

**RQS RADIO/TV-SERVICE**

**THE AVO VALVE TESTER**

**TYPE 160**

**SERVICE AND CALIBRATION**



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THE AVO VALVE TESTER TYPE 160

## THE AVO VALVE TESTER

Type 160

### C O N T E N T S

|           |                         |         |
|-----------|-------------------------|---------|
| CHAPTER 1 | Maintenance Information | Page 3  |
| CHAPTER 2 | Calibration             | Page 9  |
| CHAPTER 3 | Final Test Procedure    | Page 12 |
|           | Appendix                |         |

### ILLUSTRATIONS

Frontispiece

Fig. 1 Valve Standardising Circuit

Fig. 2 Underside of Valve Panel

Fig. 3 Instrument Chassis

Fig. 4 Circuit Diagram

#### **WARNING**

CARE SHOULD BE EXERCISED  
WHEN SERVICING DUE TO THE  
PRESENCE OF UP TO 480Vrms  
WITHIN THE INTERIOR OF THE  
INSTRUMENT.

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## **CHAPTER 1**

### **MAINTENANCE INFORMATION**

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## **C O N T E N T S**

|   |           |        |
|---|-----------|--------|
| TEST EQUIPMENT REQUIRED                 | SECTION 1 | Page 3 |
| FAULT FINDING & SERVICING NOTES         | SECTION 2 | Page 3 |
| VOLTAGE CHECKS WITH NO VALVE UNDER TEST | SECTION 3 | Page 7 |

### **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  
CV428.
- (e) Resistor 680k $\Omega$   $\pm$  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.

#### 1. 500 c/s ac Supply Operation & its Relation to Servicing

Whilst the instrument is suitable for use on 50 to 500 c/s ac supplies, service and calibration should normally be carried out using a 220/230V 50 c/s supply.

The following features play a vital part in the correct operation of the instrument on a 500 c/s supply.

- (a) The two electrostatic screens (S1 and S2) on the ht transformer prevent spurious mA/V readings and care must be taken when replacing a transformer to ensure that these screens are connected as shown in the Circuit Diagram (see Fig. 4).
- (b) The separate cable forms lying side by side across the instrument ensure that the grid circuit and its associated wiring is kept well apart from the ht wiring to prevent the transference of energy from one circuit to the other at high mains frequencies.  
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.
- (c) The 0.02 $\mu$ F (C1) and 0.02 $\mu$ F (C2) capacitors prevent spurious readings on insulation ranges when the instrument is used at high mains frequencies.

## 2. To Check Accuracy of Instrument

Before commencing servicing the instrument should be checked as follows:–

- (a) Ensure that the mains 'On/Off' switch is in the 'Off' position.
- (b) Connect the instrument to an ac voltage supply of 220/250V 50 c/s of known magnitude.
- (c) Set the instrument voltage adjustment to its appropriate position.
- (d) Switch on, noting that the panel indicator is illuminated.
- (e) Set the Mains Voltage Selector fine control such that the meter pointer lies as near as possible to the centre of the '~' zone.
- (f) Connect the AvoMeter in series with the A<sub>1</sub> link.
- (g) Using the CV491 (standardised in accordance with Para.3) with 200V dc anode volts, check that
  - i. For 16mA anode current the negative grid volts indication is within  $\pm 5\%$  of the standardised value.
  - ii. The slope (mA/V) is within  $\pm 5\%$  of the standardised value.A reading of 8mA on the external instrument will be equivalent to a dc current of 16mA through the valve (this is the value normally indicated by the anode current controls when the meter is at its null position).
- (h) Remove valve and external meter.
- (j) Set the Neg.Grid Volts control at '40'.
- (k) Connect a resistance of 680k $\Omega$   $\pm 5\%$  between grid and cathode sockets on the top cap connector panel.
- (m) Set the Circuit Selector switch to position 'Gas'.  
The panel meter should indicate full scale deflection  $\pm 20\%$ .
- (n) Disconnect the resistance and switch off.

## 3. To Obtain Standard Figures for a Valve Using dc Supplies

Using the recommended AvoMeters, the valve should be connected as shown in Fig. 1.

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 voltmeter a sensitivity of 1000 $\Omega$ /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 within  $\pm 5\%$  of the rated voltage.

- (a) Set the grid bias voltmeter to read 9V.
- (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:—

$$\frac{I_{a_2} - I_{a_1}}{V_{g_1} - V_{g_2}}$$

The result will generally be between 4 and 5mA/V (see Final Test Procedure). 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  |   | .....     |
|       |   | CV 491    |

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

4. Construction

The instrument comprises two units in a hinged transit case, the lid of which is not detachable. Electrical connection between the two units is effected by means of two 5-way side by side cables.

5. 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 both sections from the casing, this being accomplished by the removal of four hexagonal headed bolts, which form the feet of the control unit, from the underside of the case. The control panel will then be released. The valve panel can be withdrawn from its section of the case by the removal of eight fixing screws around its periphery.

6. Simple Faults

| SYMPTOMS   | POSSIBLE FAULT  | ACTION  |
|--|---|---|
| (a) No dial light indication<br><br>No dial light indication or meter deflection on SET ~ setting of Circuit Selector.                     | No mains input.<br>Dial light bulb burnt out.<br><br>Fuse blown.                          | Check mains connector.<br>Replace LP1.<br><br>Check Mains Voltage Selector setting and replace F1 and/or F2.  |
| (b) No indication of meter current<br><br>No indication of meter current and protective relay operates when testing tetrodes or penthodes. | No anode volts at valve pin.<br><br>No anode volts at valve pin but screen volts present. | Check that links A <sub>1</sub> & A <sub>2</sub> are tight and making firm contact.<br><br>Check that links A <sub>1</sub> & A <sub>2</sub> are tight and making firm contact |

7. Relay Operates and Fails to Clear

Should the relay operate due to a suspected faulty valve and fail to clear after switching of an on again with no valve in panel, set Roller Selector switch to read 000 000 000 and remove top cap connecting lead. Switch instrument off and on again.

If fault clears the most likely cause of the trouble is a short on the valve panel, certain pin(s) being shorted out to earth by stray wire or solder, or a breakdown in insulation.

If the fault still persists, however, check ht line for breakdown to earth between Roller Selector Switch on Valve Panel and ht transformer on control unit.

8. 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 (see Fig. 3). It should be noted that the bobbins if replaced, should be positioned 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 60V short circuit.
- (c) The relay should not arc excessively on a 200V short circuit on anode or screen.
- (d) The relay should not operate when checking a 120mA rectifier.

Before making any adjustments check that the lamp LP1 is operative. When the instrument is used solely on a 110V supply, it may be preferable to replace LP1 with a 100V, 15W pigmy lamp.

9. Servicing the Valve Holder Panel

The Valve Holder Panel is connected electrically to the control panel by means of two 5-way side by side cables. One of these cables embodies two thicker sections (16/.012) for H+ and H- leads. Connections to tag boards on either unit are shown in Fig. 2.

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 connection is used likewise for pins 2-9, all nine circuits approximating in length and following a similar route around the panel. These loops are further loaded with beads of ferroxcube which sufficiently damp the loop to prevent the valve under test breaking into parasitic oscillation. A diagrammatic layout is shown in Fig. 2. Ferroxcube is also used on leads feeding the selector switch, as a precaution against If oscillation.

Where it is necessary to replace valve holders, these with the exception of the B8B are fitted to the panel with nuts and bolts, and are thus easily removable. Care should be taken to replace all wire in its original position.

10. 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. To adjust skirt, slacken lock nut, rotate skirt to desired position and re-tighten lock nut. Reverse procedure to replace.

**SECTION 3 — VOLTAGE CHECKS WITH NO VALVE UNDER TEST**

Connect instrument to known 220/230V 50 c/s supply, ensuring that the mains 'On/Off' switch is in the 'Off' position, and adjust coarse and fine settings of the mains voltage selector panel to match the supply voltage as accurately as possible. Set the Circuit Selector to 'Test' and the Electrode Selector to 'A<sub>1</sub>' and proceed to check the relevant electrode voltages as follows:-

1. 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      |
|---------------|-----------------|-------------|
| 2             | 2.34            | 2.2 / 2.5   |
| 5             | 5.5             | 5.3 / 5.7   |
| 10            | 10.4            | 10.2 / 10.8 |
| 20            | 21.0            | 20.5 / 22   |
| 40            | 42.0            | 41 / 44     |
| 117           | 125.0           | 120 / 130   |

- (d) Switch off and remove the meter.



2. Anode Voltages

- (a) Connect the AvoMeter, ensuring that the mains 'On/Off' switch is in the 'Off' position, and set to its ac voltage range, between A en 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  $1.1 \times$  the voltage indicated by the 'Anode Voltage' switch  $-2 +6$  per cent.

Due allowance must be made for the limits of accuracy of the measuring instrument for each particular reading, e.g., with the 'Anode Voltage' switch set to 100, the actual voltage reading should be 110V  $-2 +6\%$ .

- (d) Switch off and remove the meter.

