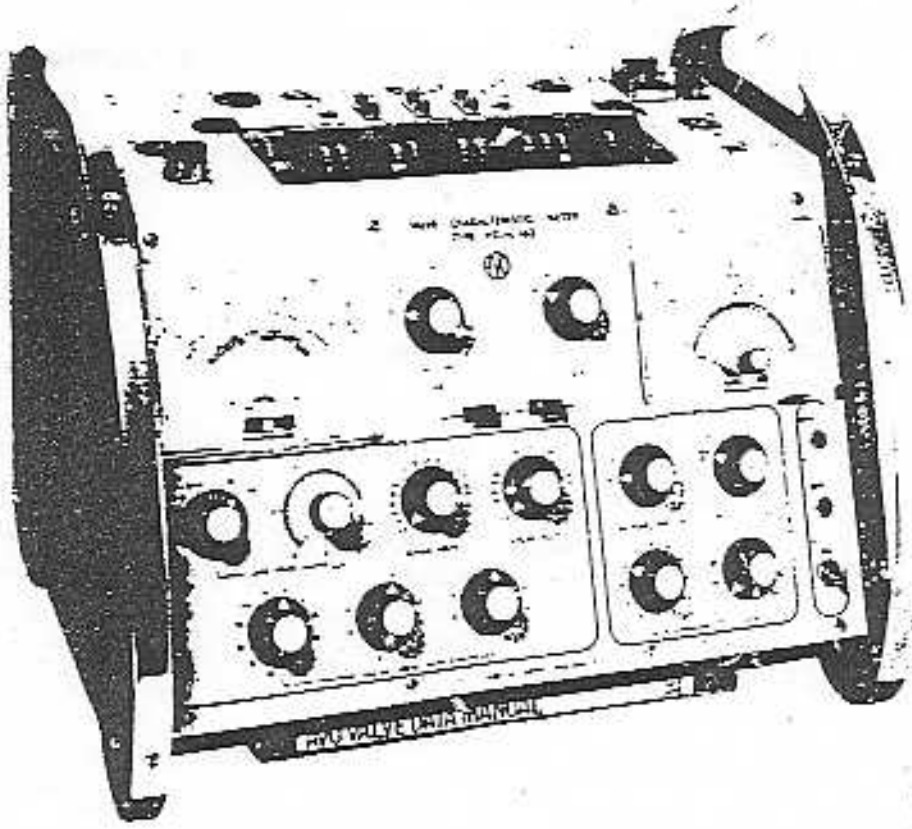
# Service Manual

## Type V.C.M. 163
## Valve Characteristic Meter



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# VALVE CHARACTERISTIC METER TYPE VCM 163

# SERVICE MANUAL

## TEST EQUIPMENT REQUIRED

(a) Electronic Avometer Type EA 113 (or equivalent)

(b) Model 8 Avometers

(c) Valve E55L (standardised for mutual conductance at 16mA anode current)
= 8233

(d) Resistors various. 1MΩ ± 5%, 1kΩ 3W variable, 3.9kΩ ± 5% 4.5W,
960Ω ± 5% with a rating of greater than 30W,
150Ω ± 1% 5W

(e) 500V Megger

(f) Valve 12AT7 and Rectifier Valve U52
= ECC81 = 5U4GB

(g) Silicon Diode DD05B
e.g. BY100

## GENERAL NOTES

Care should be exercised when servicing due to the presence of up to 480V rms within the interior of the instrument.

All measurements and tolerances stated do not include those of the testing instrument, and where necessary, these should be ascertained, in order that they may be taken into consideration during calibration procedure. It is recommended that the specified instruments are 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 the original position.

## TO CHECK THE ACCURACY USING STANDARDISED VALVES

Where the accuracy of the instrument is in doubt, standardised valves may be used to check the instrument. For this, an Ia/Vg curve must be plotted at recommended Va (See Valve Data Book). From the curve obtain the Mutual Conductance at a point (Ia/Vg) preferably given by the Valve Data Book, if it is on the linear portion of the characteristic.

$$\text{Mutual Conductance} = \frac{Ia}{Vg}$$

Adequately smoothed dc supplies should be used and Model 8 Avometers to monitor Va, Ia and Vg. A valve to be standardised must be aged for at least 24 hours and once the valve is standardised it must be labelled and dated.

# RAPID PERFORMANCE CHECKS

(a) Ensure that the mains switch is off.

(b) Ascertain the voltage of the mains supply and set the MAINS VOLTAGE SELECTOR to the value nearest to that of the mains supply. Access to the VOLTAGE SELECTOR PANEL can be gained by removal of the left-hand side panel, which exposes a coarse voltage selector marked 110, 120, 200, 210, 220, 230 and 240V. The fuse should be inserted in the position which is marked with the nearest value to the supply voltage available.

(c) Connect the mains lead of the instrument to the mains power supply. Set the MAINS switch on the panel to its 'on' position and observe that the red panel indicator lamp is illuminated.

(d) Set the CIRCUIT SELECTOR switch to the position CHECK (C) and the LEAKAGE switch to ~ . The mA meter pointer should now move across the scale and come to rest near the black region of the insulation scale thus denoting zero ohms.

(e) Rotate the SET ~ control until the meter pointer is as near as possible to the red line marked ~ in the middle of this black scale marking.

(f) If the initial setting of the MAINS VOLTAGE SELECTOR is correct, it will be possible for the meter pointer to be moved to either side of the red line using the SET ~ control.

(g) If this is not possible and rotation of the SET ~ control does not enable the pointer to reach the ~ mark from either direction, then the initial mains setting should be moved to the next appropriate tapping. If the pointer is too far right of the ~ mark, move to the next higher tapping and, in a similar manner, it should be moved to the next lower tapping if the pointer is too far to the left of the ~ mark.

(h) Once the mains voltage setting has been correctly set, provided extensive mains fluctuations do not occur, test voltages should be automatically correct throughout the instrument.

(j) Using standardised valves check that for a given anode current the bias is within ± 5% of range value ±0.25V and $g_m$ is within ± 5% f.s.d. of standardised value.

(k) Check the 'Gas' position of the CIRCUIT SELECTOR switch. Insert a 1MΩ resistance between $g'_1$ and C. Set VALVE PIN SELECTOR switches 1 and 2 to c and $g'_1$ respectively and tap pins 1 and 2 on SP14S.

(m) Adjust grid volts for half full scale deflection on mA meter. The grid volts should be between 45 and 55.

(n) Disconnect the resistance and switch off.

## SIMPLE FAULTS

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 also readily accessible.

| Symptoms | Possible Fault | Action |
|---|---|---|
| No red panel lamp indication | No mains input<br>Indicator bulb burnt out | Check mains connector<br>Replace red indicator bulb |
| No red panel lamp indication or meter deflection | Fuse blown | Check MAINS VOLTAGE SELECTOR. Replace fuse |
| No indication of meter current | No anode volts at valve pin | Check that the anode link is tight and making firm contact |
| No indication of meter current and protective relay operates when testing tetrodes or pentodes | No anode volts at valve pin (screen volts present) | Check that anode link is tight and making firm contact |

## PROTECTIVE RELAY OPERATION

(a) Connect a 960Ω ± 5% resistor with a rating of 30W between anode and cathode circuits.

(b) Set the Anode Volts to 12.6, the mA switch to Ia 100 and CIRCUIT SELECTOR to 'Test'

(c) Connect the instrument to the mains supply (See Rapid Performance Checks) and switch on.

(d) Increase the Anode Volts step by step until the cut-out operates. The voltage at which this occurs must lie within the limits 175V to 350V inclusive.

(e) Set the Anode Volts to 150 and switch instrument on and off several times. The cut-out must not operate.

(f) Repeat at 350V. The cut-out must operate every time.

Should the overload relay operate during testing (indicated by the lighting of the blue overload lamp on the front panel) switch off and check for incorrect setting of the SELECTOR switch or electrode voltages. If these are correct, but the relay continues to operate when the instrument is switched on again, the valve is probably soft and the test should proceed no further. Switch off and remove the valve under test. When switched on again, the instrument should function normally.

# SERVICING THE VALVEHOLDER PANEL

The valveholder panel is connected electrically to the control panel by means of a 12-way tagboard. The wiring of the valveholders on the panel is in the form of thirteen separate loops, all pins numbered '1' comprising a loop and linking in roller '1' of the ROLLER SELECTOR switch, and pins numbered '2' forming a second loop and linking to roller '2', and so on.

This form of connection is used for all other pins, all thirteen circuits being approximately equal in length and following a similar path around the panel. These loops are loaded with ferroxcube beads which sufficiently damp the loop to prevent the valve breaking into parasitic oscillation. Ferrox beads are also used on leads feeding the ROLLER SELECTOR switch as a further protection against oscillation.

Where it is necessary to replace valveholders, those fitted to the panel with nuts and bolts are easily removable. When removing rivetted valveholders 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.

## VOLTAGE CHECKS WITH NO VALVE UNDER TEST

Connect the instrument via a variac to the mains input. The output from the variac should be monitored with an ac voltmeter which is accurate to ± 0.5% at 240V. Adjust the variac until the voltmeter reads 240V. The mains fuse should be inserted in the VOLTAGE SELECTOR panel for 240V operation. Ensure that the instrument is switched off whilst making these adjustments.

Set switches as follows: Set ~ at mid-point, Leakage at ~ , CIRCUIT SELECTOR at CHECK (H) or CHECK (C).

Anode and Screen Voltages

(a) Set VALVE PIN SELECTOR switches TC1 and TC2 to 1 and 8 respectively

(b) Connect an Avometer Model 8 (set to measure dc volts) across the top cap sockets.

(c) Set the mA switch to Ia = 100 and CIRCUIT SELECTOR switch to Test.

(d) Vary the Anode Volts from 12.6 to 400 and observe the following limits:

| NOMINAL | ACTUAL | LIMITS |
|---|---|---|
| 12.6 | 7.24 | 6.7 - 7.2 |
| 20 | 11 | 10.3 - 11.1 |
| 30 | 16.05 | 15.2 - 16.3 |
| 40 | 21.1 | 20.2 - 21.4 |
| 50 | 26.2 | 25.1 - 26.7 |
| 60 | 31.25 | 30.1 - 31.9 |
| 75 | 38.8 | 37.5 - 39.7 |
| 90 | 46.4 | 44.7 - 47.5 |
| 100 | 51.5 | 49.7 - 52.7 |
| 125 | 64.2 | 62.2 - 65.7 |
| 150 | 77 | 74.7 - 78.7 |
| 175 | 89.65 | 87.2 - 91.7 |
| 200 | 102.3 | 100 - 105 |
| 225 | 115 | 112 - 118 |
| 250 | 128 | 125 - 131 |
| 275 | 140.5 | 137 - 144 |
| 300 | 153.3 | 150 - 157 |
| 350 | 178.9 | 175 - 183 |
| 400 | 204 | 200 - 208 |

(e) Set TC2 to 7 and observe that the above readings are repeated as the Screen Volts are varied.

Heater Voltages

(a) Set the VALVE PIN SELECTOR switches TC1 and TC2 to 2 and 3 respectively.

(b) Connect a Model 8 Avometer set for ac voltage across TC1 and TC2.

