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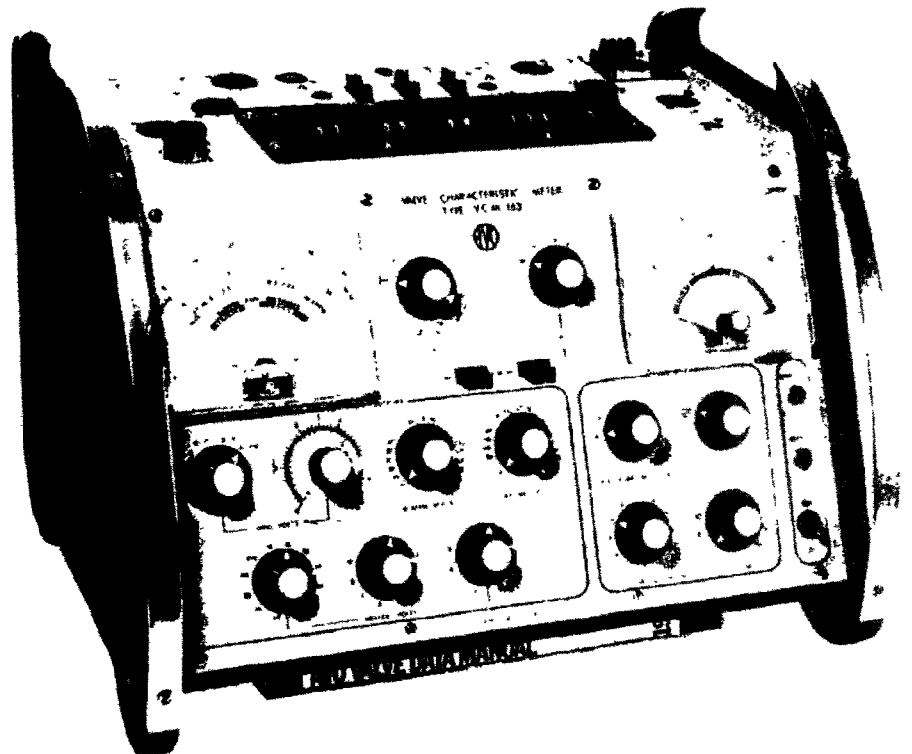
Colin Hinson

In the village of Blunham, Bedfordshire.



Users Manual Service Manual

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

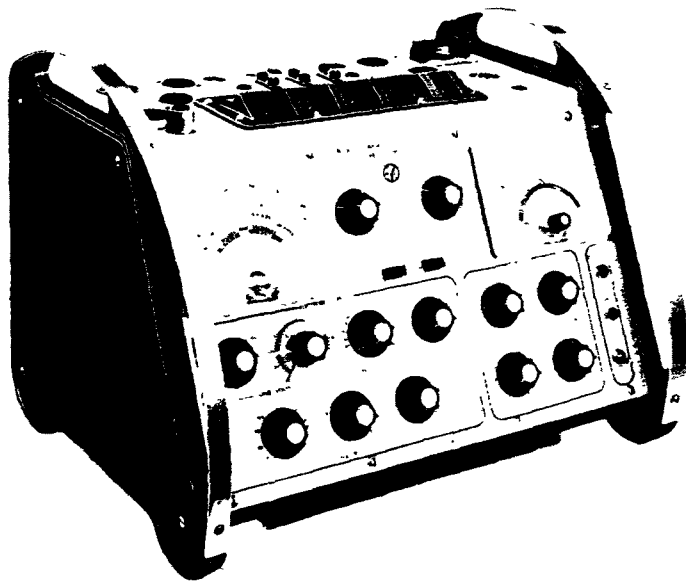


12/2/21



OPERATING
INSTRUCTIONS

**VALVE
CHARACTERISTIC
METER TYPE 163**



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INTRODUCTION

This new Avo Valve Characteristic Meter offers not only all the advantages of the Avo Valve Characteristic Meter Mk. 4, but also improved facilities which render it simpler to use. In addition it provides for the testing of greatly increased numbers and types of valves.