3. Screen Voltages

- (a) Connect the AvoMeter, ensuring that the mains 'On/Off' switch is in the 'Off' position, and set to its ac voltage range between S en C on the top cap selector panel.
- (b) Short the anode of  $V_1(a)$  to cathode (pins 2 and 5. See Fig. 3).
- (c) Switch on and rotate the 'Screen Voltage' switch through successive positions, the external meter being set to the appropriate range as required.
- (d) The meter readings obtained should be  $1.1 \times$  the voltage indicated by the 'Screen Voltage' switch  $-2 +6\%$ .

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

- (e) Switch off and remove the meter.

## CHAPTER 2

### **CALIBRATION**

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#### C O N T E N T S

|                                      |           |         |
|--------------------------------------|-----------|---------|
| TEST EQUIPMENT REQUIRED              | SECTION 1 | Page 9  |
| CHECKING THE NEG. GRID VOLTS CONTROL | SECTION 2 | Page 9  |
| CHECKING THE SET mA/V CONTROL        | SECTION 3 | Page 9  |
| CHECKING THE SET ~ INDICATION        | SECTION 4 | Page 10 |
| Ia CALIBRATION CHECK                 | SECTION 5 | Page 10 |
| SETTING THE mA/V DIAL                | SECTION 6 | Page 10 |
| THE INDICATING METER                 | SECTION 7 | Page 11 |

#### SECTION 1 – TEST EQUIPMENT REQUIRED

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

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

#### SECTION 2 – CHECKING THE NEG. GRID VOLTS CONTROL (See WARNING on page 2)

- (a) Set mains 'On/Off' switch to the 'Off' position.
- (b) Open LK (Fig. 3) and set the panel controls as follows:–  
CIRCUIT SELECTOR to TEST, ELECTRODE SELECTOR to A<sub>1</sub> and NEG. GRID VOLTS to 40.
- (c) Connect the Testmeter across RV2 (Fig. 3). Switch on and adjust RV3 (Fig. 3) until a voltage reading of 20.8V is obtained. Remove the Testmeter.
- (d) Connect the Testmeter between G<sub>1</sub> and C sockets on the top cap connection panel, or if the panel has been disconnected for servicing, to the G<sub>1</sub> and C positions on the tag board at the back of the Unit.
- (e) Check that at the 13 and 4 marks on the dial, readings of 6.75V and 2.1V ± 5% are obtained.

If either or both readings are out of tolerance, the dial should be adjusted mechanically to split the error. If it is necessary to make an adjustment, slacken the three counter-sunk screws on the top of the dial which will then be free to move within the latitude of kidney shaped slots. After adjustment, re-tighten screws and check readings. The areas marked 0, 5, 15 and 40 should correspond within the indicated area to 0V, 2.6V, 7.8V and 20.8V ± 5% respectively.

- (f) Switch off and remove the Testmeter.

#### SECTION 3 – CHECKING THE SET mA/V CONTROL

- (a) With LK still open, connect the Testmeter set to a suitable dc range, across R5.
- (b) Switch on and check that when the dial is advanced to its 10, 5 and 2mA/V positions, readings of 52.5mV, 105mV and 250mV ± 3% are obtained.
- (c) If for any reason the relationship between the dial and the potentiometer has been upset, the procedure 'Setting the mA/V Dial' given in Section 6 should be adopted.

- (d) Switch off and remove the Testmeter.

#### SECTION 4 – CHECKING THE SET ~ INDICATION

- (a) Standardise the Testmeter at 47V dc. Close the link LK and set the panel controls as follows:–  
CIRCUIT SELECTOR to 'SET ~', and ELECTRODE SELECTOR to A<sub>1</sub>.
- (b) Connect the Testmeter across RV2 and switch on.
- (c) A reading of 47V should now be obtained, whilst the meter on the the instrument panel should indicate within the '~' zone.  
If voltage reading is correct, but panel meter indication is outside '~' zone, check Resistors R3 and R4.
- (d) Switch off and remove the Testmeter.

#### SECTION 5 – Ia CALIBRATION CHECK

- (a) Open the A<sub>1</sub> link on the valve base panel and insert a Model 7 AvoMeter, set to a suitable dc range, into the circuit.
- (b) Set up the instrument and place under test any power valve capable of passing 100mA anode current, e.g., CV428.
- (c) Set the Anode Current controls to 100mA (90mA and 10mA), switch on and with the instrument set to its test position, allow the valve to warm up.
- (d) Set the panel meter pointer to zero by means of the Neg.Grid Volts control.
- (e) The external meter should indicate between 47.5mA and 52.5mA (0.5 × indicated value on Anode Current control ± 5%) the panel instrument indicating zero. If required repeat this test at any other settings of Anode Current controls.
- (f) Switch off and remove the meter.

#### SECTION 6 – SETTING THE mA/V DIAL

- (a) With the link open and the 'SET mA/V' dial at rest, set RV1 at its maximum anti-clockwise position (viewed from the front panel) and adjust friction tight the locking nuts of the U-shaped stirrup.
- (b) Connect the Testmeter, set to a suitable range across R5.
- (c) Switch on and advance the 'SET mA/V' dial to a reading of 5.
- (d) Rotate the RV1 spindle further, by means of the stirrup, in a clockwise direction until the Testmeter gives a reading of 105mV.
- (e) If this reading is achieved without further clockwise advancement of the stirrup, or if its procurement necessitates an anti-clockwise movement of the stirrup, then investigate the accuracy of R1, R2, R5 and RV1.
- (f) The locking nuts on the stirrup should now be tightened and the reading of 105mV on the voltmeter checked.
- (g) Again check that the dc millivolts developed across R5 at the 2mA/V and 10mA/V settings of the dial are 260mV and 52.5mV ± 3%.
- (h) Check that the dial can now be rotated to its 1mA/V position and that the motion is eventually arrested by the stop screw on the dial and not by the stop at the end of the potentiometer track.
- (j) Switch off and remove the meter.

## SECTION 7 – THE INDICATING METER

This is a self-contained unit which may be withdrawn from the control panel by the removal of two 2BA screws (see Fig. 3).

When used in the instrument as an anode current null indicator, the meter has a full scale deflection for approximately 10mA (not critical).

When removed from the instrument, the meter has a full scale deflection of 30 $\mu$ A and internal resistance of 3,250 $\Omega$ . When shunted by R9 only (see Circuit Diagram) the meter has a full scale deflection of 39.8 $\mu$ A



## **CHAPTER 3**

### **FINAL TEST PROCEDURE**

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#### **C O N T E N T S**

|                         |           |         |
|-------------------------|-----------|---------|
| TEST EQUIPMENT REQUIRED | SECTION 1 | Page 12 |
| FINAL TEST DETAIL       | SECTION 2 | Page 12 |

**NOTE:** When all repairs have been carried out and the instrument is re-assembled, carry out the following final test detail.

#### **SECTION 1 – TEST EQUIPMENT REQUIRED**

- (a) AVO Electronic Testmeter (or equivalent mean dc Valve Voltmeter).
- (b) Model 7 or Model 8 AvoMeter.
- (c) Valves CV428, CV491 and U52.
- (d) Resistor 1 megohm  $\pm$  1%
- (e) Resistor 680kohm  $\pm$  5%

#### **SECTION 2 – FINAL TEST DETAIL** (See WARNING on page 2)

- (a) Apply a 500V megger test between the mains input and frame.
- (b) Apply a known ac 50 c/s voltage in the range 200–250V to the instrument and with Circuit Selector at 'Set ~', set mains voltage selector until needle on panel registers as near as possible to the centre of the '~ mark'. Check that selector settings show  $\pm$  5V of the actual mains voltage.  
  
It is most important to ensure that the meter reading in the 'Set ~' position is maintained at the centre of the '~ mark' on the scale for all subsequent tests.
- (c) Set the Circuit and Electrode Selector switches as given in the table overleaf and connect a 1 megohm  $\pm$  1% resistor across the electrodes on top cap board as detailed under the heading 'Condition'. Check that a leakage of 1 megohm  $\pm$  10% is indicated on the panel meter in each case: –

| <u>Circuit Selector Switch</u> | <u>Electrode Selector Switch</u> | <u>Condition</u>   |
|--------------------------------|----------------------------------|--|
| A/R                            | A1                               | Resistor connected across A1 and any of the following S, H-, C, A2 or G.       |
| S/R                            | A1                               | Resistor connected across S and any of the following H-, C or G.               |
| C.H/R                          | A1                               | Resistor connected across C, H- or H+ and any of the following A1, A2, S or G. |
| C/H                            | C/H                              | Resistor connected across C and either H+ or H-.                               |

NOTE: In positions C.H/R and C/H check that heater volts appear across H- and H+.

- (d) Check operation of the overload cut-out with:
- i. An anode/cathode short at an anode voltage of 100.  
(Connect a short across A1 and C top cap board).
  - ii. A screen/cathode short at a screen voltage of 60.  
(Connect a short across S and C top cap board).
- (e) Check the following unloaded anode volts with the Testmeter (on appropriate ac range) connected across A1 and C on top cap board).