(c) Set the CIRCUIT SELECTOR to CHECK (H) and measure Heater Volts.

| NOMINAL | ACTUAL | NOMINAL | ACTUAL |
|---|---|---|---|
| 0.1 | 0.102 | 40 | 40.8 |
| 0.2 | 0.204 | 50 | 51 |
| 0.3 | 0.306 | 60 | 61.2 |
| 0.4 | 0.41 | 70 | 71.4 |
| 0.5 | 0.51 | 80 | 81.6 |
| 10 | 10.2 | 90 | 91.8 |
| 20 | 20.4 | 100 | 102 |
| 30 | 30.6 | 110 | 112.2 |

Limits are not given for this test, the purpose of the test is to ensure that the correct tapoings of the transformer are connected to their appropriate switch positions.

(d) Switch off and remove the meter.

## SETTING-UP PROCEDURE

Note: The Multimeter used in the following calibration procedure should be standardised at the appropriate voltages before making any adjustment as mentioned in the following paragraphs.

(a) Set all pre-set controls at approximately mid-point (RV1, RV2 and RV3 on the potentiometer board and RV1 and RV2 on the oscillator board). If the instrument has been previously calibrated and no replacement of relevant components has been necessary, do not adjust the potentiometers unless it is obvious that adjustment is required.

(b) Check mechanical zero adjustment on panel mounted meters and set zero if required on both meters.

(c) Set the VOLTAGE SELECTOR to 240 volts and check that the mains wires are connected to their appropriate tags (Red - line, Black - N, Green - E.)

(d) Carry out a continuity test with the Model 8 ensuring that earth is connected to the frame of the instrument.

(e) Using the 500V Megger, test the insulation between:

(i) *zero line and mains wire (Red - line, Black - neutral)
(ii) zero line and the frame of the instrument.

* a convenient point on the zero line is the junction of LP1 and LP2.

With the instrument supply switch at 'on' the insulation should be greater than 100MΩ).

(f) Feed the mains input from a variac (output from variac to be monitored with an ac voltmeter which is accurate to ± 0.5% at 240 volts). Adjust variac until voltmeter reads 240V.

(g) With the instrument switched on, set switches as follows:

SET ~ at mid-point, LEAKAGE at ~ , CIRCUIT SELECTOR at CHECK (H) or CHECK (C).

(h) Set the mA meter to the red line marked ~ by adjusting RV3 and ensuring that the ac voltmeter reads exactly 240V at this point.

(j) Rotate the SET ~ switch from full anti-clockwise position to full clockwise position and check that an increase is indicated on the mA meter for each position of the switch.

(k) Connect a dc voltmeter between zero line and the junction of RV2 and R21. The accuracy of the voltmeter must be ± 0.5% at 52V dc and the sensitivity 20,000Ω/V or higher.

(m) Set the CIRCUIT SELECTOR switch to Test and adjust RV2 until the voltmeter reads 52V dc, again ensuring that the mains is exactly 240V.

(n) Connect a dc voltmeter (Model 8) across zero line and the slider of RV4 (mounted on the front panel). Set the Grid volts control such that when the cursor is at zero the voltmeter reads zero and there is an indication on the meter immediately after the cursor passes the zero position.

(p) Replace the Model 8 by an electronic multimeter and with the cursor set to 5, set the Grid volts switch to each position in turn.

(q) The voltage should read 0.78, 2.6, 7.8 and 26 volts ± 3% as the Grid Volts switch is set to 0-3, 0-10, 0-30 and 0-100 respectively.

(r) Check that the oscillator board is connected to the correct H.T. transformer tappings, i.e. oscillator board tags 1 and 2 are connected to transformer tags 6 and 8. Check that the voltage across tags 1 and 2 is approximately 24V r.m.s. and the voltage across C7 (oscillator board) is approximately 12V dc ± 5%.

(s) Connect the electronic multimeter across the red and brown (earthy) sockets on the amplifier board. Set the electronic multimeter to the 30mV ac range (or as appropriate) and adjust RV1 on the oscillator board until the multimeter reads 15mV. This setting is only correct when the ambient temperature is between 18° and 22°C.

(t) Set the mA/V switch to Cal and RV1 on the potentiometer board to mid-range. (Do not adjust RV1 if it has not been replaced).

(u) Adjust RV2 (oscillator board) until the mA/V meter pointer is on the red line marked Cal. Final fine adjustment can be made by adjusting RV1 on the potentiometer board.

(v) Connect a sub-standard dc ammeter in series with a 1kΩ variable 3W resistor and 3.9kΩ ± 5%, 4.5W fixed resistor. Connect the whole arrangement across anode and cathode links on the valve panel.

(w) Set the mA switch to Ia, 3mA, the Anode Volts to 12.6 and the CIRCUIT SELECTOR switch to Test. Adjust the variable resistor to set the mA meter to full scale. The sub-standard meter should read 1.5mA ± 2.5%. Repeat this test for the following switch settings:

| Ia | Va | Sub-standard meter reading |
|---|---|---|
| 10 | 40 | 5mA ± 2.5% |
| *30 | 12.6 | 15mA ± 2.5% |
| *100 | 50 | 50mA ± 4% |

*For these settings short the 3.9kΩ resistor.

## FINAL TEST PROCEDURE

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

(a) Apply a 500V Megger test between the mains input and frame.

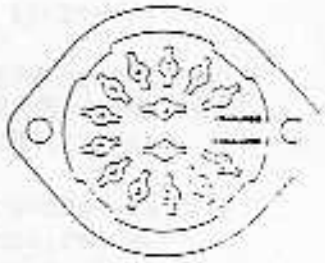
(b) Apply 240V via a variac to the instrument and adjust the meter pointer to the ~ mark on the scaleplate. (For full details see Rapid Performance Checks (d) to (g).

(c) Set the VALVE PIN SELECTOR switch to 123 456 789 XYZO

(d) Set the CIRCUIT SELECTOR switch to CHECK (C)

(e) Using the SP14S valveholder on the valve panel, connect a 1MΩ ± 5% resistor between pin 1 and the pins listed below, as the LEAKAGE switch is set to the positions shown. For each setting the mA meter should read 1MΩ ± 10%. For convenience, the pin numbering of the SP14S valveholder is given in the diagram.

| Pins | Leakage switch setting |
|---|---|
| 2 | h (C) |
| 3 | c (C) |
| 4 | $g'_1$ |
| 5 | $g''_1$ |
| 6 | $g'''_1$ |
| 7 | $g_2$ |
| 8 | a |
| 9 | $a'_d$ |
| 10 | $a''_d$ |
| 11 | $a'''_d$ |
| 12 | $a''''_a$ |



(f) Set the CIRCUIT SELECTOR switch to CHECK (H) and test as in (e) for one or two positions.

(g) Set the CIRCUIT SELECTOR switch to C/h INS and connect the 1MΩ resistor between cathode and heater. The meter should again read 1MΩ ± 10%.

(h) Set the Anode Volts to 12.6, the mA switch to Ia 100 and CIRCUIT SELECTOR to Test.

(j) Connect a resistor of 960Ω ± 5% having a rating of much greater than 30W between anode and cathode circuits.

(k) Increase the Anode volts step by step until the cut-out operates. The voltage at which this occurs must lie within the limits of 175V to 350V inclusive.

(m) Set the Anode volts to 150 and switch instrument on and off several times. The cut-out must not operate. Repeat at 350 volts. The cut-out must operate every time.

(n) Set VALVE PIN SELECTOR switch to 817 231 141, Anode and Screen volts to 125V, Grid volts to 3V and Heater volts to 6.3V. Set the ELECTRODE SELECTOR switch to a'. Insert an ESSL standardised valve and obtain the values applicable to the valve as standardised. Ensure that the valve does not oscillate.

(p) Repeat (n) for the following settings:

| Valve Pin Selector | Electrode Selector |
|---|---|
| 817 231 151 | a" |
| 817 231 161 | a"' |

(q) Set the CIRCUIT SELECTOR switch to Gas position and observe that both meters read zero. (Half a division on the top scale is permitted). Both meters must also read zero when the mA/V push-button is depressed.

(r) Using standardised valves* check that for a given anode current the bias is within ± 5% of range value ± 0.25V and that $g_m$ is within ± 5% f.s.d. of standardised value.

*One valve for each range and a directly heated valve must be tested.

(s) Check the Gas position of the CIRCUIT SELECTOR switch. Insert a one megohm resistor between $g'_1$ and C, set VALVE PIN SELECTOR switches 1 and 2 to c and $g'_1$ respectively and tap pins 1 and 2 on SP14S. Adjust Grid volts for half full scale deflection on mA meter. The voltage across the 1MΩ resistor should be between 45 and 55V.

(t) Using the Avo Valve Data Manual set up the instrument to test a valve 12AT7. Switch the CIRCUIT SELECTOR to Gas. There should be no reverse deflection of the pointer for any bias more negative than -3V.

(u) Connect a 150Ω resistor ± 1%, 5W in series with a silicon diode DD058. Use this as a standard rectifier to test the D/R ranges. Set the VALVE PIN SELECTOR switches 1 and 2 to c and $a'_d$ respectively, and tap pins 1 and 2 on SP14S.
The readings should be as listed below:

| D/R Range | Reading on 100 scale |
|---|---|
| 180mA | 67 - 82 |
| 120mA | 70 - 85 |
| 60mA | 75 - 90 |
| 30mA | 80 - 95 |
| 15mA | 85 - 95 |
| 5mA | 87 - 97 |
| 1mA | 95 -103 |

(v) Set up the instrument in accordance with the Avo Valve Data Manual to test a rectifier valve U52 using a valve which is known to be good. Set the ELECTRODE SELECTOR at $a'_d$ and $a''_d$ and check that the pointer lies near the centre of the 'Good' region, i.e. between 70 and 80 on the 0 - 100 scale.

(w) Re-set the VALVE PIN SELECTOR switch to supply diode anodes $a'''_d$ and $a''''_d$ instead of $a'_d$ and $a''_d$. (VALVE PIN SELECTOR SETTINGS 030 ZOY 020).

Check as in (v) that the same readings are now obtained in the appropriate position of the ELECTRODE SELECTOR switch.

(x) Switch off and remove all test instruments. Set the CIRCUIT SELECTOR and mA switches to Test and . respectively before transport.

## SPARE PARTS LISTS

Individual assemblies are illustrated in Figs. 2 to 9 incl. An associated Parts List is given for each assembly which details the description and relevant Part No. of the individual components.

An overall interior view of the instrument is given in Fig. 1 which indicates the location of the individual assemblies.

Following the illustrations additional Parts Lists in Circuit Reference No. order are given for each Circuit Diagram.

## PROCEDURE FOR ORDERING SPARE PARTS

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

(i) Identify the spare part required from the appropriate Figure and ascertain the AVO Part No.

(ii) When ordering state the Part No. and description of the item required, its location in the instrument and instrument serial number.

Overseas users should send their requirements to the AVO representative on their territory. If Parts are required in the United Kingdom application should be made direct to Avo Limited.