Provision is made for testing the recently introduced Nuvistor and Compactron type valves and in fact, valves with any number of pin connections up to thirteen can now be tested. The range of heater voltages has been extended to allow between 0 and 119.9 volts to be applied to the heater in 0.1 volt steps. In addition the full range of h.t. voltage is available for both anode and screen voltages. The use of 'C' core transformers provides improved regulation on both h.t. and l.t. supplies.

Re-arrangement of the front panel controls has simplified the setting-up of the instrument, but one of the main features of this instrument is the further simplification of the measurement of mutual conductance. Improved circuit design has eliminated the necessity for 'backing off' the standing anode current prior to measuring mutual conductance and two 'clarity' style panel meters are now provided, one of which is used specifically for mutual conductance measurements. During testing, whatever operating conditions are selected, the value of mutual conductance will be monitored continuously on this separate meter. Facilities are also provided for the comparative testing of mutual conductance. Measurement of anode and screen current is provided by the second panel meter and a 'good;replace' scale indicates the quality of diodes and rectifiers. Provision of these two meters not only simplifies operation of the instrument but also improves the readability of the scaleplate.

Facilities for monitoring screen characteristics are provided by simple spring-return push button switches and when testing some multiple valves the circuit is now arranged, such that only the section under test is actually conducting. The SET \sim control may be adjusted and inter-electrode leakage may be checked with the valve either hot or cold, measurement of leakage current now being made at 50V d.c. instead of a peak voltage of up to 150V as in the Valve Characteristic Meter Mk.4. The impedance loading in the anode circuit has been considerably reduced and it is now possible for valves having an impedance of as low as 200 Ω to be tested without serious loss of accuracy.

Improved overload protection is also incorporated, which is indicated visually on the front panel further reducing the possibility of any damage to the instrument due to inadvertent shorting of the electrode voltages. Using the links provided on the valve panel, a load may be inserted in both anode and cathode circuits and the heater circuit may be broken for the measurement of heater current.

FUNCTION

The instrument is a double purpose Valve Tester as follows:—

- (a) It provides a rapid diagnosis of the condition of the valve under test, the instrument operating as a simple 'go' or 'no go' device.
- (b) Sufficient data may be obtained enabling an operator to plot static and dynamic characteristics, or similar information, using selected anode and cathode loads.

Valves with any number of base connections up to thirteen and up to two top caps can be tested. The instrument will check the majority of the receiving valves and some small transmitting valves.

Whilst good bad testing on a semi-production basis will undoubtedly be one of the main uses for this tester, it is certain that the instrument will find considerable use in laboratories and service departments where engineers and skilled personnel will be available, and where more precise details of valve performance can be used to advantage. To this end, facilities on the tester, enable I_a/V_g , I_a/V_s , I_s/V_s and I_s/V_g characteristics to be plotted over a wide range of voltages, these being readily available from the calibrated panel controls. At the same time mutual conductance will also be continuously displayed on the second panel meter, whatever operating conditions are selected.

The Avo Valve Data Manual which is supplied with the instrument provides a line of data for each valve likely to be encountered. The data given comprises the pin combinations, in the order of their standard numbering and in the form in which they appear in the VALVE PIN SELECTOR switch window, top cap or side contact connection if any, heater volts, anode volts, screen volts, negative grid volts, operating anode current and mutual conductance (or load current in the case of a rectifier). Where multiple electrode assemblies are concerned test details for each assembly are given. Should it be necessary to test a valve that does not appear in the manual, the base connections and manufacturers' or other recommended test data can be directly set up.

CONSTRUCTION

The mechanical construction of the instrument has been designed to combine a pleasing streamlined appearance with a high degree of mechanical strength. All components likely to require adjustment or replacement in service are located to ensure maximum of accessibility. All main controls are front panel mounted and the instrument is supplied complete with mains lead.

Fourteen valve bases together with an additional SP14/S socket, which will accept a range of adaptors, is provided. A thirteen way, fifteen bank VALVE PIN SELECTOR switch enables any valve pin to be connected to any electrode circuit. The SELECTOR switch is marked with figures and letters which enable code numbers to be set up from the 'AVO' Valve Data Manual.