Nominal Volts:    60    100    150    250    400

Actual ac Volts:    66    110    165    275    440

Limits:                    -2 +6%

- (f) Check the following unloaded heater volts with the Testmeter (on appropriate ac range) connected across H+ and H- on top cap board.

| Nominal Volts | Actual ac Volts | Limits      |
|---------------|-----------------|-------------|
| 2             | 2.34            | 2.2 / 2.5   |
| 5             | 5.5             | 5.3 / 5.7   |
| 10            | 10.4            | 10.2 / 10.8 |
| 20            | 21.0            | 20.5 / 22   |
| 40            | 42.0            | 41 / 44     |
| 117           | 125.0           | 120 / 130   |

- (g) Insert a CV428 in the appropriate socket, set the instrument to the correct Electrode Selector switch to A1 and obtain a balance the check that:

- i. By varying the grid voltage, an anode current of 100mA is obtainable.
- ii. The valve does not oscillate.

NOTE: The meter reading should not vary appreciably when the hand is placed near or on the insulated anode lead.

- iii. By varying screen voltage the anode current varies accordingly.

- (h) Insert a CV491 (12AU7) strapped as single triode and standardised for mutual conductance at 16mA (anode current) with 200V applied to the anode, connect the H.R. Testmeter (on 10mA ac range) across the A1 link. Then check that:
- i. For 16mA anode current on the CT160 the external Testmeter reading is 8mA.
  - ii. Negative grid volts is  $\pm 5\%$  of the standard figure.
  - iii. Mutual conductance is  $\pm 5\%$  of the standard figure.
- NOTE: The mutual conductance figure for the CV491 will normally be in the order of 4mA per volt at an anode current of 16mA. The tolerance specified for measurement of mutual conductance on the instrument applies only to this point on the mutual conductance control.
- (j) Remove the CV491 and with the bias control set at 40 connect a  $680k\Omega \pm 5\%$  resistor between G and C connections on top cap board.
- Check that, with the Circuit Selector switch set to 'Gas' the CT160 meter shows f.s.d. within 20%.
- (k) Insert a U52 in the appropriate socket, set the Circuit Selector switch to test and Electrode Selector switch to D1. Insert the Testmeter (on appropriate dc current range) in series with the load from the top cap board (D1) to the rectifier anode.
- Check that for all load switch positions:
- i. The CT160 meter reading is approximately in centre of 'good' scale.
  - ii. That the Testmeter readings are within  $\pm 10\%$  of nominal value.
- (m) Repeat test as in (j) with anode load connected to D2 on top cap board and Electrode Selector to D2.

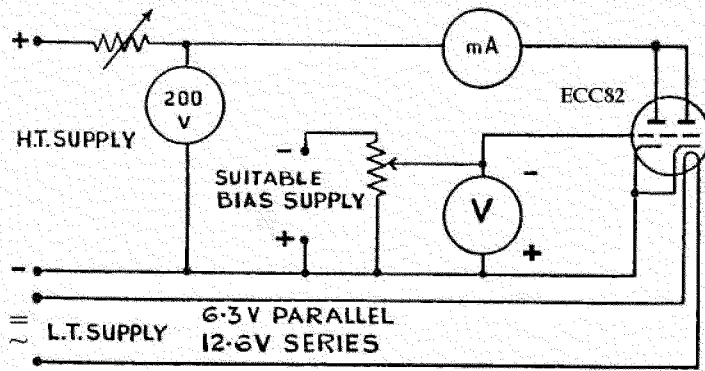


FIG.1

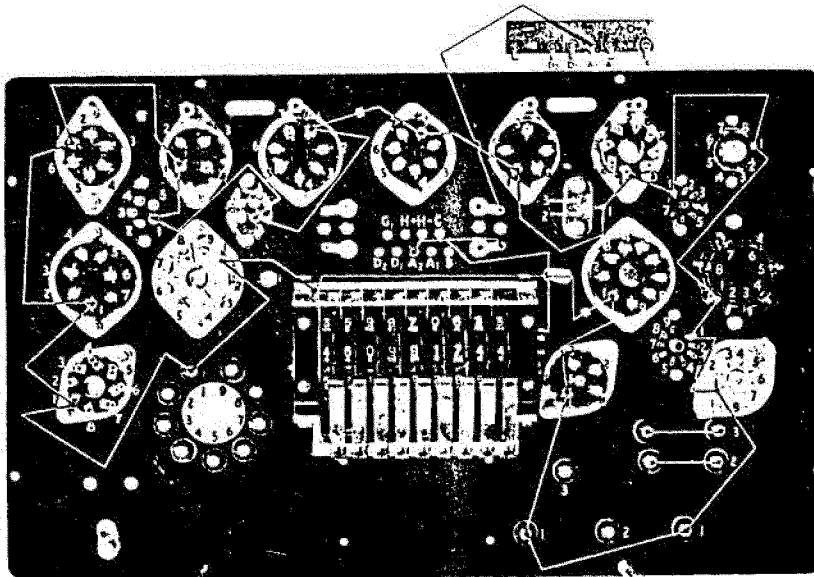


FIG.2



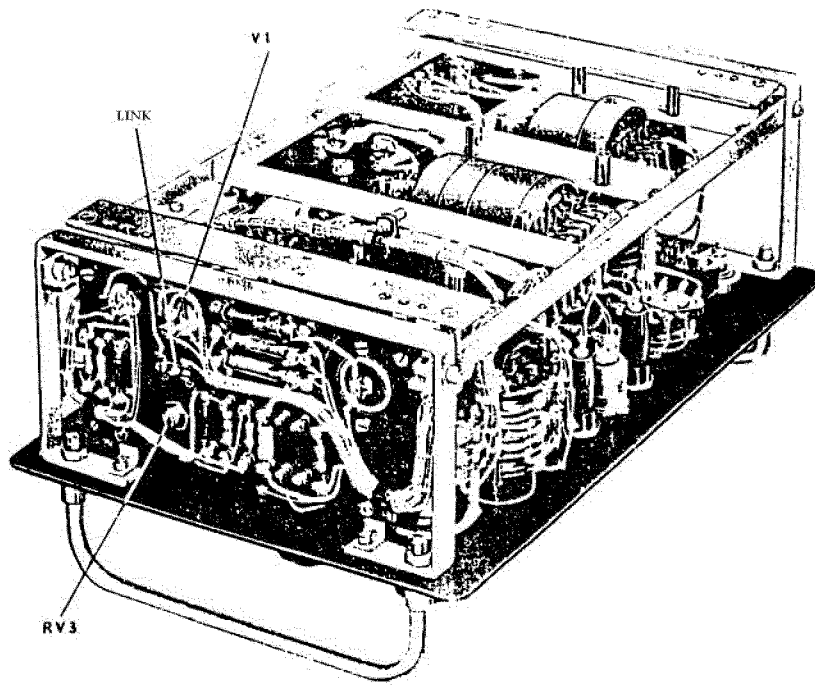
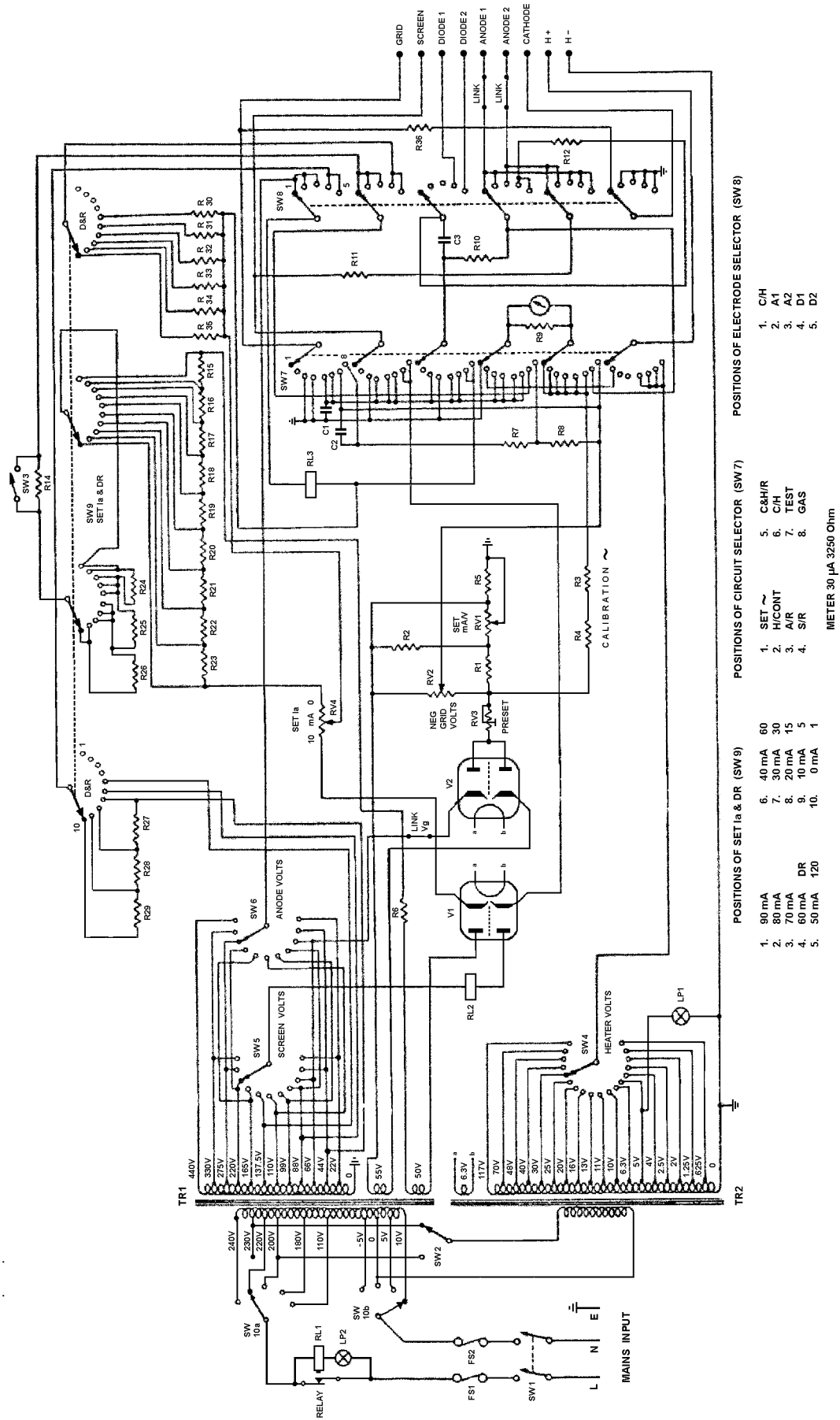