FIG. 1 CHASSIS ASSEMBLY

| Item No. | Description | AVO Part No. |
|---|---|---|
| 1 | mA/Volt Switch Assembly S8 (see Fig. 6) | 45190 |
| 2 | Valve Panel Assembly (see Fig. 5) | 45215 |
| 3 | mA Switch Assembly S3 (see Fig. 7) | 45189 |
| 4 | Front Panel Assembly (see Fig. 2) | 45193 |
| 5 | Grid Volts Switch Assembly S10 (see Fig.8) | 45188 |
| 6 | Component Board Assembly (see Fig. 9) | 45194 |
| 7 | Amplifier Board Assembly (see Fig. 3) | 45001 |
| 8 | Oscillator & Power Unit Board Assembly (see Fig. 4) | 45002 |
| RV1 | Potentiometer 500Ω | 27133-325 |
| RV2 | Potentiometer 1kΩ | 27133-331 |
| RV3 | Potentiometer 2kΩ | 27133-341 |
| T1 | H.T. Transformer Assembly | 45185 |
| T2 | L.T. Transformer Assembly | 45197 |
| RL1 | Relay | 45211 |
| C1-C4 | Capacitors 1μF 400V | 27538-318 |
| D4 | Diode OD058 | 28461-501 |
| D5, D6 | Diode IN2069 | 28462-696 |

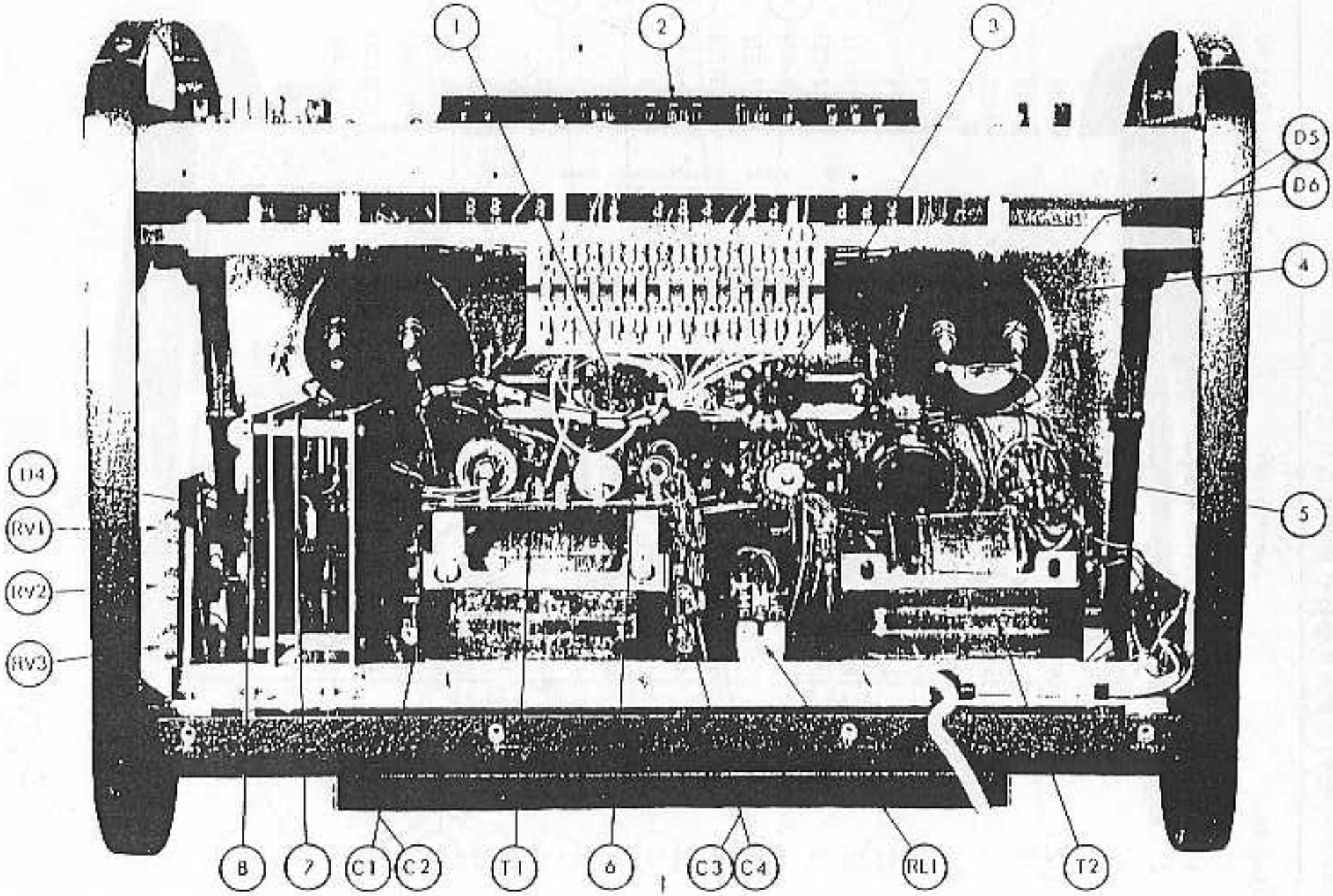



Fig1 Chassis Assembly

FIG. 2- FRONT PANEL ASSEMBLY 45193

| Item No. | Description | Avo Part No. |
|---|---|---|
| 1 | Switch Circuit Selector S5 | 45187 |
| 2 | Switch Electrode Selector S4 | 45828 |
| 6 | Switch mA/V S8 (see Fig. 6) | 45190 |
| 9 | Switch mA S3 (see Fig. 7) | 45189 |
| 12 | Switch Grid Volts S10 (see Fig. 8) | 45188 |
| 13 | Switch Heater Volts S11 | 45818 |
| 14 | Switch Heater Volts S12, S13 | 45825 |
| 15 | Switch Screen & Anode Volts S1, S2 | 45803 |
| 20 | Switch Set Cycles S14 | 45823 |
| 21 | Switch Leakage S6 | 45816 |
| 22 | Toggle Switch On/Off S15 | 25454-251 |
| 23 | Indicator Lamp (Red) LP2 | 25517-233 |
| 24 | Bulb 6.5V 0.35A | 25514-679 |
| 25 | Indicator Lamp (Blue) LP1 | 25517-235 |
| 26 | Potentiometer Grid Volts RV4 | 27238-232 |
| 28 | Front Panel | 3286-619 |
| 30 | Meter Assembly mA/V | 45206 |
| 31 | Meter Assembly mA | 45191 |
| 33 | Knob Assembly | 45913 |
| 37 | Push-button switch mA/V S7 | 45431 |
| 38 | Push-button switch mA S9 | 45524 |
| 39 | Knob Collet Black | 23762-235 |
| 40 | Knob Cap Grey | 23762-884 |
| 41 | Knob Skirt Black | 23762-854 |
| 42 | Resistor 2.4k ± 1% (R33) | 26232-382 |
| 43 | Resistor 56k ± 2% (R32) | 26834-497 |

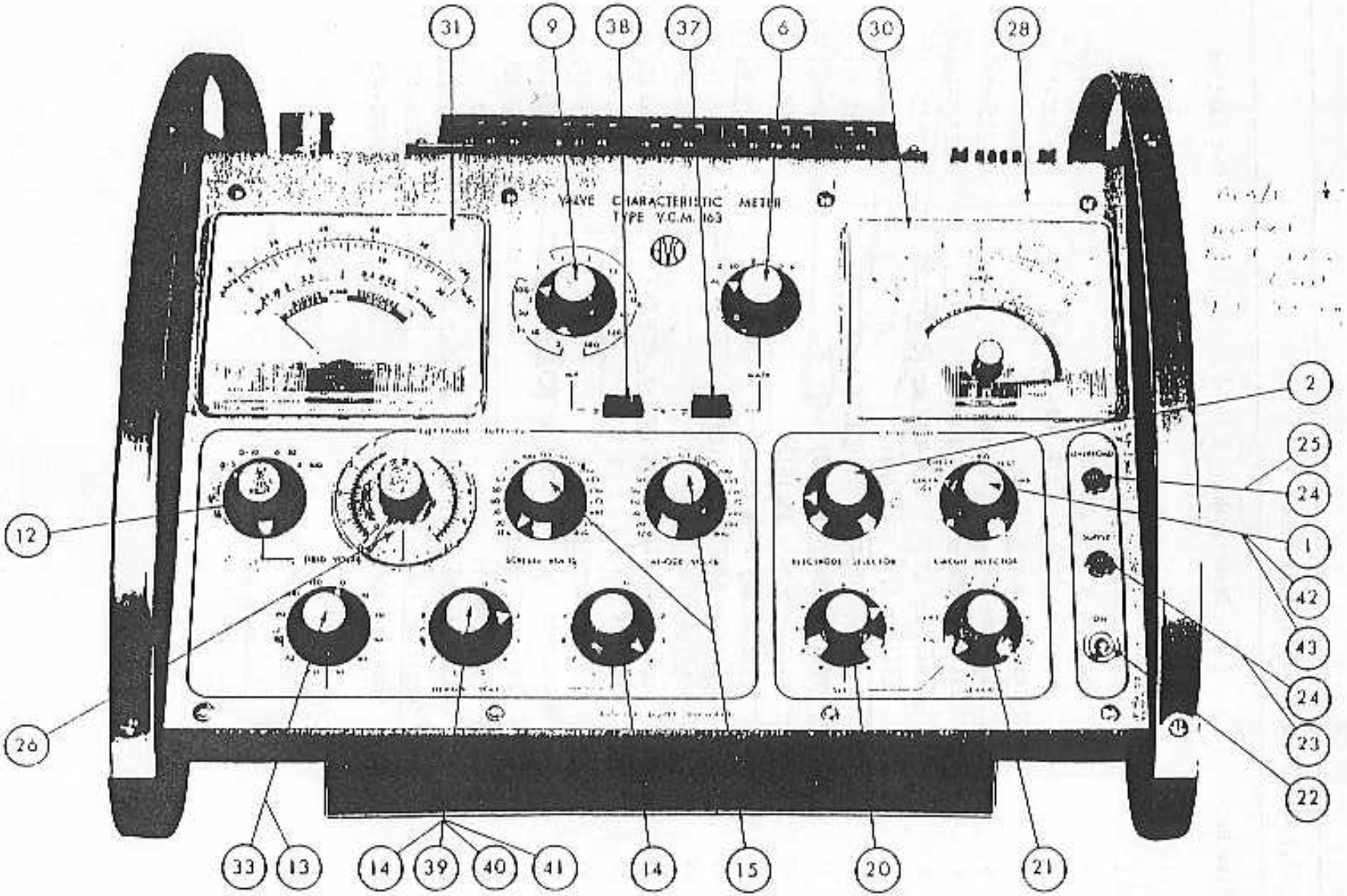



Fig 2 Front Panel Assembly 45193

FIG.3-AMPLIFIER BOARD ASSEMBLY 45001

| Item No. | Description | Avc Part No. |
|---|---|---|
| 1 | Printed Circuit Board | 3218-326 |
| 2 | Transistors 2N2925 (VT1, 2 & 3) | 28552-601 |
| 3 | Resistor 9.1k ± 2% (R2) | 26834-479 |
| 4 | Capacitor 0.01μF ± 20% 160V dc (C4) | 27532-103 |
| 5 | Resistor 56k ± 2% (R6) | 26834-497 |
| 6 | Resistor 10k ± 2% (R5, R8) | 26834-479 |
| 7 | Resistor 20k ± 2% (R7, R11) | 26834-485 |
| 8 | Capacitor 330pF ± 20% 400V dc (C10) | 27530-331 |
| 9 | Resistor 3.3k ± 2% (R9) | 26834-467 |
| 10 | Capacitor 10μF 15V dc (C3, 5 & 6) | 27462-403 |
| 11 | Resistor 82k ± 2% (R10) | 26834-503 |
| 12 | Resistor 5.6k ± 2% (R13) | 26834-473 |
| 13 | Resistor 22k ± 2% (R12) | 26834-487 |
| 14 | Capacitor 50μF 15V dc (C7) | 27462-413 |
| 15 | Resistor 200Ω ± 1% (R14) | 26232-368 |
| 16 | Capacitor 0.47μF ± 10% 160V dc (C8,C9) | 27537-147 |
| 17 | Diode IN 914 (D1, 2, 3 & 4) | 28433-001 |
| 19 | Printed Circuit Tags | 25255-372 |
| 20 | Capacitor 1μF ± 2% 150V dc (C1) | 27533-849 |
| 21 | Resistor 10Ω ± 1% (R1) | 26232-323 |
| 22 | Transformer | 45003 |
| 23 | Capacitor 1990pF ± 2% 125V dc (C2) | 27522-133 |
| 24 | Resistor 15k ± 1% (R3) | 26232-407 |
| 25 | Resistor 30k ± 1% (R4) | 26232-409 |