PERFORMANCE

The instrument will test valves with pin connections up to thirteen as follows:—

- (1) Check the heater continuity.
- (2) Measure insulation between electrodes with the valve cold.
- (3) Measure insulation between electrodes with the valve hot.
- (4) Measure cathode heater insulation (for indirectly heated valves).
- (5) Rapidly indicate whether a valve is good or bad, use being made of a coloured replace/good scale with mutual conductance as the operative parameter.
- (6) Measure the mutual conductance of a valve. (Both control grid to anode and control grid to screen.)
- (7) Measure the anode and screen current in single and multiple valves.
- (8) Produce sufficient data to enable static and dynamic characteristic curves to be plotted.
- (9) Check rectifiers and diodes under load conditions.
- (10) Measure gas current up to 100 μ A f.s.d.

An automatic visual warning device operates if certain circuits within the instrument are inadvertently overloaded by the operator, or if a short occurs with a valve under test. The use of specially designed circuits, virtually eliminates the possibility of a valve under test bursting into spurious oscillation.

ADAPTORS

If the valve base required is not available on the valve panel, it will be necessary to use an adaptor. Adaptors which can be plugged into the SP14/S socket on the valve panel as follows:— UX4, UX5, UX6, UX7, MO8 and B7. Adaptors are also available for use with the International Octal Valveholder as follows:—5AA and 7AA (Acorn Valves) 6A7, B3G, B7A, B8B, Continental 8 pin (F8). Additional adaptors can be supplied to customers' requirements.

POWER REQUIREMENTS

The instrument operates from the following a.c. supplies:— 110V, 120V, 200-240V in 10 volt steps. Power supply frequency 50 to 60c/s. A fine voltage control is provided which compensates for mains voltage variation in two volt steps from —10 volts to +10 volts inclusive. Power consumption, 50 watts maximum.

**PRINCIPLES
OF OPERATION**

The tester is basically designed to check the valve according to its static characteristics which would normally require the provision of the requisite range of variable d.c. supplies. The difficulty lies in the regulation problems involved in the supply of a wide range of d.c. anode and screen voltage, on which the loading might vary from a fraction of a milliamp to 100mA dependent on the type of valve being tested and the nature of the test being performed. Such a requirement could, of course, be met by the provision of a number of regulated power supplies but this would render the instrument both cumbersome and expensive, whilst the considerable metering required would not only mean additional expense, but also make the instrument difficult to use and would not entirely overcome all the problems.

It can be shown however, that if alternating electrode voltages are applied in their correct proportions, an amplifying valve can (by virtue of its property of self rectification) be caused to give d.c. anode and screen currents, which for all practical purposes, bear an almost constant relationship to those obtained from its d.c. static characteristics.

This immediately simplifies the problem of providing power supplies for the valve under test and the design of mains transformers to give negligible regulation errors over a wide range of secondary currents is a comparatively simple matter, whilst the range of electrode voltage may be simply provided by appropriate secondary tapplings selected by calibrated switches. This eliminates the necessity for separate metering, thus minimising to a very large extent, problems of size, weight and cost.

A slight difficulty occurs in the supply of the variable negative grid bias voltage, which would normally consist of an alternating voltage of suitable magnitude applied in anti-phase to the anode voltage. Since rectification occurs at the anode (and screen) and the grid should not pass current, it will be readily seen that during the half cycle the anode and screen are not passing current a positive half cycle of considerable magnitude is applied to the grid with the result that the latter can pass a damaging amount of current. The inclusion of a simple half wave rectifier circuit without smoothing, between the transformer winding and the variable grid voltage supply, will suppress the positive half cycle whilst still maintaining the sinusoidal form of the operative negative half cycle.

The operation of the Valve Tester is based on the following relationship:—

If applied r.m.s. anode (and screen) voltage	= $1.11 \times V_a$ d.c.
and	
Mean value of half wave rectified bias voltage	= $0.5 \times V_g$ d.c.
then,	
Mean d.c. anode current	= $0.5 \times I_a$ d.c. (where I_a d.c. is static anode current) if V_a d.c. and V_g d.c. were applied d.c. test voltages.

