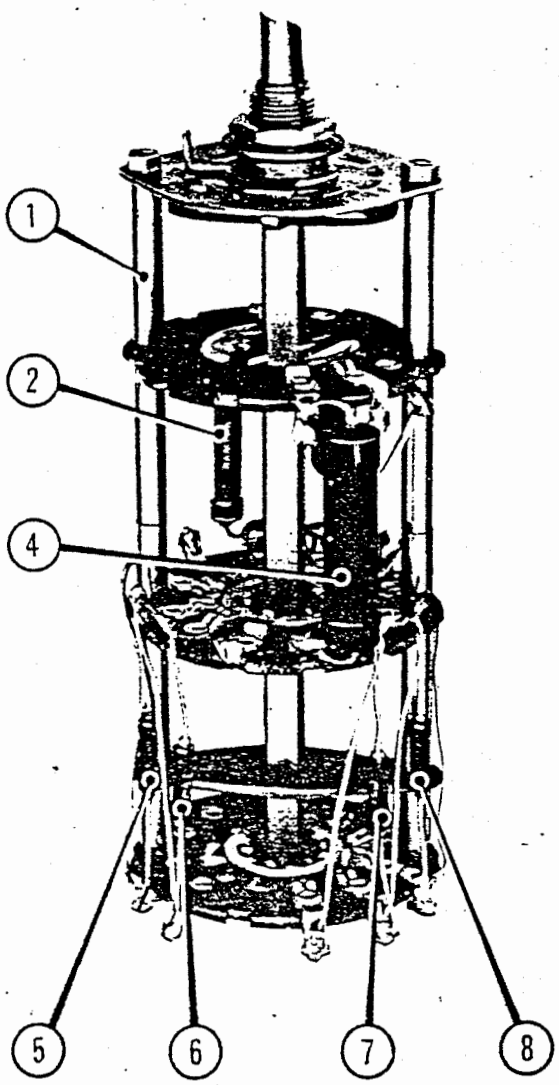


PLATE 10 GRID VOLTAGE SWITCH ASSEMBLY

Item	*Description*	*Circuit Ref.*	*Part No.*
1	Grid voltage switch	SD	21207-16
2	Resistor 37.9kΩ ±1%	R42	12049-702
‡ 3	Capacitor 0.01 μF ±20% 150V	C2	12049-443
4	Resistor 16.8kΩ ±1%	R41	12049-701
5	Resistor 2.5kΩ ±1%	R9	12049-701
6	Resistor 2.5kΩ ±1%	R10	12049-701
7	Resistor 2.5kΩ ±1%	R11	12049-701
8	Resistor 2.5kΩ ±1%	R12	12049-701
9	Resistor 2.5kΩ ±1%	R13	12049-701
10	Resistor 2.5kΩ ±1%	R14	12049-701
11	Resistor 2.5kΩ ±1%	R7	12049-701
12	Resistor 2.5kΩ ±1%	R8	12049-701

‡See Table of Component Changes (page 38)