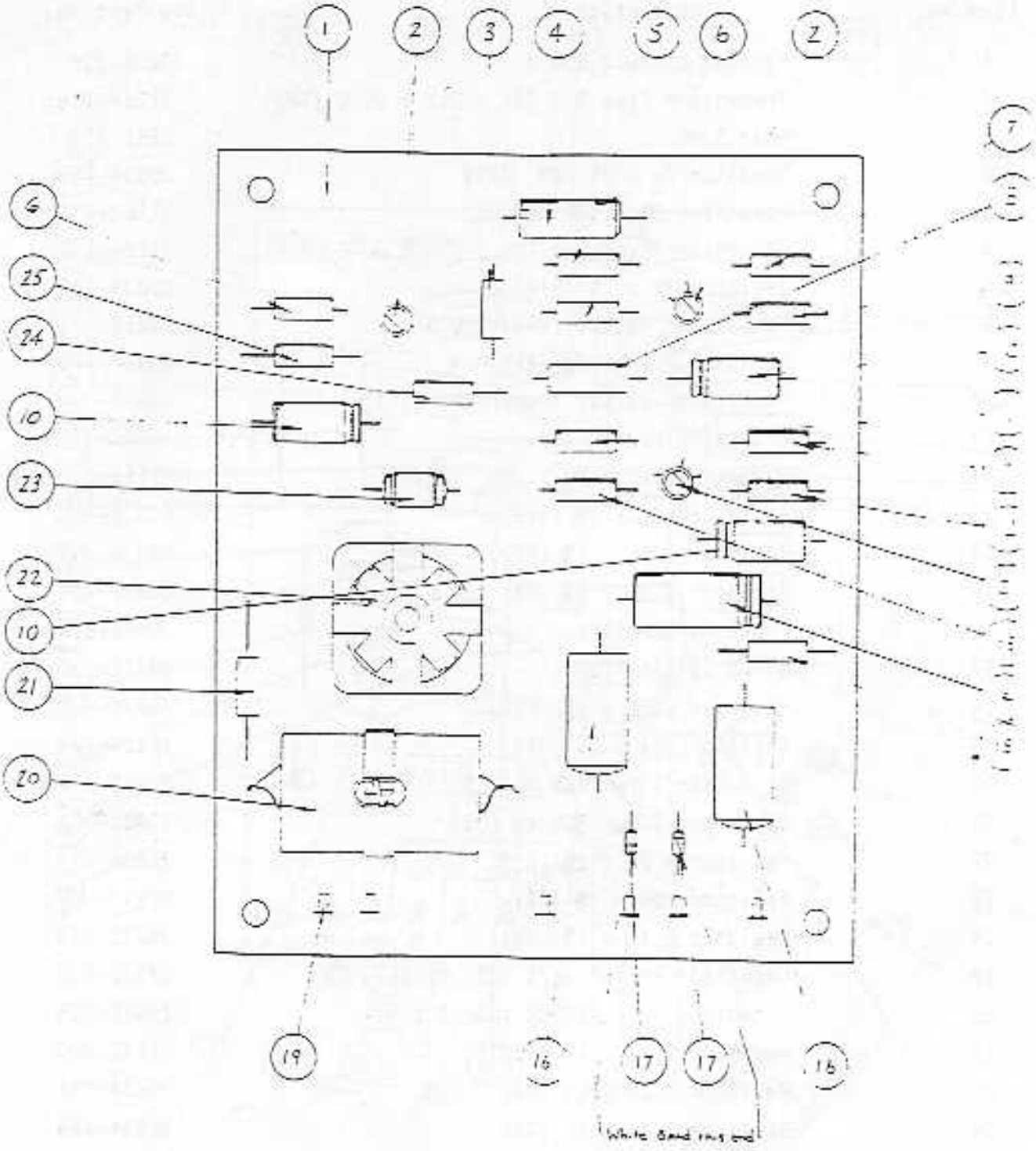



Fig 3 Amplifier Board Assembly 45001

FIG.4- OSCILLATOR AND POWER UNIT BOARD ASSEMBLY 45002

| Item No. | Description | Avo Part No. |
|---|---|---|
| 1 | Printed Circuit Board | 3218-328 |
| 2 | Thermistor Type R14 10k ± 20% @ 20°C (TH2) | 27284-318 |
| 3 | Heat Sink | 3566-616 |
| 4 | Resistor 1k ± 2% (R9, R10) | 26834-466 |
| 5 | Capacitor 50µF 15V dc (C6) | 27462-413 |
| 6 | Thermistor Type A14 10k ± 20% @ 20°C (TH1) | 27284-330 |
| 7 | Resistor 3k ± 2% (R14) | 26834-466 |
| 8 | Transistor 2N2926 (VT1, 2 & 3) | 28552-601 |
| 9 | Resistor 4.3k ± 2% (R15) | 26834-470 |
| 10 | Oscillator Output transformer (T1) | 45004 |
| 11 | Printed Circuit Tags | 25255-372 |
| 12 | Potentiometer 4.7k ± 20% (RV2) | 27113-712 |
| 13 | Resistor 30Ω ± 2% (R18) | 26834-418 |
| 14 | Resistor 1.5k ± 2% (R11) | 26834-459 |
| 15 | Resistor 3.3k ± 2% (R8) | 26834-467 |
| 16 | Diode IS 921 (D1) | 28461-824 |
| 17 | Diode IZ12575 (D2) | 28476-287 |
| 18 | Resistor 620Ω ± 2% (R17) | 26834-450 |
| 19 | Resistor 36k ± 2% (R6) | 26834-492 |
| 20 | Capacitor 100µF 15V dc (C7) | 27462-417 |
| 21 | Capacitor 200µF 30V dc (C8) | 27462-421 |
| 22 | Resistor 8.2k ± 2% (R3) | 26834-477 |
| 23 | Resistor 20k ± 1% (R1) | 26232-404 |
| 24 | Resistor 6.8k ± 1% (R2) | 26232-393 |
| 25 | Capacitor 1990pF ± 2% 125V dc (C1, C2) | 27522-133 |
| 26 | Capacitor 10µF 15V dc (C3, 4 & 5) | 27462-405 |
| 27 | Resistor 5.1k ± 1% (R13) | 26232-390 |
| 28 | Resistor 1.2k ± 2% (R5) | 26834-457 |
| 29 | Resistor 2.4k ± 2% (R4) | 26834-464 |
| 30 | Potentiometer 1k ± 20% (RV1) | 27113-719 |
| 31 | Resistor 10k ± 2% (R7) | 26834-479 |
| 32 | Resistor 270Ω ± 2% (R12) | 26834-441 |
| 33 | Resistor 10Ω ± 1% (R19) | 26232-325 |
| 34 | Printed Circuit Socket | 45052 |
| 35 | Printed Circuit Socket | 45085 |
| 40 | Resistor 9.1k ± 2% (R16) | 26834-478 |

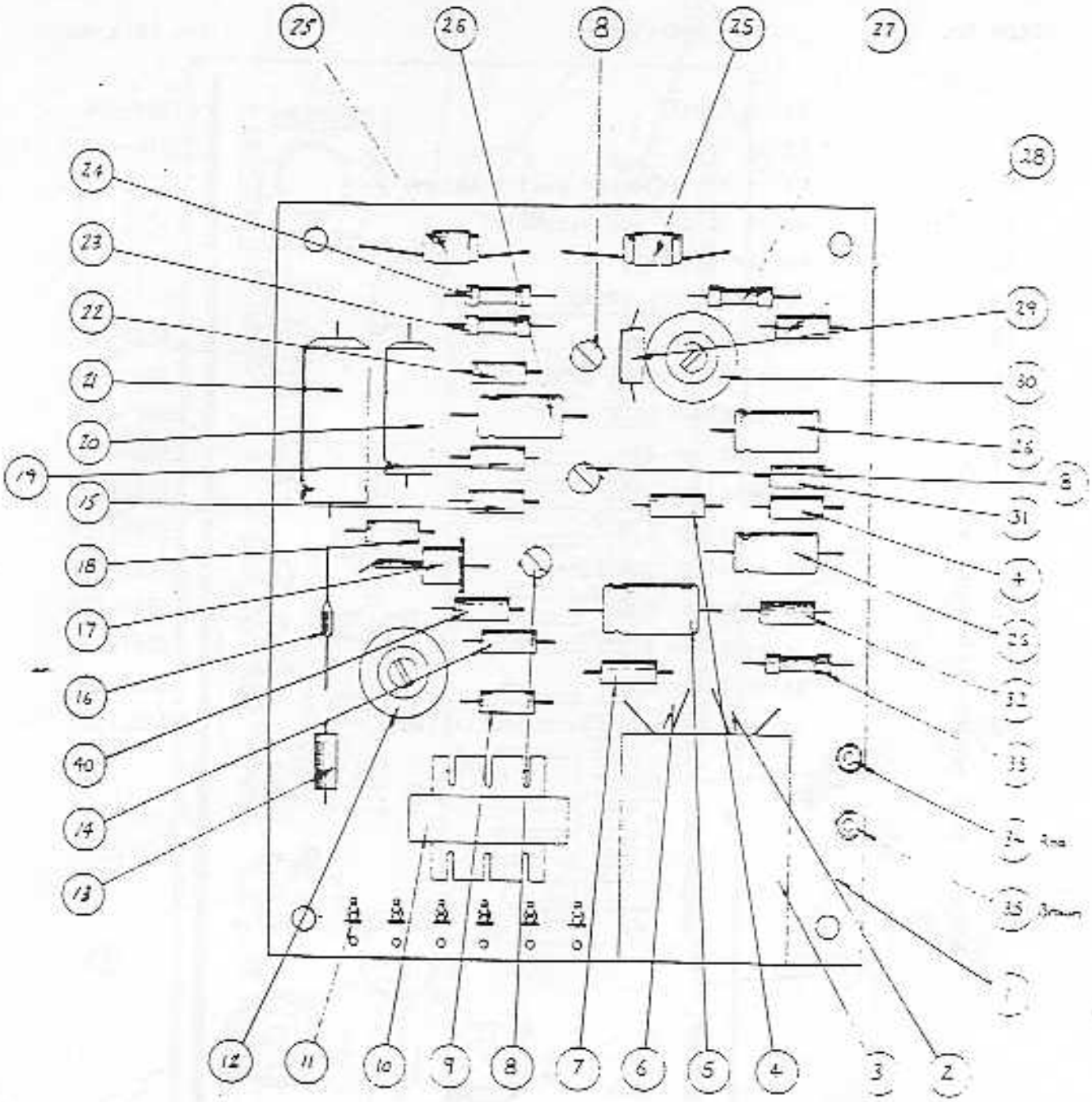



Fig 4. Oscillator and Power Unit Board Assembly 45002

FIG.5- VALVE PANEL ASSEMBLY 45215

| Item No. | Description | Avo Part No. |
|---|---|---|
| 1 | Valve Panel | 3267-506 |
| 2 | Escutcheon | 3876-424 |
| 4 | Valve Pin Selector switch Assembly | 45210 |
| 5 | Valve Holder sub-assembly | 45212 |
| 13 | Holder Assembly | 21199-A |
| 14 | Socket 14-way SP14S | 25423-283 |
| 15 | Valveholder 89G | 28281-163 |
| 16 | Valveholder B4/5 SP5E | 28281-122 |
| 17 | Valveholder B10B | 28281-738 |
| 18 | Valveholder 89A | 28281-709 |
| 19 | Valveholder 89D | 28281-736 |
| 20 | Valveholder I.O | 28281-154 |
| 21 | Valveholder Compactron | 28231-757 |
| 22 | Valveholder B8G | 28281-676 |
| 23 | Valveholder 87G | 28281-632 |
| 24 | Valveholder B8A — | 28281-663 |
| 42 | Ferroxcube Bead (Not illustrated) | 27888-321 |