This relationship holds for all practical purposes over the full characteristic which enables accurate testing of valves, at any point on their characteristic to be carried out with simple and compact apparatus. This accuracy is just as necessary on the simple 'go' 'no go' type of instrument as on a complete characteristic meter, as it may be necessary to set the test point anywhere on the characteristic to correspond to required working conditions. Further, in the absence of any predetermined test figure it must be possible to determine test conditions directly from the manufacturers' published curves or data.

**BASIC
CIRCUITRY**

One of the main functions of the tester is that of comparative testing of mutual conductance. This is accomplished by applying the appropriate anode, screen, grid and heater voltages to the valve and superimposing upon the grid bias voltage, a small signal at a high audio frequency. The anode current of the valve passes through a low impedance filter. This extracts the signal frequency component of the current and rejects the power frequency (and its harmonics). The signal frequency component is amplified and its mean value displayed on a meter. By suitable choice of circuit values this becomes a direct measure of the valve mutual conductance, this figure being compared with the nominal mutual conductance to give comparative goodness on a coloured scale. Fig. 1. shows this arrangement in diagrammatic form.

Facilities are provided for calibrating the oscillator/amplifier combination and the circuit is arranged such that the accuracy is dependent only on the ratio of resistor values.

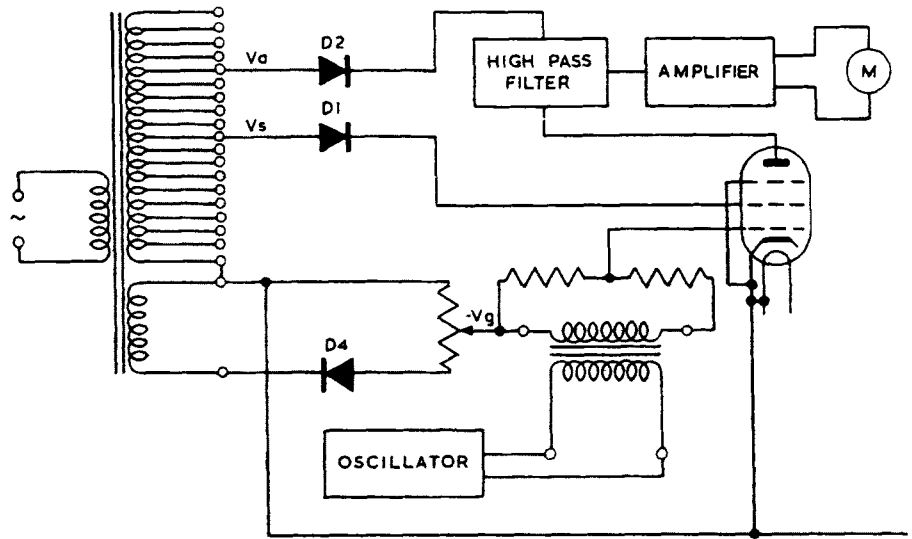


FIGURE 1
Basic Circuit
for Mutual
Conductance measurement

The maximum value of high frequency test signal applied to the grid of the valve is approximately 35mV r.m.s. on the 0 to 6mA/V range and the circuit is so arranged that the amplitude of the test signal is inversely proportional to the value of the mA/V range selected by the range switch.

The stopper diodes D1 and D2 shown in the screen and anode supplies in Fig. 1. are included as a precaution against spurious oscillations which have been known to occur with a few types of valve when anode or screen become negative to the control grid. Inaccuracies could occur if such oscillation is present.