FIG. 3



- POSITIONS OF SET Ia & DR (SW9)
- |     |       |
|-----|-------|
| 1.  | 90 mA |
| 2.  | 80 mA |
| 3.  | 70 mA |
| 4.  | 60 mA |
| 5.  | 50 mA |
| 6.  | 40 mA |
| 7.  | 30 mA |
| 8.  | 20 mA |
| 9.  | 10 mA |
| 10. | 0 mA  |
- POSITIONS OF CIRCUIT SELECTOR (SW7)
- |    |        |
|----|--------|
| 1. | SET ~  |
| 2. | HICONT |
| 3. | AIR    |
| 4. | S/R    |
| 5. | C&H/R  |
| 6. | CIH    |
| 7. | TEST   |
| 8. | GAS    |
- POSITIONS OF ELECTRODE SELECTOR (SW8)
- |    |     |
|----|-----|
| 1. | CIH |
| 2. | A1  |
| 3. | A2  |
| 4. | D1  |
| 5. | D2  |
- METER 30  $\mu$ A 3250 Ohm

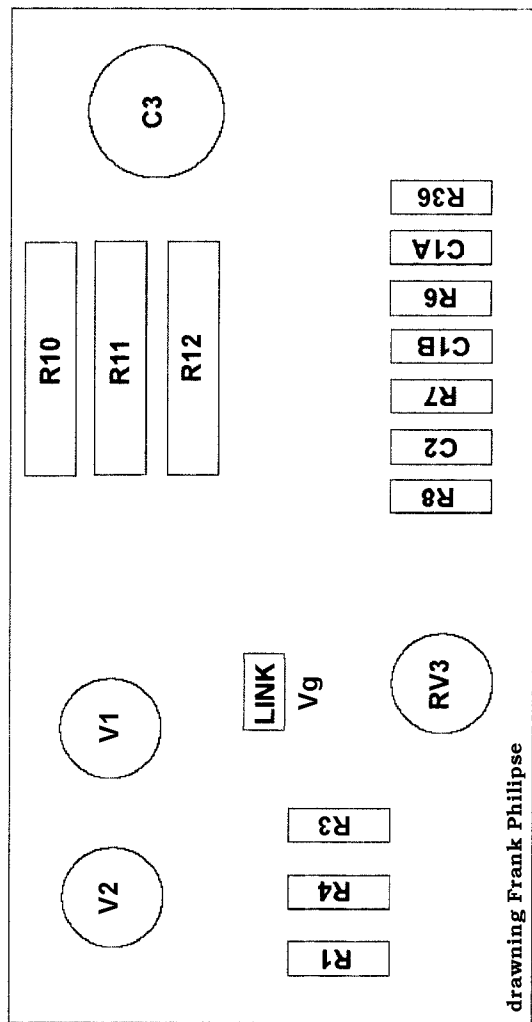
**Circuit Diagram Avometer Type 160**

**FIG.4**

- a High Stability Carbon Resistor  $\pm 1\%$  Welwyn Type A3611 (1/4 W.)
- b As above but Welwyn Type A3623 (3/4 W.)
- c Vitreous Wire Wound Resistor  $\pm 5\%$  Welwyn Type AW3111 (8 W.)
- d As above but  $\pm 2\frac{1}{2}\%$
- e High Stability Carbon Resistor  $\pm 2\%$  Welwyn Type A3611 (1/4 W.)
- f Vitreous Wire Wound Resistor 180  $\Omega \pm 5\%$  Welwyn Type AW3111 (8 W.) overwound by AVO to 200  $\Omega \pm 0.5\%$

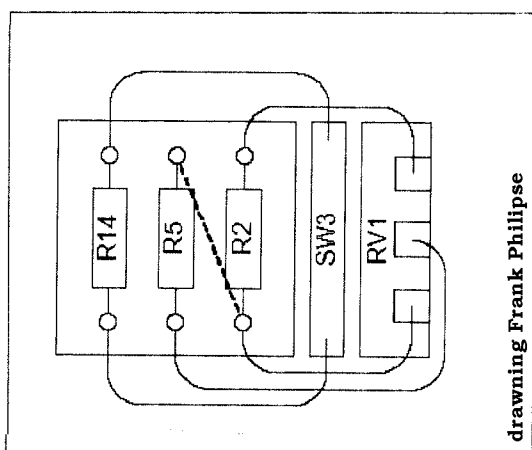
| Circuit Ref. No. | Value          | Tol % | Type | Circuit Ref. No. | Value          | Tol % | Type |
|------------------|----------------|-------|------|------------------|----------------|-------|------|
| R1               | 2.34K $\Omega$ | 1     | b    | R19              | 80 $\Omega$    | 2     | c    |
| R2               | 70 $\Omega$    | 1     | a    | R20              | 80 $\Omega$    | 2     | c    |
| R3 + R4          | 1.32M $\Omega$ | 1     | a    | R21              | 80 $\Omega$    | 2     | c    |
| R5               | 500 $\Omega$   | 1     | a    | R22              | 80 $\Omega$    | 2     | c    |
| R6               | 700 $\Omega$   | 2     | c    | R23              | 80 $\Omega$    | 2     | c    |
| R7               | 0.33M $\Omega$ | 2     | c    | R24              | 240 $\Omega$   | 2     | c    |
| R8               | 10K $\Omega$   | 2     | c    | R25              | 240 $\Omega$   | 2     | c    |
| R9               | 10K $\Omega$   | 1     | a    | R26              | 240 $\Omega$   | 2     | c    |
| R10              | 200 $\Omega$   | 0.5   | f    | R27              | 600 $\Omega$   | 2     | c    |
| R11              | 8K $\Omega$    | 5     | c    | R28              | 3K $\Omega$    | 2     | c    |
| R12              | 500 $\Omega$   | 2 1/2 | d    | R29              | 15K $\Omega$   | 2     | c    |
| R13              | not used       |       |      | R30              | 814K $\Omega$  | 2     | c    |
| R14              | 22K $\Omega$   | 2     | c    | R31              | 406K $\Omega$  | 2     | c    |
| R15              | 80 $\Omega$    | 2     | c    | R32              | 202K $\Omega$  | 2     | c    |
| R16              | 80 $\Omega$    | 2     | c    | R33              | 100K $\Omega$  | 2     | c    |
| R17              | 80 $\Omega$    | 2     | c    | R34              | 31.5K $\Omega$ | 2     | c    |
| R18              | 80 $\Omega$    | 2     | c    | R35              | 4.35K $\Omega$ | 2     | c    |