PLATE 10 GRID VOLTAGE SWITCH ASSEMBLY



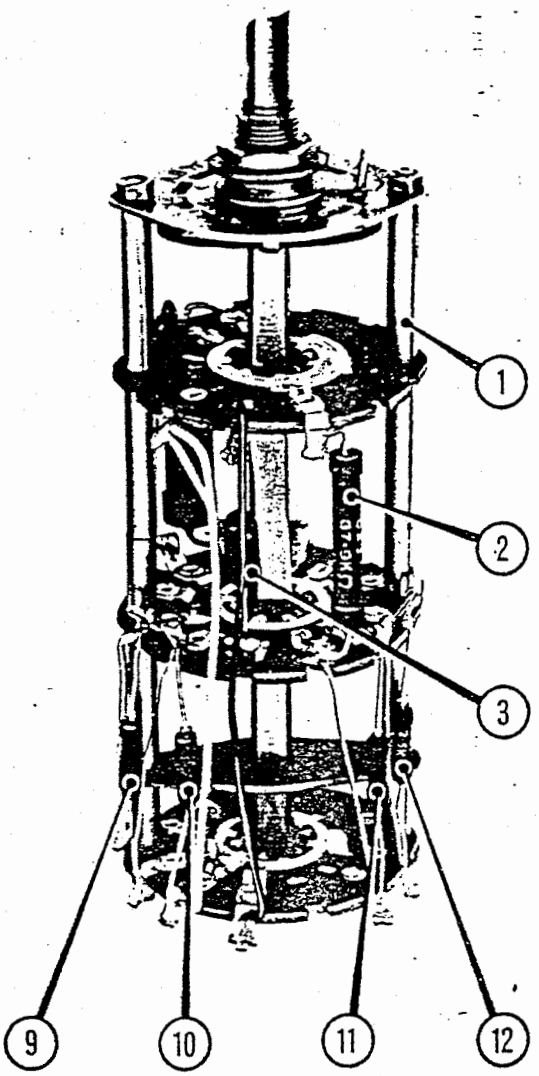
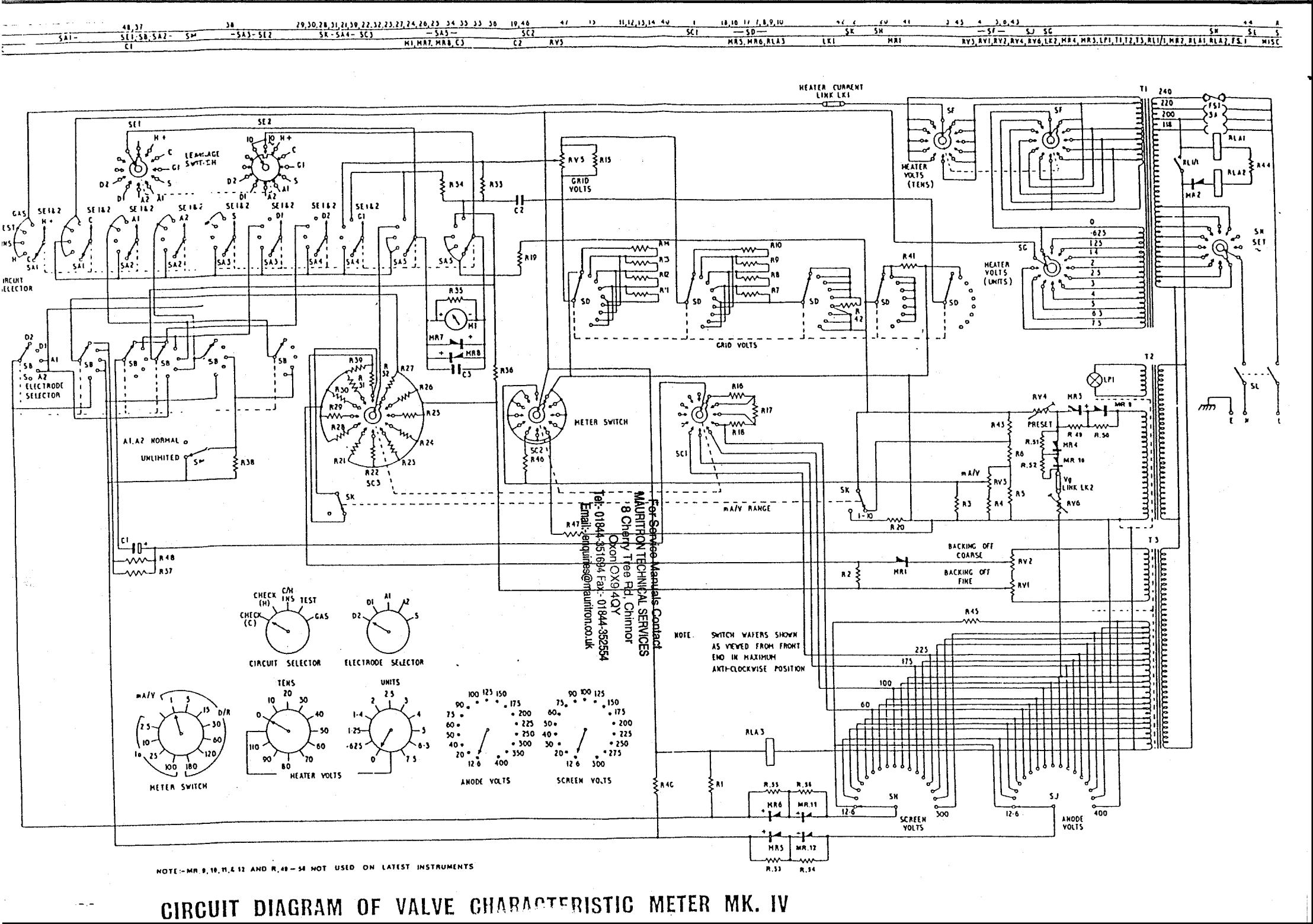