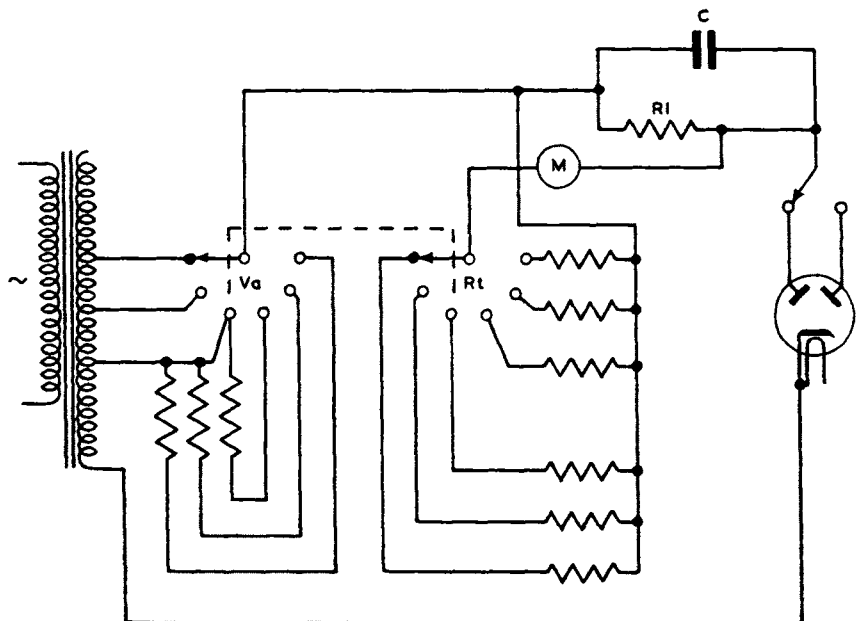


FIGURE 2
The basic circuit
of the
rectifier test

The rectifier is loaded with a resistor R_1 in Fig. 2, and a reservoir capacitor C in parallel. Sinusoidal voltage V_a is applied of sufficient magnitude to operate the rectifier on the linear portion of its characteristic, so that the combination should pass a rectified current equal to the maximum load current for the valve. The voltmeter M measures the voltage developed across the load R_1 in Fig. 2 and the meter ranges are selected by the appropriate range resistor R_t in Fig. 2 such that the rated current through the load will deflect the meter M approximately to the middle of the 'good' zone of the scale. The proportionate deflection on the coloured scale denotes the state of the valve. Switching of anode voltage and meter range is ganged so that rectified currents of 1mA, 5mA, 30mA, 60mA, 120mA, 180mA, per anode are available, each anode of a full wave rectifier being tested separately. The 1mA and 5mA ranges are also suitable for signal diode testing. Perfect diodes give approximately full scale deflection on each range. Small signal diodes, and small current, high voltage rectifiers, since they may be either of very high or very low impedance are catered for by special circuit arrangements which tend to be 'current forcing'. Hence low impedance diodes tend to read as perfect diodes at full scale deflection whilst high impedance diodes tend to read lower down on the 'good' region of the scale.

A combination of the positions marked on the LEAKAGE switch and the CIRCUIT SELECTOR switch provides facilities for checking heater continuity and cathode leakage prior to the application of operating voltages to the valve. In addition inter-electrode leakage may be measured with the valve hot with a maximum of 50V d.c. applied.

Since a short circuit, is in fact, a measure of the leakage test voltage (derived from the grid voltage supply) this is used in checking the setting of the mains voltage of the instrument at position SET \sim . At this position a short is placed on the insulation test circuit and the Mains Voltage Selector is adjusted until the meter pointer is at the SET \sim position, at which point the grid voltage and therefore all other operating voltages are correctly proportioned.

A safety relay having two heavy duty contacts in the primary circuit of the h.t. transformer and a current coil connected in the anode and screen circuits, will be operated by an overload, associated with either or both of these circuits. If the relay is operated, an additional light duty contact will 'make', to form a hold circuit and at the same time a blue warning lamp mounted on the front panel will be illuminated. As a further precaution, the two heavy duty contacts will break, disconnecting the h.t. transformer from the mains supply. Normal operation cannot be restored until the instrument is switched off, the fault should then be rectified and the instrument switched on again.

The problem of self oscillation, which can occur with high slope valves occurs at a random high frequency and is due to inter-valveholder wiring. This has been almost entirely eliminated by wiring the valveholder panel in continuous loops of pre-determined lengths, so that any valve inserted would tend to oscillate at a definite frequency dependent on the loop lengths. These separate inter-connection loops are then loaded with ferroxcube beads so that irrespective of the valveholder and pin combination used, oscillation cannot occur when testing valves with conventional characteristics.