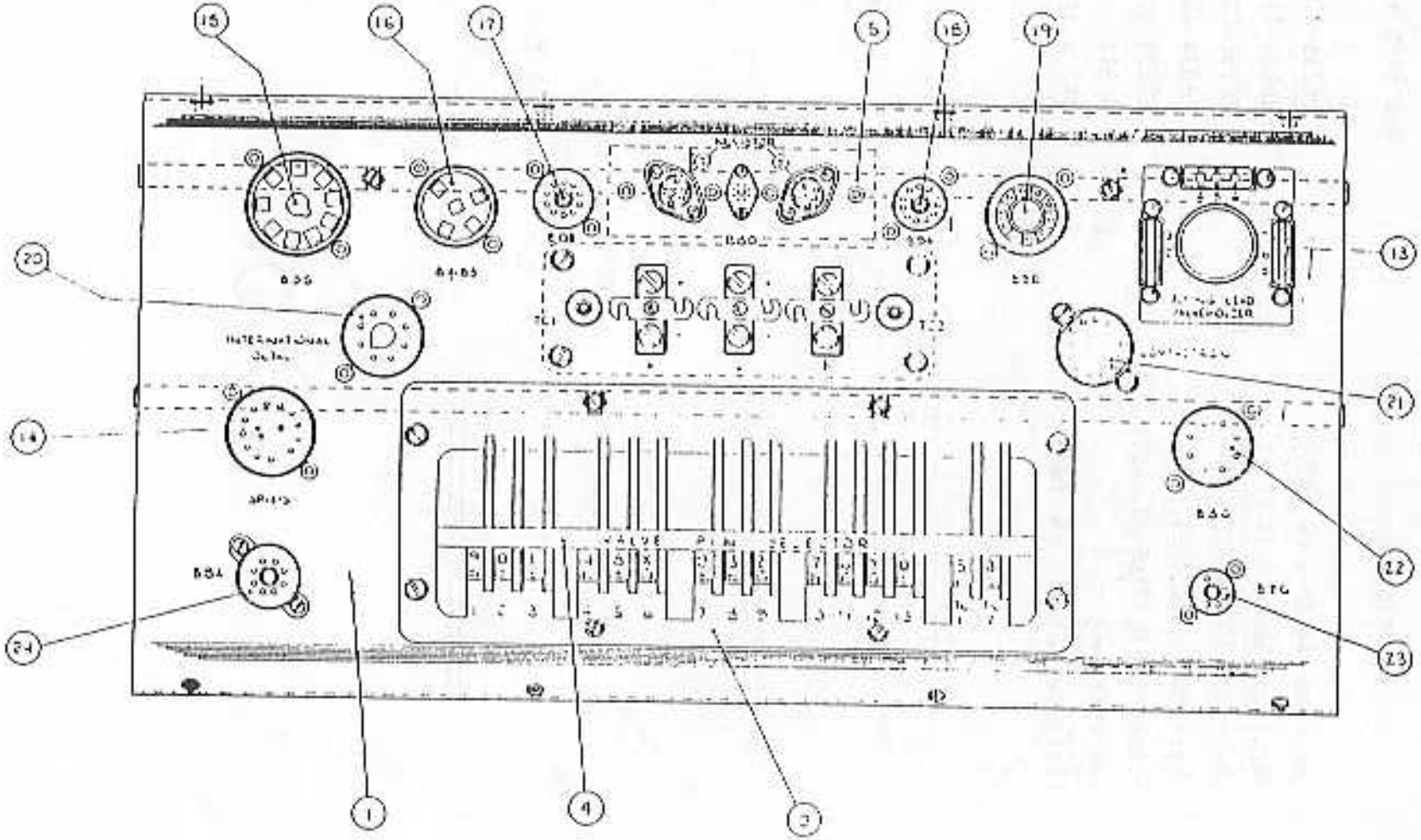



Fig 5. Valve Panel Assembly 45215

FIG.6- mA VOLT SWITCH ASSEMBLY 45190

| Item No. | Description | Avo Part No. |
|---|---|---|
| 1 | Resistor 44.4Ω ± 1% (R28) | 26235-710 |
| 2 | Resistor 88.9Ω ± 1% (R29) | 26235-717 |
| 3 | Resistor 310Ω ± 1% (R30) | 26235-736 |
| 4 | Resistor 1.3kΩ ± 2% (R31) | 26834-458 |
| 5 | Capacitor 0.015μF +0, -20% (C8) | 27532-393 |
| 8 | mA Volt switch | 45821 |
| 9 | Resistor 2.4kΩ ± 2% (R35) | 26834-464 |

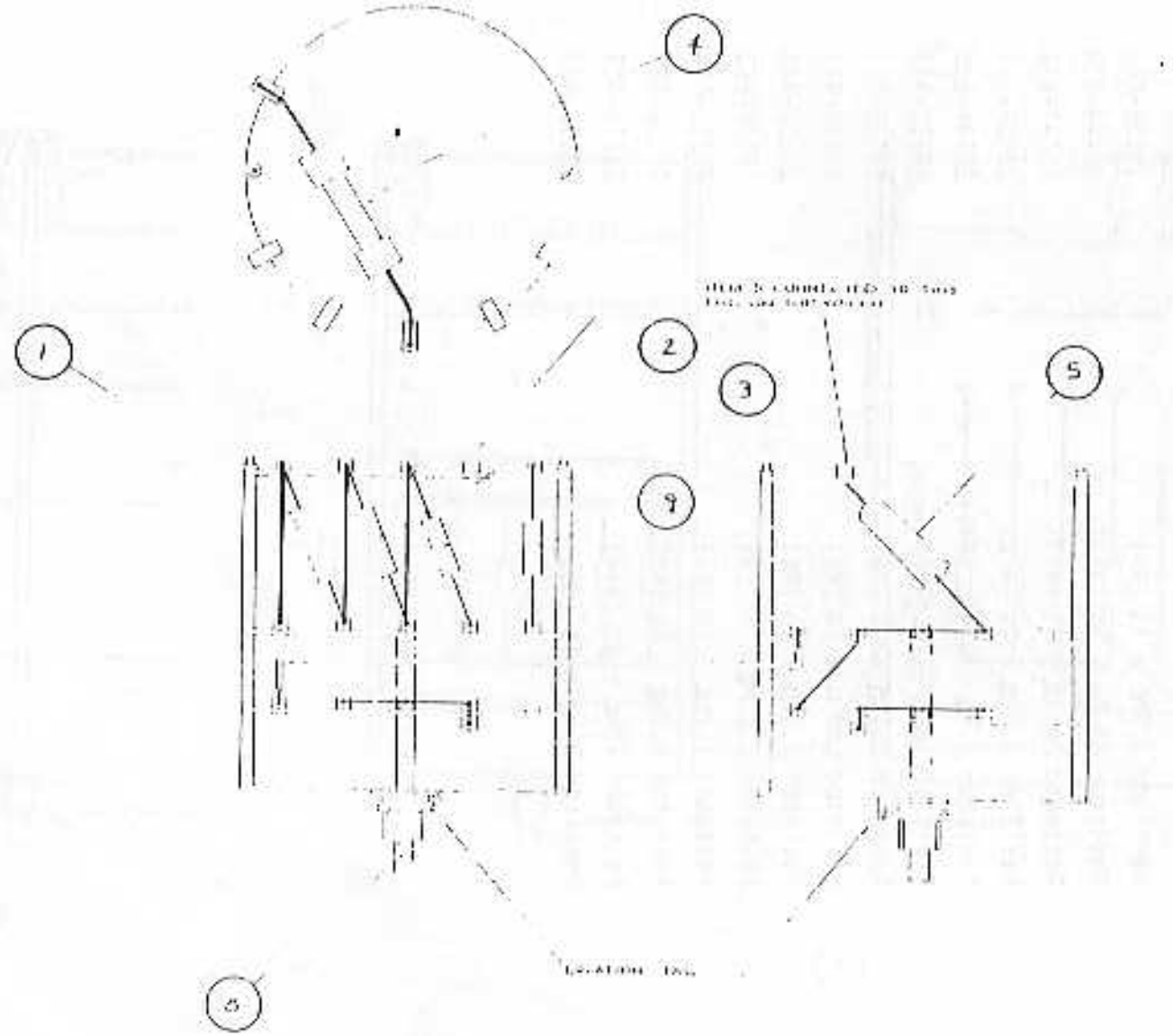



Fig 6. mA Volt Switch Assembly 45190

FIG.7- mA SWITCH ASSEMBLY 45189

| Item No. | Description | Avo Part No. |
|---|---|---|
| 1 | mA Switch | 45815 |
| 2 | Resistor 3.4MΩ ± 1% (R4) | 26236-666 |
| 3 | Resistor 82.8Ω ± 1% (R14) | 26434-232 |
| 4 | Resistor 24.3Ω ± 1% (R13) | 26441-632 |
| 5 | Resistor 8.02Ω ± 1% (R12) | 26437-372 |
| 6 | Resistor 2.4Ω ± 0.05Ω (R11) | 26434-830 |
| 7 | Resistor 16kΩ ± 1% (R10) | 26232-402 |
| 8 | Resistor 281kΩ ± 1% (R8) | 26235-911 |
| 9 | Resistor 680kΩ ± 1% (R7) | 26232-44[illegible] |
| 10 | Resistor 1.3MΩ ± 1% (R6) | 26232-448 |
| 11 | Resistor 2.27MΩ ± 1% (R5) | 26236-660 |
| 12 | Resistor 1.1kΩ ± 1% (R15) | 26233-871 |
| 13 | Resistor 4.3kΩ ± 1% (R16) | 26232-388 |
| 14 | Resistor 22kΩ ± 1% (R17) | 26232-405 |
| 15 | Resistor 91kΩ ± 1% (R9) | 26232-420 |

Fig 7 MA Switch Assembly 45109

FIG.8- GRID VOLTS SWITCH ASSEMBLY 45188

| Item No. | Description | Avo Part No. |
|---|---|---|
| 1 | Grid Volts Switch | 45817 |
| 2 | Resistor 310Ω ± 1% (R23) | 26235-736 |
| 3 | Resistor 1.11kΩ ± 1% (R25) | 26235-767 |
| 4 | Resistor 4.29kΩ ± 1% (R27) | 26235-793 |
| 5 | Resistor 9.7kΩ ± 1% (R22) | 26338-327 |
| 6 | Resistor 9kΩ ± 1% (R24) | 26338-325 |
| 7 | Resistor 7kΩ ± 1% (R26) | 26338-322 |
| 8 | Resistor 2.2MΩ ± 1% (R20, R21) | 26233-653 |
| 9 | Resistor 4.7kΩ ± 2% (R19) | 26334-471 |