TABLE OF COMPONENTS								
CCT. REF.	VALUE	REMARKS		CCT. REF.	VALUE	REMARKS	CCT. REF.	VALUE
R1	100KΩ	± 10%	*	R37	1k	± 2.5%	SA	Circuit Selector
R2	760Ω	± 2%		R38	24Ω	± 10%	SB	Electrode Selector
R3	2KΩ	± 1%	*	R39	1kΩ	± 1%	SC	Meter Switch
R4	1860Ω	± 1%		R40	100k	± 10%	SD	Grid Voltage
R5	300Ω	± 1%		R41	16.8kΩ	± 1%	SE	Leakage Switch
R6	25.6kΩ	± 1%		R42	37.9kΩ	± 1%	SF	Heater Volts (tens)
R7	2.5kΩ	± 1%		R43	25.9kΩ	± 1%	SG	Heater Volts (Units)
R8	2.5kΩ	± 1%		R44	2.2kΩ	± 5%	SH	Screen Voltage
R9	2.5kΩ	± 1%		R45	470kΩ	± 10%	SJ	Anode Voltage
R10	2.5kΩ	± 1%	*	R46	10kΩ	±.2%	SK	MA/V Range
R11	2.5kΩ	± 1%	*	R47	2Ω	± 20%	SL	ON/OFF
R12	2.5kΩ	± 1%	*	R48	1kΩ	± 2.5%	SM	Normal/Unlimited
R13	2.5kΩ	± 1%	*	R49	2.2MΩ	± 20%	SN	Set c/s
R14	2.5kΩ	± 1%	*	R50	2.2MΩ	± 20%	RV1	Backing off (coarse) 25Ω
R15	3.54kΩ	± 1%	*	R51	2.2MΩ	± 20%	RV2	Backing off (fine) 250Ω
R16	15kΩ	± 2%	*	R52	2.2MΩ	± 20%	RV3	Slope (MA/V) 10KΩ
R17	3kΩ	± 2%	*	R53	2.2MΩ	± 20%	RV4	Grid Voltage (preset) 5KΩ
R18	600Ω	± 2%	*	R54	2.2MΩ	± 20%	RV5	Grid Voltage 10KΩ
R19	2.96MΩ	± 1%	*	R55	2.2MΩ	± 20%	RV6	Set c/s (preset) 5KΩ
R20	51.8kΩ	± 1%	*	R56	2.2MΩ	± 20%		
R21	1.22MΩ	± 2%		FS1	3A			
R22	814kΩ	± 2%		C1	8μF REV			
R23	406kΩ	± 2%	*	C2	0.01μF			
R24	202kΩ	± 2%	*	C3	8μF REV			
R25	100kΩ	± 2%	*	MR1	SD94			
R26	31.5kΩ	± 2%	*	MR2	10DE8			
R27	4.35kΩ	± 2%	*	MR3	10DE8			
R28	249kΩ	± 1%	*	MR4	10DE8			
R29	59.6kΩ	± 1%	*	MR5	10DE8			
R30	21.8kΩ	± 1%	*	MR6	10DE8			
R31	2.9kΩ	± 1%	*	MR7	SD91			
R32	6.8kΩ	± 1%	*	MR8	SD91			
R33	56kΩ	± 10%		LP1	6.5V 0.3A			
R34	10kΩ	± 2%						
R35	10kΩ	± 1%						
R36	200Ω	± 0.5%						

* SEE TABLE OF COMPONENT CHANGES BELOW

TABLE OF COMPONENT CHANGES		
CHANGE NO.	DATE OF CHANGE	ALTERATIONS
1	March 1960	C2 changed from 0.1μF to 0.01μF R33 changed from 8kΩ ±10% to 56kΩ ±10%
2	April 1960	C3 added to circuit
3	May 1960	R46 and R47 added to circuit
4	Oct. 1960	Rectifiers MR7 changed from 2E4 to 2E1 Rectifiers MR8 added (2E1) Rectifiers MR9 MR10 added (2E1)
5	Nov. 1960	Rectifiers MR1 was 1/6A changed to 2E4
6	March 1961	R48 – R56 added
7	March 1961	R37 changed from 500Ω to 1KΩ
8	June 1961	R39 changed to 1.3KΩ ± 2% was 760Ω
9	March 1962	R39 changed to 1kΩ ± 1%
10	March 1962	R51 – R52 deleted from circuit
11	May 1962	Rectifiers MR1 – MR6 and MR9 – MR12 changed to SD94 or SD94A, MR7–MR8 changed to SD91 (MR2 – 4 was either OA10 or DD006) (MR7 was OA210 or DD006)
12	July 1962	RV6 connected to 150V tap on transformer, was on 125V tap.
13	June 1963	Rectifiers MR9 – 12 and Resistors R49, R50 R53 – R56 deleted Rectifiers MR5 – MR6 changed to type 10DE 8



CIRCUIT DIAGRAM OF VALVE CHARACTERISTIC METER MK. IV