\*) 2 pcs 0.04  $\mu$ Fd in series



drawing Frank Philipse

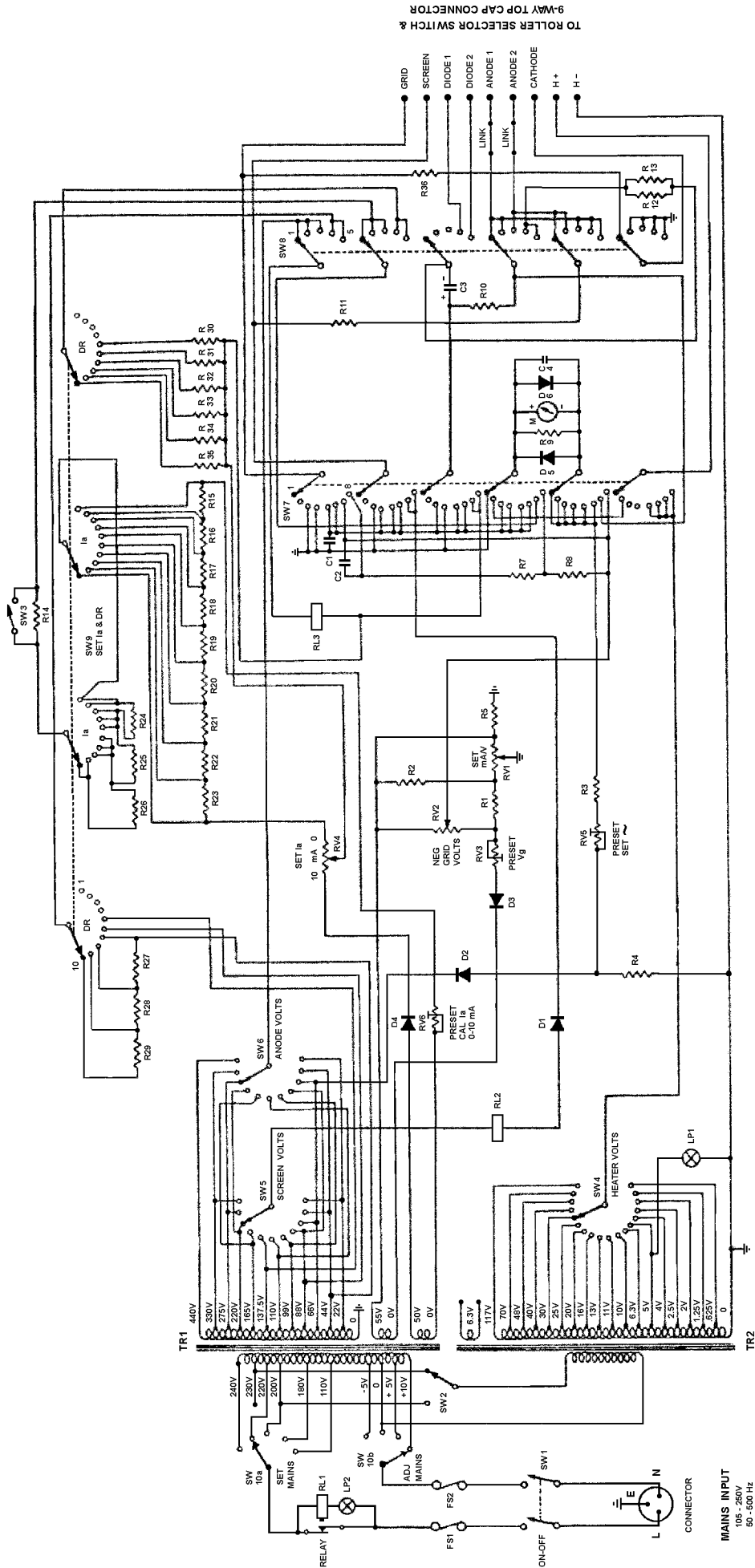
Component Board



drawing Frank Philipse

Set mA/V Assembly

# Avo Valve Tester Type 160



POSITIONS OF ELECTRODE SELECTOR (SW 8)

1. C/H
2. A1
3. A2
4. D1
5. D2

POSITIONS OF CIRCUIT SELECTOR (SW 7)

1. SET ~
2. H/CONT
3. A/R
4. S/R
5. C&H/R
6. C/H
7. TEST
8. GAS

POSITIONS OF SET Ia & DR (SW 9)

- |          |          |    |
|----------|----------|----|
| 1. 90 mA | 6. 40 mA | 60 |
| 2. 80 mA | 7. 30 mA | 30 |
| 3. 70 mA | 8. 20 mA | 15 |
| 4. 60 mA | 9. 10 mA | 5  |
| 5. 50 mA | 10. 0 mA | 1  |

M = METER 30  $\mu$ A 3250 Ohm

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|   |   |
|---|---|
| a | High Stability Carbon Resistor ± 1% Welwyn Type A3611 (1W.)                                       |
| c | Vitreous Wire Wound Resistor ± 5% Welwyn Type AW3111 (8W.)  |
| d | As above but ± 2 1/2% (5W.)   |
| e | High Stability Carbon Resistor ± 2% Welwyn Type A3611 (1W.)                                       |
| f | Vitreous Wire Wound Resistor 180 Ω ± 5% Welwyn Type AW3111 (8W.) overwound by AVO to 200 Ω ± 0.5% |

| Circuit Ref. No. | Value     | Tol % | Type | Circuit Ref. No. | Value   | Tol % | Type |
|------------------|-----------|-------|------|------------------|---------|-------|------|
| R1               | 2.34K Ω   | 1     | a    | R18              | 80 Ω    | 2     | e    |
| R2               | 698 Ω     | 1     | 0.6W | R19              | 80 Ω    | 2     | e    |
| R3               | 1.22M Ω   | 5     | 0.6W | R20              | 80 Ω    | 2     | e    |
| R4               | 82K Ω     | 1     | 0.6W | R21              | 80 Ω    | 2     | e    |
| R5               | 499 Ω     | 1     | 0.6W | R22              | 80 Ω    | 2     | e    |
| R6               | cancelled |       |      | R23              | 80 Ω    | 2     | e    |
| R7               | 330K Ω    | 1     | 0.6W | R24              | 240 Ω   | 2     | e    |
| R8               | 10K Ω     | 1     | 0.6W | R25              | 240 Ω   | 2     | e    |
| R9               | 200 Ω     | 1     | 0.6W | R26              | 600 Ω   | 2     | e    |
| R10              | 200 Ω     | 0.5   | f    | R27              | 3K Ω    | 2     | e    |
| R11              | 8K Ω      | 8     | c    | R28              | 15K Ω   | 2     | e    |
| R12              | 1K Ω      | 2 1/2 | d    | R29              | 814K Ω  | 2     | e    |
| R13              | 1K Ω      | 2 1/2 | d    | R30              | 406K Ω  | 2     | e    |
| R14              | 22K Ω     | 2     | e    | R31              | 202K Ω  | 2     | e    |
| R15              | 80 Ω      | 2     | e    | R32              | 100K Ω  | 2     | e    |
| R16              | 80 Ω      | 2     | e    | R33              | 31.5K Ω | 2     | e    |
| R17              | 80 Ω      | 2     | e    | R34              | 31.5K Ω | 2     | e    |

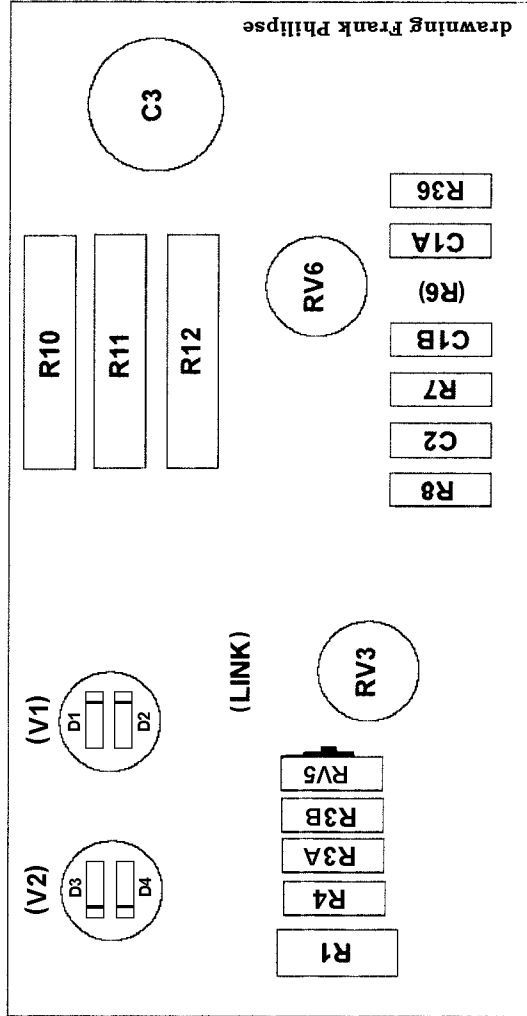
R3 = 1M2 + 20K in series

\*) 2 pcs 0.04 μF in series

! changed

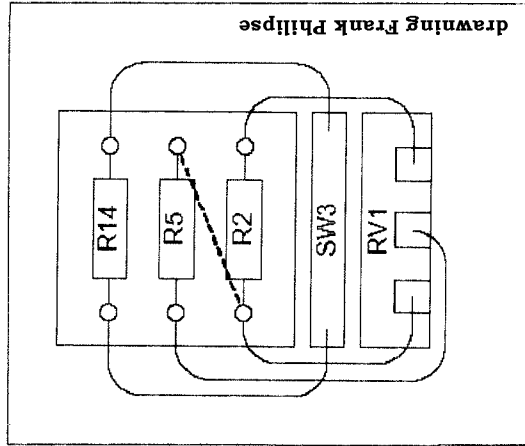
() cancelled

| Circuit Ref. No. | Value      | Tol %   | Type       |
|------------------|------------|---------|------------|
| R35              | 4.35K Ω    | 2       | e          |
| R36              | 10K Ω      | 2       | e          |
| RV1              | 2.5K Ω     |         |            |
| RV2              | 10K Ω      |         |            |
| RV3              | 500 Ω      |         |            |
| RV4              | 90 Ω       |         |            |
| RV5              | 20K Ω      |         |            |
| RV6              | 2K Ω       |         |            |
| C1               | .02 μF     | 400V    | Wkg. volts |
| C2               | .02 μF     | 200V    | Wkg. volts |
| C3               | 8 μF       | 350V    | Wkg. volts |
| C4               | 8 μF       | 100V    | Wkg. volts |
| VI-V2            | cancelled  |         |            |
| DI-D4            | 1M4007     |         |            |
| D5-D6            | 1M4148     |         |            |
| FS1              | 3 amp      |         |            |
| FS2              | 6.3V, 0.3A | E10     |            |
| LP1              | 230V 15W   | Red E14 |            |
| LP2              |            |         |            |