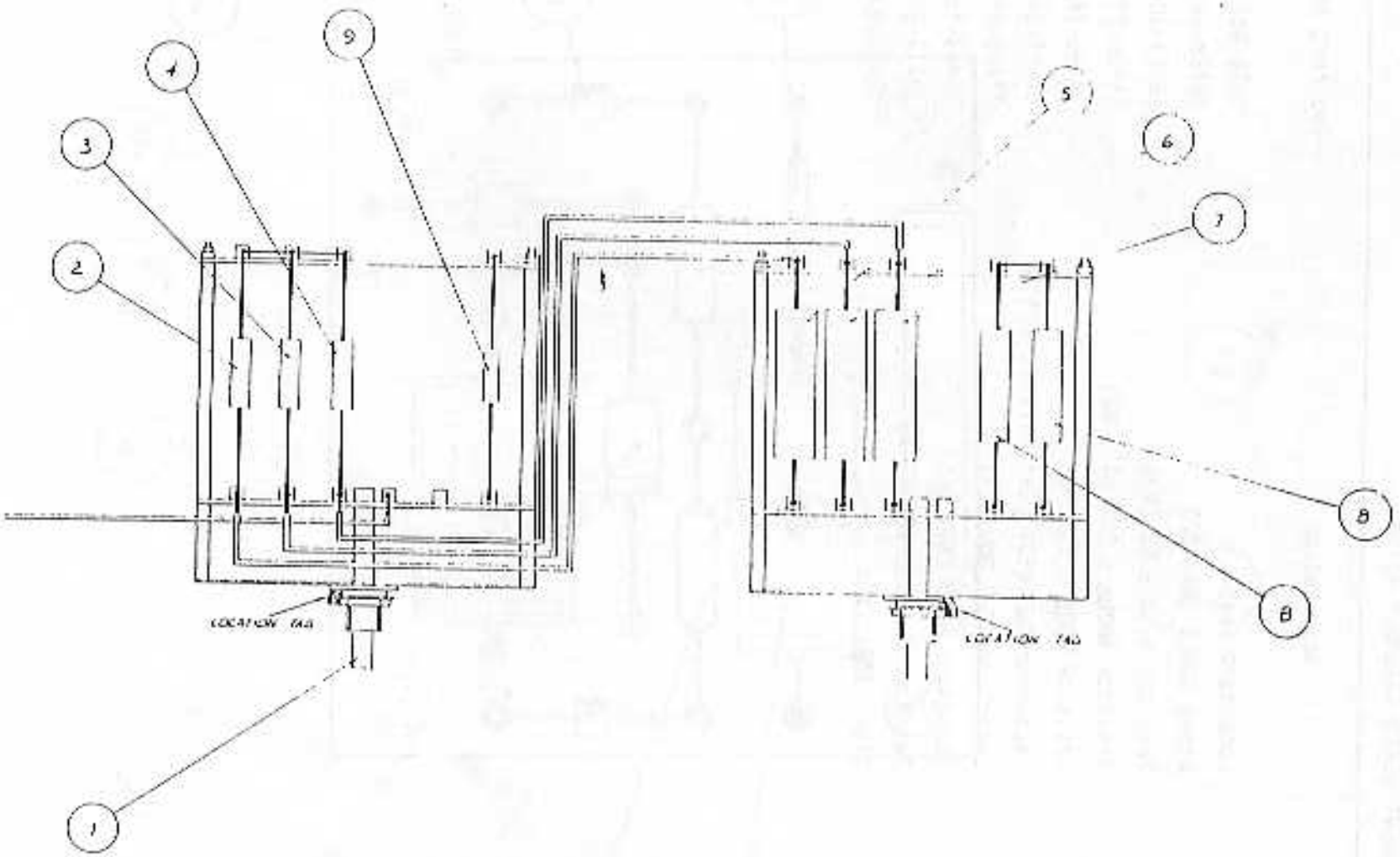



Fig 8 Grid Volts Switch Assembly 45188

FIG.9- COMPONENT BOARD ASSEMBLY 45194

| Item No. | Description | Avo Part No. |
|---|---|---|
| 1 | Component Board | 3836-452 |
| 2 | Diode DD058 (D1, D2) | 28468-601 |
| 3 | Resistor 1.5Ω ± 5% (R34) | 26713-105 |
| 6 | Resistor 100kΩ ± 20% (R1, R2) | 26136-221 |
| 7 | Resistor 700Ω ± 2% (R3) | 26782-267 |
| 9 | Capacitor 8μF 450V Electrolytic (C5) | 27461-214 |
| 10 | Capacitor 25μF 30V (C7) | 27463-410 |
| 11 | Capacitor 60μF 250V (C6) | 27463-660 |
| 12 | Resistor 0.68Ω ± 10% (R18) | 26711-253 |
| 13 | Diode 1081 (D3) | 23461-841 |

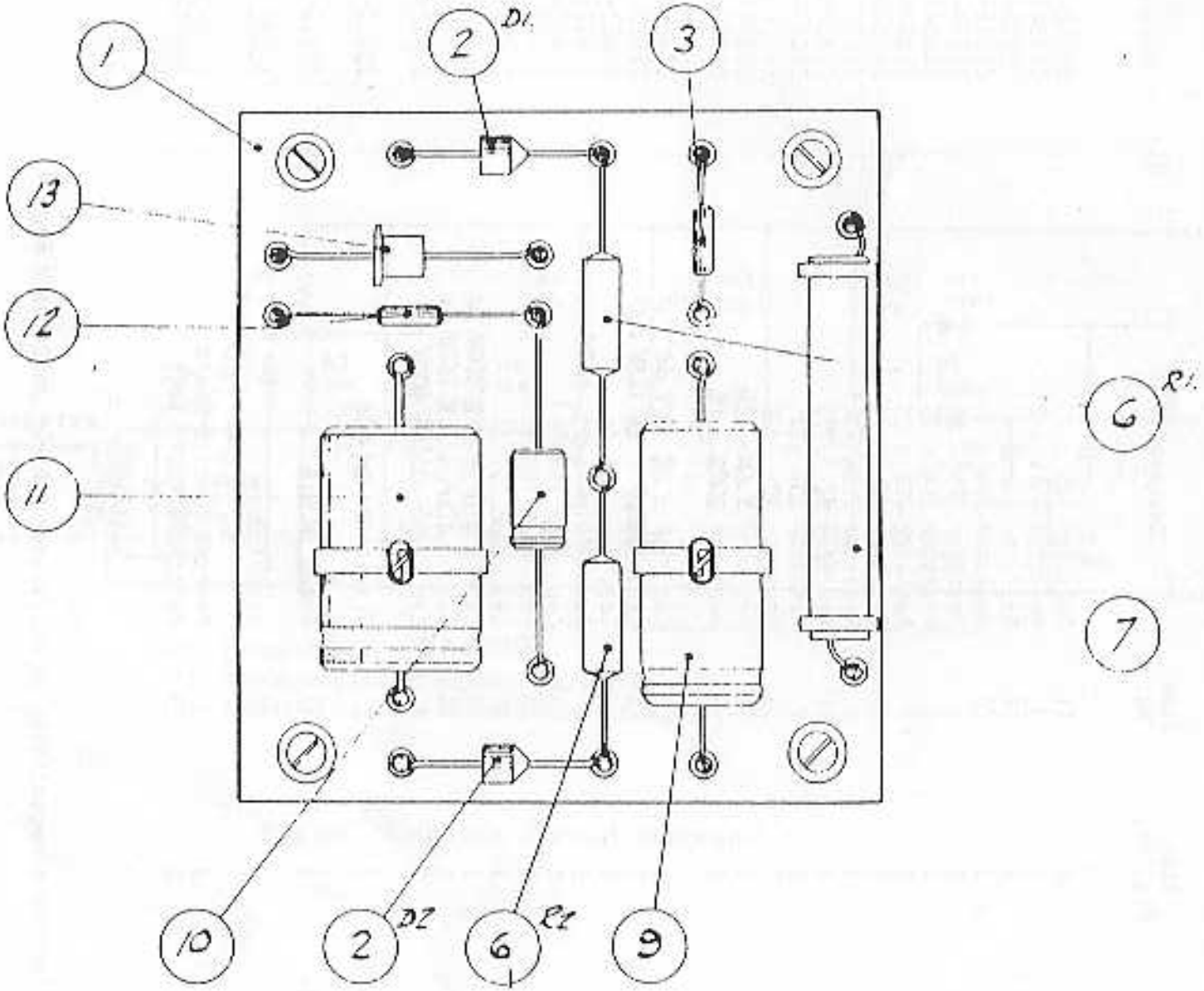
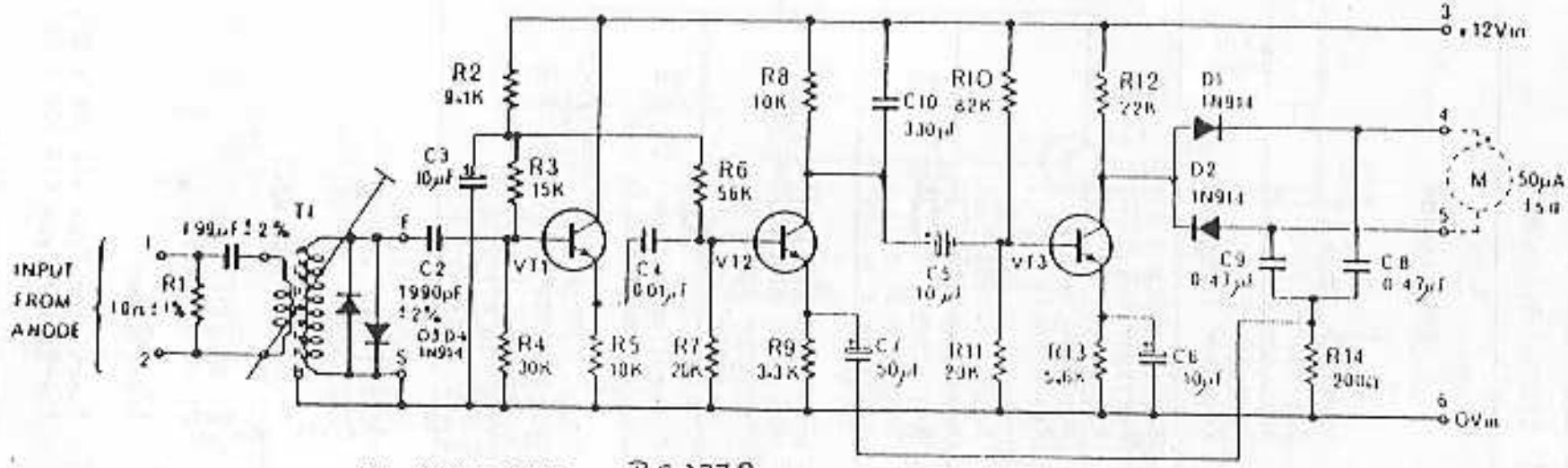