THE VALVE HOLDER PANEL AND VALVE PIN SELECTOR SWITCH

The valveholder panel comprises 14 valveholders of the following type: — British 4·5 pin (B4 and B5) B7G, B8A, B8D, B8G, B9D, B9G, International Octal, B10B, 5 pin Nuvistor, 7 pin Nuvistor, 12 pin Compactron, and a flying lead valveholder. In addition a SP14/S chassis mounting socket is provided for use with a range of adaptors thus enabling obsolete or new type valves to be tested. The following adaptors are available:—UX4, UX5, UX6, UX7, MO8, B7. Adaptors are also available for use with the International Octal valveholder as follows:— 5AA and 7AA (Acorn valves) 6A7, B3G, B7A, B8B, Continental 8 pin (F8). Additional adaptors can be supplied to customers' requirements.

All valveholders are wired with their corresponding pins in parallel, i.e. all pins numbered '1' are wired together, all pins numbered '2' and so on. This wiring combination is associated with the VALVE PIN SELECTOR switch which enables any one of the thirteen standard pin numbers to be connected to any one of the electrode test circuits in the instrument, thus enabling any electrode combination to be set up for all valveholders.

It will be seen that the SELECTOR switch comprises fifteen thumb rollers numbered from left to right 1 to 13, TC1 and TC2. This numbering appears on the escutcheon immediately in front of the rollers and corresponds to the valve pins in the order of their standard pin numbering. Thus valves with any number of pin connections up to thirteen can be accommodated. To cater for top cap and other external valve connections two sockets have been provided together with short leads fitted at one end with a plug for insertion into the sockets, whilst the remote end is fitted with a universal connection clip to cater for most types of external valve connections. Also on the valve holder panel are three links marked a, c and h which enables a resistive load to be inserted in the appropriate anode or cathode circuits, and the current to be measured in the heater circuit.

The thirteen positions of each roller are marked as under:—

0	1	2	3	4	5	6	7	8	9	X	Y	Z
—	c	h—	h+	g ₁ '	g ₁ ''	g ₁ '''	g ₂	a	a _d '	a _d ''	a _d '''	a _d ''''

The numbers and symbols are provided in order that the switch can be rapidly set up from the code numbers given in the Avo Valve Data Manual, the corresponding electrode denominations being shown by the letter which appears in the escutcheon opening immediately below the number thus:—

0 —	Corresponds to a pin which should not be connected, and on which an internal electrode may be anchored. Such pins are marked, I.C' in manufacturers' literature. This switch position leaves the particular valve pin disconnected from any circuit.
1 c	Corresponds to cathode or any other electrode normally connected to cathode i.e., g ₃
2 h—	Corresponds to heater, normally earthy or connected to negative, L.T. in the case of a battery valve.
3 h+	Corresponds to other heater connection or centre tap.
4 g ₁ '	Corresponds to control grid.
5 g ₁ ''	Corresponds to the control grid of the second section of a multiple valve.
6 g ₁ '''	Corresponds to the control grid of the third section of a multiple valve.
7 g ₂	Corresponds to the screen grid in a single or multiple valve.
8 a	Corresponds to the anode of single or multiple amplifier valves.
9 a _d '	Corresponds to the first diode anode of signal diodes, rectifiers or multiple electrode valves.
X a _d ''	Corresponds to the second diode anode of signal diodes, rectifiers or multiple electrode valves.
Y a _d '''	Corresponds to the third diode anode present in some valves.
Z a _d ''''	Corresponds to the fourth diode anode present in some valves.