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Component Board



Set mAV Assembly

# Avo Valve Tester Type 160 (modification)

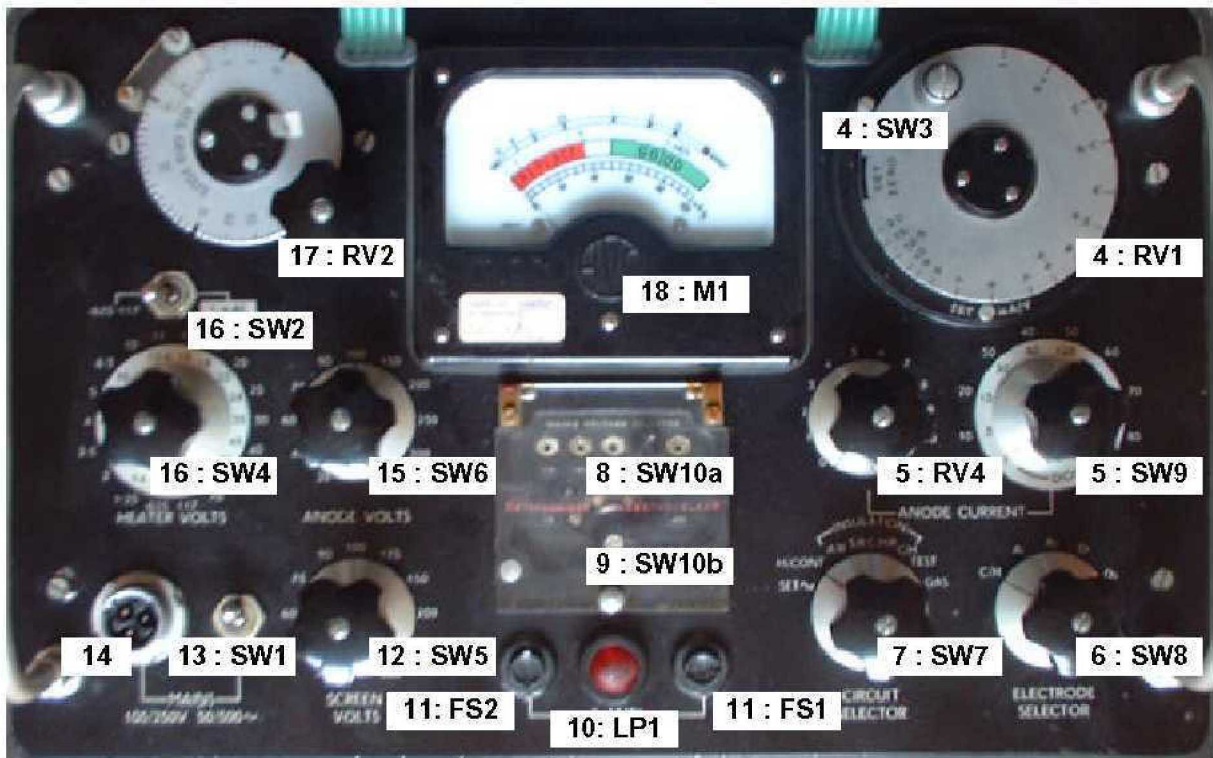


Figure 1

Table 1 Key to Figure 1

| pos. | Circuit ref. | Description                      |
|------|--------------|----------------------------------|
| 1    | not shown    | Roller Selector Switch           |
| 2    | not shown    | Disc Seal Valve Holders          |
| 3    | not shown    | Top Cap Connector Panel          |
| 4    | RV1 + SW3    | Set mA/V Control                 |
| 5    | RV4, SW9     | Anode Current Controls           |
| 6    | SW8          | Electrode Selector               |
| 7    | SW7          | Circuit Selector                 |
| 8    | SW10a        | Mains Voltage Coarse Adjustment  |
| 9    | SW10b        | Mains Voltage Fine Adjustment    |
| 10   | LP1          | Indicator Lamp                   |
| 11   | FS1, FS2     | Fuses                            |
| 12   | SW5          | Screen Voltage Switch            |
| 13   | SW1          | Mains on/off Switch              |
| 14   |              | Mains Input Socket               |
| 15   | SW6          | Anode Voltage Switch             |
| 16   | SW2, SW4     | Heater Voltage Switches          |
| 17   | RV2          | Negative Grid Volts Control      |
| 18   | M1           | Panel Indicating Meter           |
| 19   | not shown    | Anode Links                      |
| 20   | not shown    | Special Flying Lead Valve Holder |

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**Table 2 SW7 circuit selector**

| <b>pos</b> | <b>text</b> | <b>description</b>                          |
|------------|-------------|---|
| 1          | SET~        | Mains Voltage Check                         |
| 2          | H/CONT      | Heater Continuity (SW8=C/H)                 |
| 3          | A/R         | Cold Insulation Check (SW8: A1, A2, D1, D2) |
| 4          | S/R         | Cold Insulation Check (SW8: A1)             |
| 5          | C.H/R       | Hot Insulation Check (SW8: A1, D1, D2)      |
| 6          | C/H         | Hot Insulation Check (SW8=C/H)              |
| 7          | TEST        |   |
| 8          | GAS         |   |

**Table 3 SW8 electrode selector**

| <b>pos</b> | <b>text</b> | <b>description</b> |
|------------|-------------|--------------------|
| 1          | C/H         |                    |
| 2          | A1          |                    |
| 3          | A2          |                    |
| 4          | D1          |                    |
| 5          | D2          |                    |

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# **APPENDIX**

## **THE "AVO" VALVE TESTER TYPE 160**

### **Schedule of Spare Parts**

## INTRODUCTION

Throughout the past decade the Avo Valve Tester Type 160 has proved itself to be unrivalled for versatility and reliability. It is, however, inevitable that this instrument will fail from time to time and, when it does, we are anxious to ensure that it is repaired to the highest possible standard. We have, therefore, produced this schedule of spares which will form a useful guide to the trained engineer who has the task of servicing this instrument.

### **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. State the part number of the items required, also the quantity.
2. State the serial number of the instrument. This will be found on an identification label attached to the instrument.
3. When ordering spare parts for the movement assembly, the movement serial number must also be stated.

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

If the spares are required for use in Great Britain, application should be made direct to our Spares Department.

MAIN ASSEMBLY 40508—C

| Item No. | Part No. | Description  | Circuit Ref. | Qty. off |
|----------|----------|--|--------------|----------|
| 1        | 40508-B  | Complete Case Assembly .. .. .                                   |              | 1        |
| 2        | 40508-B1 | Case Top Assembly .. .. .  |              | 1        |
| 3        | 40508-B2 | Case Bottom Assembly .. .. .                                     |              | 1        |
| 4        | 40462-A  | Chassis Assembly (see below for breakdown details) .. .. .       |              | 1        |
| 5        | 14740-4  | Metal Foot for item 2 .. .. .                                    |              | 4        |
| 6        | 14740-3  | Metal Foot for item 3 .. .. .                                    |              | 4        |
| 7        | 13714-3  | Spacing Washer for items 5 & 6 .. .. .                           |              | 8        |
| 8        | 40374-2  | Gasket for Valve Panel Assembly .. .. .                          |              | 1        |
| 9        | 40510-A  | Valve Panel Assembly (see page 44 for breakdown details) .. .. . |              | 1        |
| 10       | 40507-1  | Seal between items 3 & 4 .. .. .                                 |              | 1        |
| 11       | 20970-A  | Hinge Assembly .. .. .   |              | 2        |
| 12       | 20970-B  | Clasp Assembly .. .. .   |              | 2        |
| 13       | 14635-3  | Release Block for item 12 .. .. .                                |              | 2        |
| 14       | 14011-1  | Mains Lead .. .. .   |              | 1        |
| 15       | 11237-E  | Top Cap Lead .. .. .   |              | 2        |
| 16       | 14746    | Identity Label .. .. .   |              | 1        |
| 17       | 11727-5  | Handle Clamp .. .. .   |              | 2        |
| 18       | 14555-1  | Dust Excluder .. .. .  |              | 1        |
| 19       | 11727-A  | Handle Assembly .. .. .  |              | 1        |
| 20       | 11596-1  | Rubber Foot .. .. .  |              | 4        |
| 21       | 14773-2  | Rubber Foot Support .. .. .                                      |              | 4        |

CHASSIS ASSEMBLY 40462-A

| Item No. | Part No. | Description   | Circuit Ref. | Qty. off |
|----------|----------|---|--------------|----------|
| 1        |          | Negative Grid Volts Assembly (see page 40 for breakdown details) .. .. .        |              | 1        |
| 2        | 15220-A  | Knob Assembly (see page 45 for breakdown details)                               |              | 7        |
| 3        | 40650-B  | Movement Assembly (see page 41 for breakdown details) .. .. .                   |              | 1        |
| 4        | 40471-A  | Mains Adjuster .. .. .  |              | 1        |
| 5        | 14627-2  | Cover for item 4 .. .. .  |              | 1        |
| 6        | 40465-A  | Mutual Conductance Control Assembly (see page 42 for breakdown details) .. .. . |              | 1        |
| 7        | 14663-2  | Indicator Pillar .. .. .  |              | 1        |
| 8        | 45330    | 5-way Connector Lead .. .. .  |              | 1        |
| 9        | 13845-3  | Handle .. .. .  |              | 2        |