Fig 9. Component Board Assembly 45194

FIG. 10 - AMPLIFIER CIRCUIT DIAGRAM

| Circuit Ref. | Assy Fig. No. | Item No. | Description | Qty | AVO Part No. |
|---|---|---|---|---|---|
| R1 | 3 | 21 | Resistor 10Ω ± 1% | 1 | 26232-[illegible]* |
| R2 | 3 | 3 | Resistor 9.1k ± 2% | 1 | 26834-[illegible]* |
| R3 | 3 | 24 | Resistor 15k ± 1% | 1 | 26232-[illegible] |
| R4 | 3 | 25 | Resistor 30k ± 1% | 1 | 26232-[illegible] |
| R5 | 3 | 6 | Resistor 10k ± 2% | 2 | 26834-[illegible]* |
| R6 | 3 | 5 | Resistor 56k ± 2% | 1 | 26834-[illegible] |
| R7 | 3 | 7 | Resistor 20k ± 2% | 2 | 26834-[illegible] |
| R8 | 3 | 6 | Resistor 10k ± 2% | 2 | 26834-[illegible]* |
| R9 | 3 | 9 | Resistor 3.3k ± 2% | 1 | 26834-[illegible]* |
| R10 | 3 | 11 | Resistor 82k ± 2% | 1 | 26834-[illegible] |
| R11 | 3 | 7 | Resistor 20k ± 2% | 2 | 26834-[illegible] |
| R12 | 3 | 13 | Resistor 22k ± 2% | 1 | 26834-[illegible] |
| R13 | 3 | 12 | Resistor 5.6K ± 2% | 1 | 26834-[illegible] |
| R14 | 3 | 15 | Resistor 2000Ω ± 1% | 1 | 26232-[illegible] |
| C1 | 3 | 20 | Cap. 1μF ± 2% 150V dc | 1 | 27532-[illegible] |
| C2 | 3 | 23 | Cap. 1990pF ± 2% 125V dc | 1 | 27622-[illegible]* |
| C3 | 3 | 10 | Cap. 10μF 15V dc | 3 | 27462-[illegible]* |
| C4 | 3 | 4 | Cap. 0.01μF ± 20% 160V dc | 1 | 27632-[illegible] |
| C5 | 3 | 10 | Cap. 10μF 15V dc | 3 | 27462-[illegible]* |
| C6 | 3 | 10 | Cap. 10μF 15V dc | 3 | 27462-[illegible]* |
| C7 | 3 | 14 | Cap. 50μF 15V dc | 1 | 27462-[illegible]* |
| C8 | 3 | 16 | Cap. 0.47μF ± 10% 160V dc ) | 2 | 27637-[illegible] |
| C9 | 3 | 16 | Cap. 0.47μF ± 10% 160V dc ) | | |
| C10 | 3 | 8 | Cap. 330pF ± 20% 400V dc | 1 | 27533-[illegible] |
| VT1-VT3 | 3 | 2 | Transistor 2N 926 | 3 | 28532-[illegible]* |
| D1-D4 | 3 | 17 | Diode IN 914 | 4 | 29430-[illegible] |
| T1 | 3 | 22 | Transformer | 1 | 45003 |
| - | 3 | 1 | Printed Circuit Board | 1 | 3218-308 |
| - | 3 | 19 | Printed Circuit Tags | 6 | 25255-[illegible]* |

* Additional quantities on Oscillator & Power Unit Board Fig. 4




VT1 2N2925 (GREEN) BC 237B
VT2 - 2N2926 (ALL EXCEPT BROWN) BC 237B
VT3 - 2N2926 (ALL EXCEPT BROWN & RED) BC 237A

Fig 10 Amplifier Circuit Diagram

1 棕
2 橙綠
3 紅
4 紫紅
5 白綠
6 綠

FIG. 11 - OSCILLATOR & POWER UNIT CIRCUIT DIAGRAM

| Circuit Ref. | Assy Fig. No. | Item No. | Description | Qty | AVO Part No. |
|---|---|---|---|---|---|
| R1 | 4 | 23 | Resistor 20k ± 1% | 1 | 26232-404 |
| R2 | 4 | 24 | Resistor 6.8k ± 1% | 1 | 26232-393 |
| R3 | 4 | 22 | Resistor 8.2k ± 2% | 1 | 26834-477 |
| R4 | 4 | 29 | Resistor 2.4k ± 2% | 1 | 26834-464 |
| R5 | 4 | 28 | Resistor 1.2k ± 2% | 1 | 26834-457 |
| R6 | 4 | 14 | Resistor 36k ± 2% | 1 | 26834-482 |
| R7 | 4 | 31 | Resistor 10k ± 2% | 1 | 26834-[illegible]* |
| R8 | 4 | 16 | Resistor 3.3k ± 2% | 1 | 26834-467* |
| R9 | 4 | 4 | Resistor 1k ± 2% ) | 2 | 26834-455 |
| R10 | 4 | 4 | Resistor 1k ± 2% ) | | |
| R11 | 4 | 12 | Resistor 1.5k ± 2% | 1 | 26834-459 |
| R12 | 4 | 32 | Resistor 270Ω ± 2% | 1 | 26834-441 |
| R13 | 4 | 27 | Resistor 5.1k ± 1% | 1 | 26232-[illegible] |
| R14 | 4 | 7 | Resistor 3k ± 2% | 1 | 26834-466 |
| R15 | 4 | 9 | Resistor 4.3k ± 2% | 1 | 26834-471 |
| R16 | 4 | 40 | Resistor 9.1k ± 2% | 1 | 26834-[illegible]* |
| R17 | 4 | 18 | Resistor 620Ω ± 2% | 1 | 26834-[illegible] |
| R18 | 4 | 13 | Resistor 30Ω ± 2% | 1 | 26834-471 |
| R19 | 4 | 33 | Resistor 10Ω ± 1% | 1 | 26232-[illegible]* |
| RV1 | 4 | 30 | Potentiometer 1k ± 20% | 1 | 27113-[illegible] |
| RV2 | 4 | 12 | Potentiometer 4.7k ± 20% | 1 | 27113-[illegible] |
| C1 | 4 | 25 | Cap. 1990pF ± 2% 125V dc ) | 2 | 27682-[illegible]* |
| C2 | 4 | 35 | Cap. 1990pF ± 2% 125V dc ) | | |
| C3 | 4 | 25 | Cap. 10uF 15V dc ) | 3 | 27462-405 |
| C4 | 4 | 26 | Cap. 10uF 15V dc ) | | |
| C5 | 4 | 26 | Cap. 10uF 15V dc ) | | |
| C6 | 4 | 5 | Cap. 50uF 15V dc | 1 | 27462-413* |
| C7 | 4 | 20 | Cap. 100uF 15V dc | 1 | 27462-417 |
| C8 | 4 | 21 | Cap. 200uF 30V dc | 1 | 27462-421 |
| VT1-VT3 | 4 | 8 | Transistors 2N 2926 | 3 | 29562-601 |
| D1 | 4 | 16 | Diode IS921 | 1 | 28461-824 |
| D2 | 4 | 17 | Diode IZ 12T5 | 1 | 28475-281 |
| T1 | 4 | 10 | Transformer | 1 | 45004 |
| TH1 | 4 | 6 | Thermistor Type A14 10k ± 20% | 1 | 27284-330 |
| TH2 | 4 | 2 | Thermistor Type R14 10k ± 20% | 1 | 27284-318 |
| - | 4 | 1 | Printed Circuit Board | 1 | 3218-328 |
| - | 4 | 3 | Heat Sink | 1 | 3566-615 |
| - | 4 | 11 | Printed Circuit Tags | 6 | 26295-372* |
| - | 4 | 34 | Printed Circuit Socket | 1 | 46082 |
| - | 4 | 35 | Printed Circuit Socket | 1 | 46085 |

* Additional quantities on Amplifier Board Fig. 3

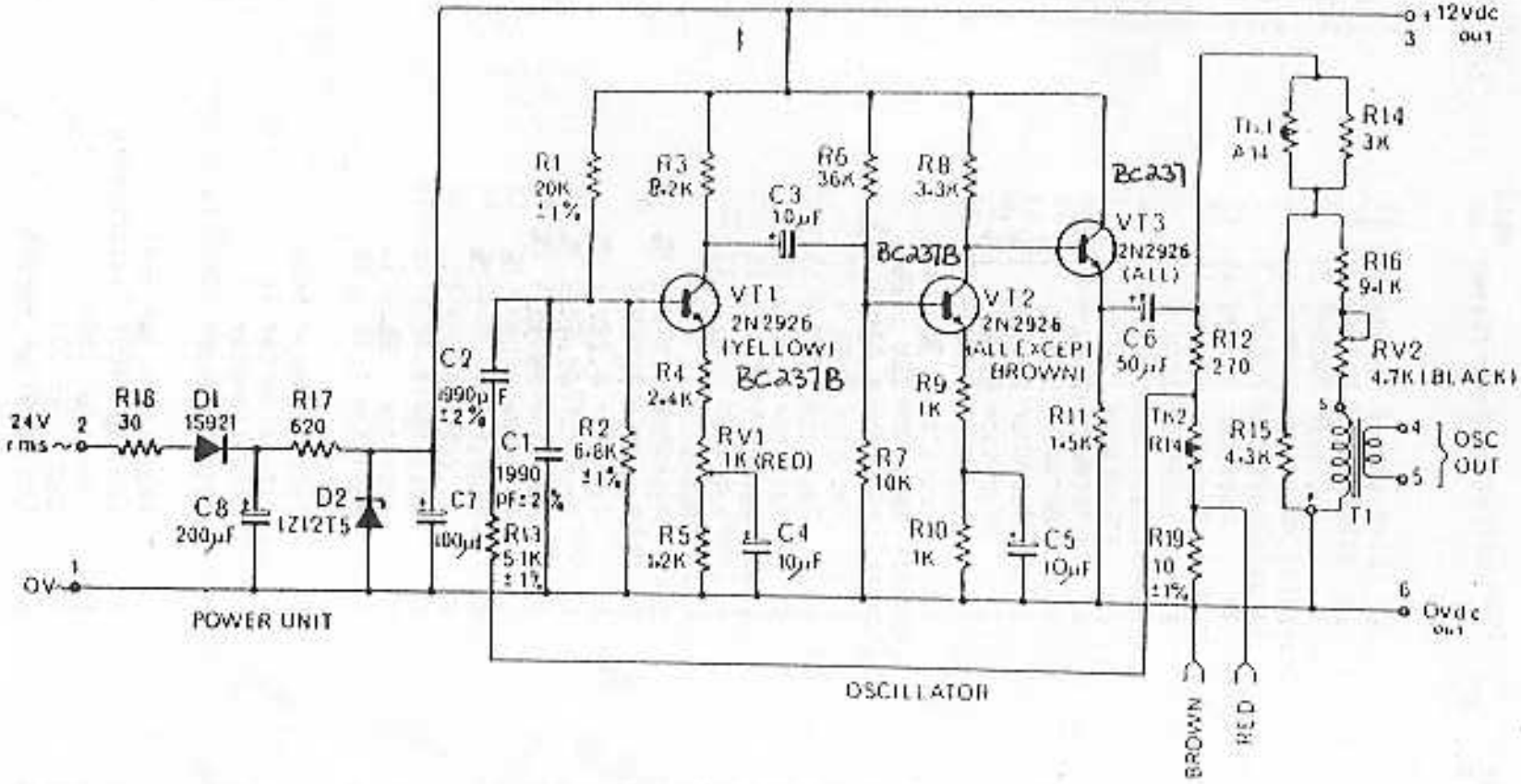



Fig 11 Oscillator and Power Unit Circuit Diagram

FIG. 12 - VCM 163 CIRCUIT DIAGRAM

| Circuit Ref. | Assy Fig. No. | Item No. | Description | Qty | AVO Part No. |
|---|---|---|---|---|---|
| R1 | 9 | 6 | Resistor 100k ± 20% ) | 2 | 26136-221 |
| R2 | 9 | 6 | Resistor 100k ± 20% ) | | |
| R3 | 9 | 7 | Resistor 700Ω ± 2% | 1 | 26782-267 |
| R4 | 7 | 2 | Resistor 3.4M ± 1% | 1 | 26232-666 |
| R5 | 7 | 11 | Resistor 2.27M ± 1% | 1 | 26236-660 |
| R6 | 7 | 10 | Resistor 1.3M ± 1% | 1 | 26232-448 |
| R7 | 7 | 9 | Resistor 680k ± 1% | 1 | 26232-447 |
| R8 | 7 | 8 | Resistor 281k ± 1% | 1 | 26235-811 |
| R9 | 7 | 15 | Resistor 91k ± 1% | 1 | 26232-429 |
| R10 | 7 | 7 | Resistor 16k ± 1% | 1 | 26230-402 |
| R11 | 7 | 6 | Resistor 2.4Ω ± 0.05% | 1 | 26434-810 |
| R12 | 7 | 5 | Resistor 8.02Ω ± 1% | 1 | 26437-[illegible] |
| R13 | 7 | 4 | Resistor 24.3Ω ± 1% | 1 | 26447-[illegible] |
| R14 | 7 | 3 | Resistor 82.8Ω ± 1% | 1 | 26444-[illegible] |
| R15 | 7 | 12 | Resistor 1.1k ± 1% | 1 | 26233-[illegible] |
| R16 | 7 | 13 | Resistor 4.3K ± 1% | 1 | 26233-[illegible] |
| R17 | 7 | 14 | Resistor 22k ± 1% | 1 | 26232-[illegible] |
| R18 | 9 | 12 | Resistor 0.68Ω ± 10% | 1 | 26711-[illegible] |
| R19 | 8 | 9 | Resistor 4.7k ± 2% | 1 | 26634-[illegible] |
| R20 | 8 | 8 | Resistor 2.2M ± 1% ) | 2 | 26233-[illegible] |
| R21 | 8 | 8 | Resistor 2.2M ± 1% ) | | |
| R22 | 8 | 5 | Resistor 9.7k ± 1% | 1 | 26330-[illegible] |
| R23 | 8 | 2 | Resistor 310Ω ± 1% | 1 | 26235-[illegible] |
| R24 | 8 | 6 | Resistor 9k ± 1% | 1 | 26234-[illegible] |
| R25 | 8 | 3 | Resistor 1.11k ± 1% | 1 | 26235-[illegible] |
| R26 | 8 | 7 | Resistor 7k ± 1% | 1 | 26330-[illegible] |
| R27 | 8 | 4 | Resistor 4.29K ± 1% | 1 | 26233-[illegible] |
| R28 | 6 | 1 | Resistor 44.4Ω ± 1% | 1 | 26235-[illegible] |
| R29 | 6 | 2 | Resistor 88.9Ω ± 1% | 1 | 26235-[illegible] |
| R30 | 6 | 3 | Resistor 310Ω ± 1% | 1 | 26235-[illegible] |
| R31 | 6 | 4 | Resistor 1.3k ± 2% | 1 | 26634-[illegible] |
| R32 | 2 | 43 | Resistor 56k ± 2% | 1 | 26633-[illegible] |
| R33 | 2 | 42 | Resistor 2.4k ± 1% | 1 | 26232-[illegible] |
| R34 | 9 | 3 | Resistor 1.5Ω ± 5% | 1 | 26711-[illegible] |
| R35 | 6 | 9 | Resistor 2.4k ± 2% | 1 | 26634-464 |
| RV1 | 1 | - | Potentiometer 500Ω | 1 | 27133-325 |
| RV2 | 1 | - | Potentiometer 1k | 1 | 27133-337 |
| RV3 | 1 | - | Potentiometer 2k | 1 | 27133-341 |
| RV4 | 2 | 26 | Potentiometer 10k ± 1% | 1 | 27238-232 |
| C1-C4 | 1 | - | Capacitors 1μF 400V | 4 | 27538-319 |
| C5 | 9 | 9 | Cap. 8μF 450V Electrolytic | 1 | 27461-214 |
| C6 | 9 | 11 | Cap. 60μF 250V | 1 | 27463-360 |
| C7 | 9 | 10 | Cap. 25μF 30V | 1 | 27463-410 |
| C8 | 6 | 5 | Cap. 0.015μF +0-20% | 1 | 27532-393 |
| D1,D2 | 9 | 2 | Diode DD058 | 2 | 28461-301 |
| D3 | 9 | 13 | Diode 1081 | 1 | 28461-841 |
| D4 | 1 | - | Diode DD058 | 1 | 28461-501 |
| D5,D6 | 1 | - | Diode IN 2069 | 2 | 28462-696 |

FIG. 12 - VCM 163 CIRCUIT DIAGRAM (contd.)

| Circuit Ref. | Assy Fig. No. | Item No. | Description | Qty | AVO Part No. |
|---|---|---|---|---|---|
| S1 | 2 | 15 | Switch Screen Volts ) | 2 | 45803 |
| S2 | 2 | 15 | Switch Anode Volts ) | | |
| S3 | 2 | 9 | Switch mA | 1 | 45189 |
| S4 | 2 | 2 | Switch Electrode Selector | 1 | 45828 |
| S5 | 2 | 1 | Switch Circuit Selector | 1 | 45187 |
| S6 | 2 | 21 | Switch Leakage | 1 | 45816 |
| S7 | 2 | 37 | Switch push-button mA/V | 1 | 45431 |
| S8 | 2 | 6 | Switch mA/V | 1 | 45190 |
| S9 | 2 | 38 | Switch push-button mA | 1 | 45524 |
| S10 | 2 | 12 | Switch Grid Volts | 1 | 45188 |
| S11 | 2 | 13 | Switch Heater Volts | 1 | 45818 |
| S12 | 2 | 14 | Switch Heater Volts ) | 2 | 45825 |
| S13 | 2 | 14 | Switch Heater Volts ) | | |
| S14 | 2 | 20 | Switch Set Cycles | 1 | 45823 |
| S15 | 2 | 22 | Switch On/Off | 1 | 25454-251 |
| T1 | 1 | - | H.T. Transformer Assembly | 1 | 45186 |
| T2 | 1 | - | L.T. Transformer Assembly | 1 | 45197 |
| RL1 | 1 | - | Relay | 1 | 45211 |
| LP1 | 2 | 25 | Indicator Lamp (Blue) | 1 | 25517-239 |
| LP2 | 2 | 23 | Indicator Lamp (Red) | 1 | 25517-233 |
| M1 | 2 | 31 | Meter Assembly mA | 1 | 45191 |
| M2 | 2 | 30 | Meter Assembly mA/V | 1 | 45206 |
| - | 2 | 24 | Bulb 6.5V 0.35A | 1 | 25514-679 |
| - | 2 | 28 | Front Panel | 1 | 3286-619 |
| - | 2 | 33 | Knob Assembly | 1 | 45913 |
| - | 2 | 39 | Knob Collet Black | 12 | 23762-235 |
| - | 2 | 40 | Knob Cap Grey | 12 | 23762-884 |
| - | 2 | 41 | Knob Skirt Black | 12 | 23762-854 |

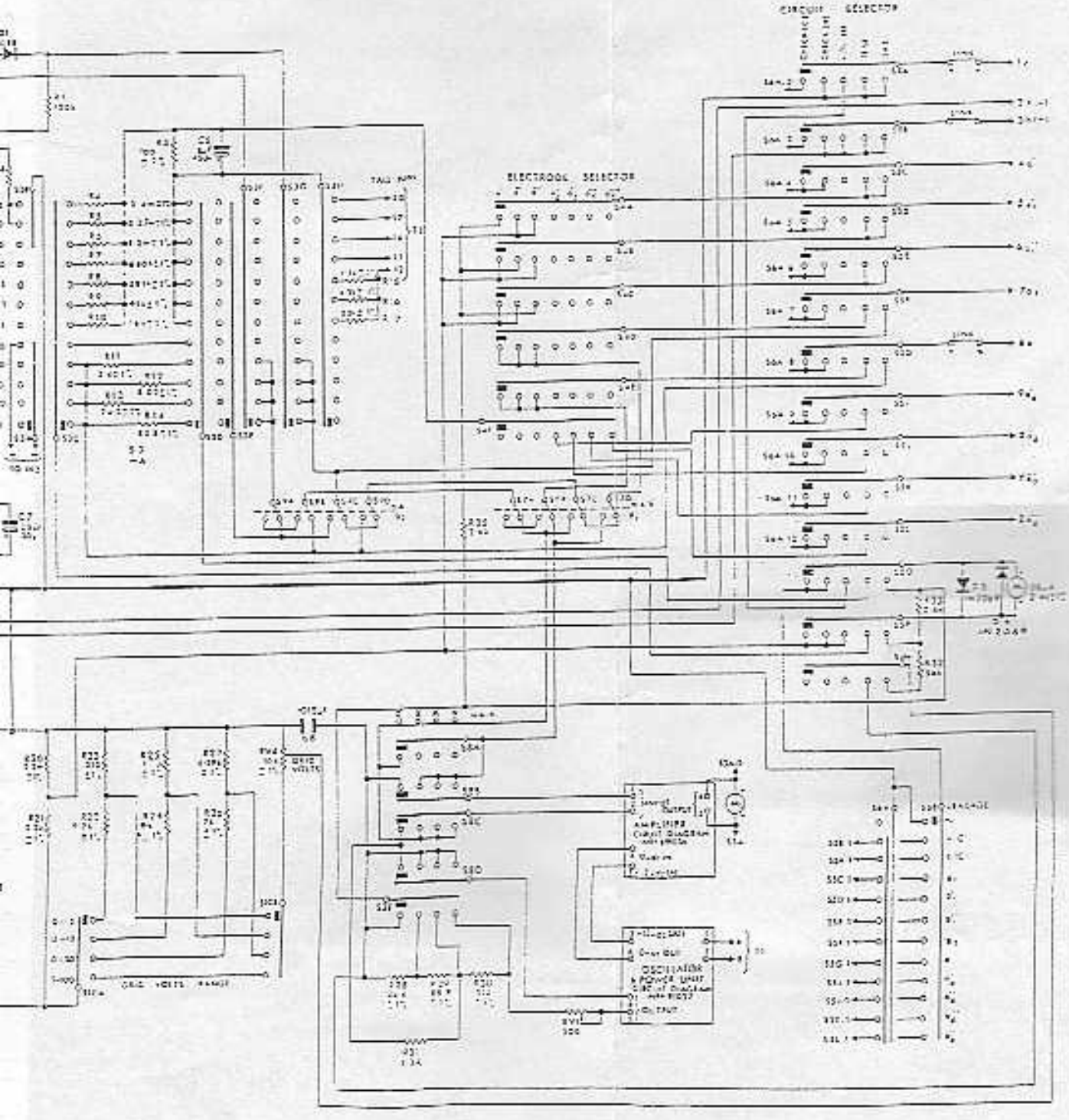



*Figure 6*

CIRCUIT DIAGRAM: VALVE CHARACTERISTIC METER TYPE VCM 163