CHASSIS ASSEMBLY 40462-A (Contd.)

| Item No. | Part No. | Description  | Circuit Ref. | Qty. off |
|----------|----------|--|--------------|----------|
| 10       | 13846-5  | Handle Bush for item 9 .. .. .                                       |              | 4        |
| 11       | N.82     | Stiff Nut .. .. .  |              | 4        |
| 12       | 20888-1  | End Frame .. .. .  |              | 2        |
| 13       | 20967-A  | Component Board Assembly (see page 42 for breakdown details) .. .. . |              | 1        |
| 14       | 14274-1  | "L" Shaped Mounting Bracket .. .. .                                  |              | 6        |
| 15       | 13701-9  | Movement Mounting Pillar.. .. .                                      |              | 2        |
| 16       | 10266-1  | 2BA Tag for item 15 .. .. .  |              | 2        |
| 17       | 14558-2  | Anode Current Potentiometer .. .. .                                  | RV4          | 1        |
| 18       | 40464-A  | Anode Current Switch (see page 43 for breakdown details) .. .. .     |              | 1        |
| 19       | 20909-1  | Electrode Selector Switch .. .. .                                    | S9           | 1        |
| 20       | 14822-3  | Circuit Selector Switch .. .. .                                      | S8           | 1        |
| 21       | 12239-6  | Fuse (2 amperes) .. .. .   | S7           | 1        |
| 22       | 12049-89 | Fuse Holder .. .. .  | F1, F2       | 2        |
| 23       | 12049-88 | Fuse Holder Cap .. .. .  |              | 2        |
| 24       | 50010-14 | Indicator Lamp 6.3V, 0.3A .. .. .                                    | LP1          | 1        |
| 25       | 13698-1  | Indicator Lamp Assembly complete .. .. .                             |              | 1        |
| 26       | 20911-1  | Screen Volt Switch .. .. .   | S5           | 1        |
| 27       | 13657-1  | Toggle Switch .. .. .  | S1, S2       | 2        |
| 28       | 14010-1  | Input Plug .. .. .   |              | 1        |
| 29       | 14822-2  | Heater Volt Switch .. .. .   | S4           | 1        |
| 30       | 20911-1  | Anode Volt Switch .. .. .  | S6           | 1        |
| 31       | 40468-2  | Front Panel .. .. .  |              | 1        |
| 32       | 11310-A  | Tag Board Assembly .. .. .   |              | 2        |
| 33       | 20901-B  | L.T. Transformer Assembly .. .. .                                    | T2           | 1        |
| 34       | 20892-1  | Transformer Angle .. .. .  |              | 1        |
| 35       | 20899-B  | H.T. Transformer Assembly .. .. .                                    | T1           | 1        |
| 36       | 20908-A  | Lamp Board Assembly .. .. .  |              | 1        |
| 37       | 40466-A  | Relay Assembly (see page 43 for breakdown details)                   |              | 1        |
| 39       | 14653-1  | Lamp (200V red) for item 36 .. .. .                                  |              | 1        |

NEGATIVE GRID VOLTAGE CONTROL

| Item No. | Part No. | Description                  | Circuit Ref. | Qty. off |
|----------|----------|------------------------------|--------------|----------|
| 1        | 14267-1  | Knob .. .. .                 |              | 1        |
| 2        | S.745    | Screw 6BA Tin-plated .. .. . |              | 1        |
| 3        | W.39     | Coiled Washer 6BA .. .. .    |              | 1        |
| 4        | 14670-2  | Knob Carrier .. .. .         |              | 1        |
| 5        | 20245-52 | Spring Dowel.. .. .          |              | 1        |
| 6        | 14711-2  | Spindle .. .. .              |              | 1        |
| 7        | 14275-2  | Bush .. .. .                 |              | 1        |
| 8        | 13908-2  | Hexagonal Locknut .. .. .    |              | 1        |

NEGATIVE GRID VOLTAGE CONTROL (Contd.)

| Item No. | Part No. | Description                             | Circuit Ref. | Qty. off |
|----------|----------|---|--------------|----------|
| 9        | 14631-3  | Friction Washer .. .. .                 |              | 2        |
| 10       | W.3      | Washer 4BA .. .. .                      |              | 1        |
| 11       | 14669-2  | Collar .. .. .                          |              | 1        |
| 12       | N.77     | Hexagonal Locknut 4BA Timplated .. .. . |              | 2        |
| 13       | 14630-1  | Cover .. .. .                           |              | 1        |
| 14       | S.867    | Instrument Head Screw 8BA .. .. .       |              | 3        |
| 15       | 14559-2  | Negative Grid Volts Dial .. .. .        |              | 1        |
| 16       | 13920-2  | Dial Flange .. .. .                     |              | 1        |
| 17       | A.1510   | Cheesehead Screw 4BA Timplated .. .. .  |              | 5        |
| 18       | 14632-4  | Friction Disc .. .. .                   |              | 1        |
| 19       | S.869    | Countersunk Screw 8BA Timplated .. .. . |              | 3        |
| 20       | 13917-2  | Clamp Plate .. .. .                     |              | 1        |
| 21       | 14560-1  | Cursor .. .. .                          |              | 1        |
| 22       | S.740    | Cheesehead Screw 6BA Timplated .. .. .  |              | 2        |
| 23       | 14710-2  | Pillar .. .. .                          |              | 2        |
| 24       | 13843-10 | Pillar .. .. .                          |              | 2        |
| 25       | 14557-1  | Potentiometer Strap .. .. .             |              | 1        |
| 26       | 14558-1  | Potentiometer .. .. .                   | RV2          | 1        |

MOVEMENT ASSEMBLY 40650-B

| Item No. | Part No. | Description                           | Circuit Ref. | Qty. off |
|----------|----------|---------------------------------------|--------------|----------|
| 1        | 40537-2  | Moulded Front Cover .. .. .           |              | 1        |
| 2        | 40538-A  | Moulded Case Rear .. .. .             |              | 1        |
| 3        | 12730-2  | Window Glass .. .. .                  |              | 1        |
| 4        | 30006-W  | Swamp Bobbin .. .. .                  |              | 1        |
| 5        | 14824-3  | Scale-Plate .. .. .                   |              | 1        |
| 6        | 21124-D  | Moving Coil Assembly complete .. .. . |              | 1        |
| 7        | 10194-B  | Fixed Jewel Assembly .. .. .          |              | 1        |
| 8        | 10184-B  | Sprung Jewel Assembly .. .. .         |              | 1        |
| 9        | 10191-4  | Zero Adjuster .. .. .                 |              | 1        |
| 10       | 10158-4  | Pivot .. .. .                         |              | 2        |
| 11       | 10075-16 | Hair Spring .. .. .                   |              | 2        |

MUTUAL CONDUCTANCE CONTROL ASSEMBLY 40465-A

| Item No. | Part No.  | Description   | Circuit Ref. | Qty. off |
|----------|-----------|---|--------------|----------|
| 1        | 14630-1   | Cover .. .. .   |              | 1        |
| 2        | 20969-1   | Ma/V Dial .. .. .                                     |              | 1        |
| 3        | 14666-2   | Dial Support .. .. .                                  |              | 1        |
| 4        | S.1512    | Screw, 4BA (secures items 2 & 3) .. .. .              |              | 1        |
| 5        | 20902-1   | Dial Housing .. .. .                                  |              | 1        |
| 6        | 14660-2   | Drive Bracket .. .. .                                 |              | 1        |
| 7        | 14659-2   | Drive Pin .. .. .                                     |              | 1        |
| 8        | N.5       | Hexagonal Nut, 5BA Nickel-plated (for item 7) .. .. . |              | 2        |
| 9        | 14652-1   | Switch Wafer .. .. .                                  |              | 1        |
| 10       | 14662-1   | Potentiometer .. .. .                                 | RV1          | 1        |
| 11       | 40465-34  | Resistor Board (tag) .. .. .                          |              | 1        |
| 12       | 12049-381 | Resistor $70\Omega \pm 1\%$ .. .. .                   | R2           | 1        |
| 13       | 12049-382 | Resistor $500\Omega \pm 1\%$ .. .. .                  | R5           | 1        |
| 14       | 12049-387 | Resistor $22k\Omega \pm 2\%$ .. .. .                  | R14          | 1        |
| 15       | 45482     | Telephone Mechanism .. .. .                           |              | 1        |

COMPONENT BOARD ASSEMBLY 20967-A

| Item No. | Part No.  | Description                             | Circuit Ref. | Qty. off |
|----------|-----------|---|--------------|----------|
| 1        | 20967-29  | Board (tagged) .. .. .                  |              | 1        |
| 2        | 12049-380 | Resistor $2.34k\Omega \pm 1\%$ .. .. .  | R1           | 1        |
| 3        | 12049-398 | Resistor $1.32M\Omega \pm 1\%$ .. .. .  | R3, R4       | 2        |
| 4        | 12241-12  | Valve Type D77 (CV140) .. .. .          | V1, V2       | 2        |
| 5        | 13738-1   | Valve Holder, B7G .. .. .               |              | 2        |
| 6        | 13819-1   | Valve Can .. .. .                       |              | 2        |
| 7        | 13062-2   | Link .. .. .                            |              | 1        |
| 8        | 14709-A   | Resistor $200\Omega \pm 0.5\%$ .. .. .  | R10          | 1        |
| 9        | 12049-400 | Resistor $8k\Omega \pm 5\%$ .. .. .     | R11          | 1        |
| 10       | 12049-401 | Resistor $500\Omega \pm 3.5\%$ .. .. .  | R12          | 1        |
| 11       | 12049-404 | Capacitor $8\mu F$ electrolytic .. .. . | C3           | 1        |
| 12       | 13699-1   | Clip for item 11 .. .. .                |              | 1        |
| 13       | 13659-6   | Insuloid Clip .. .. .                   |              | 1        |
| 14       | 12049-439 | Resistor $700\Omega \pm 1\%$ .. .. .    | R6           | 1        |
| 15       | 12049-402 | Capacitor $0.04\mu F$ .. .. .           | C1           | 2        |
| 16       | 12049-384 | Resistor $330k\Omega \pm 2\%$ .. .. .   | R7           | 1        |
| 17       | 12049-403 | Capacitor $0.02\mu F$ .. .. .           | C2           | 1        |
| 18       | 12049-632 | Resistor $10k\Omega \pm 2\%$ .. .. .    | R8           | 1        |
| 19       | 13935-1   | Spindle Lock .. .. .                    |              | 1        |
| 20       | 10770-9   | Potentiometer $500\Omega$ .. .. .       | RV3          | 1        |
| 21       | 12049-237 | Resistor $10k\Omega \pm 10\%$ .. .. .   | R36          | 1        |



RELAY ASSEMBLY 40466-A

| Item No. | Part No. | Description               | Circuit Ref. | Qty. off |
|----------|----------|---------------------------|--------------|----------|
| 1        | 40466-24 | Relay Board (tagged)      |              | 1        |
| 2        | 14655-2  | Nylock Anchor Plate (4BA) |              | 1        |
| 3        | 14548-4  | Contact                   |              | 1        |
| 4        | 14650-A  | Contact Screw             |              | 1        |
| 5        | 10466-2  | Contact                   |              | 1        |
| 6        | 14647-2  | Armature Spring           |              | 1        |
| 7        | 11832-5  | Split Pin                 |              | 2        |
| 8        | 14648-2  | Spring                    |              | 1        |
| 9        | 14644-2  | Spring Retainer           |              | 2        |
| 10       | 14643-2  | Armature                  |              | 1        |
| 11       | 14642-2  | Pole Piece                |              | 1        |
| 12       | 14646-2  | Contact Spring            |              | 1        |
| 13       | 20885-A  | Wound Bobbin              |              | 1        |
| 14       | 14645-2  | Armature Retainer         |              | 1        |
| 15       | 20885-B  | Wound Bobbin              |              | 2        |
| 16       | 13658-2  | Anchor Plate              |              | 1        |

ANODE CURRENT SWITCH ASSEMBLY 40464

| Item No. | Part No.  | Description                    | Circuit Ref. | Qty. off |
|----------|-----------|--------------------------------|--------------|----------|
| 1        | 40464-1   | Anode Current Switch           |              | 1        |
| 2        | 12049-29  | Resistor $80\Omega \pm 2\%$    | R15-R23      | 9        |
| 3        | 12049-388 | Resistor $240\Omega \pm 2\%$   | R24-R26      | 3        |
| 4        | 12049-389 | Resistor $600\Omega \pm 2\%$   | R27          | 1        |
| 5        | 12049-390 | Resistor $3k\Omega \pm 2\%$    | R28          | 1        |
| 6        | 12049-391 | Resistor $15k\Omega \pm 2\%$   | R29          | 1        |
| 7        | 12049-392 | Resistor $814k\Omega \pm 2\%$  | R30          | 1        |
| 8        | 12049-393 | Resistor $406k\Omega \pm 2\%$  | R31          | 1        |
| 9        | 12049-394 | Resistor $202k\Omega \pm 2\%$  | R32          | 1        |
| 10       | 12049-395 | Resistor $100k\Omega \pm 2\%$  | R33          | 1        |
| 11       | 12049-396 | Resistor $31.5k\Omega \pm 2\%$ | R34          | 1        |
| 12       | 12049-397 | Resistor $4.35k\Omega \pm 2\%$ | R35          | 1        |

VALVE PANEL ASSEMBLY 40510

| Item No. | Part No. | Description                                       | Circuit Ref. | Qty. off |
|----------|----------|---|--------------|----------|
| 1        | 40140-9  | Valve Holder, UX6 .. .. .                         |              | 1        |
| 3        | 40140-4  | Valve Holder, UX4 .. .. .                         |              | 1        |
| 5        | 40140-3  | Valve Holder, UX7 (large) .. .. .                 |              | 1        |
| 6        | 40140-20 | Valve Holder, UX7 (small) .. .. .                 |              | 1        |
| 7        | 40140-6  | Valve Holder, UX5 .. .. .                         |              | 1        |
| 8        | 40140-7  | Valve Holder, Mazda Octal .. .. .                 |              | 1        |
| 9        | 40140-1  | Valve Holder, British 9-pin .. .. .               |              | 1        |
| 10       | 40140-14 | Valve Holder, B7G .. .. .                         |              | 1        |
| 11       | 40140-11 | Valve Holder, B8A .. .. .                         |              | 1        |
| 12       | 40140-10 | Valve Holder, 8-pin side contact .. .. .          |              | 1        |
| 13       | 40140-19 | Valve Holder, B9A .. .. .                         |              | 1        |
| 14       | 40140-16 | Valve Holder, B8G .. .. .                         |              | 1        |
| 15       | 40140-5  | Valve Holder, British 4/5-pin .. .. .             |              | 1        |
| 16       | 40140-8  | Valve Holder, International Octal .. .. .         |              | 1        |
| 17       | 10281-1  | Valve Holder, B9G .. .. .                         |              | 1        |
| 18       | 40140-2  | Valve Holder, British 7-pin .. .. .               |              | 1        |
| 19       | 10509-1  | Valve Holder, B3G .. .. .                         |              | 1        |
| 20       | 40166-3  | Escutcheon for item 22 .. .. .                    |              | 1        |
| 21       | 14651-1  | Grommet .. .. .                                   |              | 2        |
| 22       | 40157-C  | Roller Selector Switch .. .. .                    |              | 1        |
| 23       | 20903-A  | Top Cap Escutcheon .. .. .                        |              | 1        |
| 24       | 20968-1  | Ceramic Valve Holder Segment .. .. .              |              | 17       |
| 25       | 30008-62 | Bakelite Washer for item 24 .. .. .               |              | 34       |
| 26       | 14714-A  | Valve Holder Spring Assembly for item 24 .. .. .  |              | 8        |
| 27       | 14714-B  | Valve Holder Spring Assembly (short) for item 24) |              | 9        |
| 28       | 30008-63 | Bakelite Washer for item 24 .. .. .               |              | 17       |
| 29       | 14264-2  | Collar for item 24 .. .. .                        |              | 17       |
| 30       | 40506-3  | Valve Holder Panel .. .. .                        |              | 1        |
| 31       | 14745-1  | Warning Label .. .. .                             |              | 1        |
| 32       | 11310-B  | Tag Board Assembly .. .. .                        |              | 2        |
| 33       | 14732-2  | Plug Block .. .. .                                |              | 1        |
| 34       | 14273-1  | Tool Clip .. .. .                                 |              | 1        |
| 35       | 14746    | Identity Label .. .. .                            |              | 1        |
| 36       | 11673-3  | Pillars for item 32 .. .. .                       |              | 4        |
| 37       | 14750-2  | Pillars adjacent to item 22 .. .. .               |              | 2        |
| 38       | 14747-1  | Ferrocube Bead .. .. .                            |              | 22       |
| 39       | 13561-1  | Insulating Plug for item 37 .. .. .               |              | 2        |
| 40       | 14739-2  | Special Screw for item 37 .. .. .                 |              | 2        |
| 41       | 14745-2  | Warning Label .. .. .                             |              | 1        |

KNOB ASSEMBLY 15220-A

| Item<br>No. | Part<br>No. | Description                         | Circuit<br>Ref. | Qty.<br>off |
|-------------|-------------|-------------------------------------|-----------------|-------------|
| 1           | 14267-1     | Knob .. .. .                        |                 | 1           |
| 2           | 14268-4     | Knob Skirt, silver with marker line |                 | 1           |
| 3           | 14266-6     | Knob Carrier                        |                 | 1           |
| 4           | 14269-4     | Retaining Nut                       |                 | 1           |
| 5           | 15066-2     | Knob Washer, between items 2 & 4    |                 | 1           |
| 6           | 20245-52    | Spring Dowel                        |                 | 1           |
| 7           | S.745       | Screw, knob securing                |                 | 1           |
| 8           | W.39        | Spring Washer 6BA double coil       |                 | 1           |