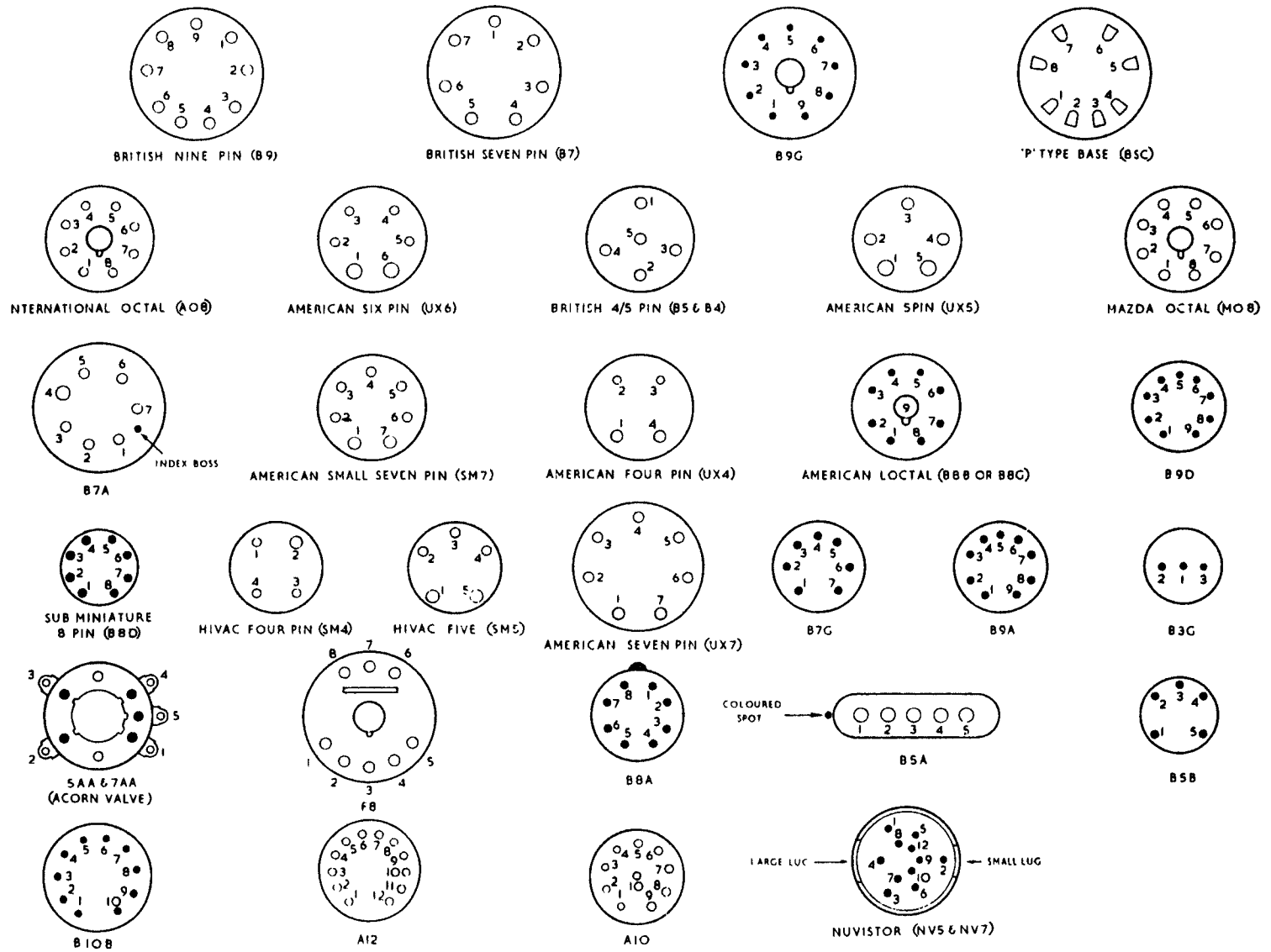


FIGURE 3 **DIAGRAM OF STANDARD PIN CONNECTIONS**
(viewed from underside of base)

LINKS ON THE VALVE HOLDER PANEL

These links are connected in the anode, cathode and heater circuits respectively. The links in the anode and cathode enable a load to be inserted in the appropriate circuit of the valve under test. By removing these shorting links, and inserting the required resistive load across the terminals which it is desired to include in the circuit, it is possible to obtain the dynamic characteristic of the valve or electrode system under test. The link in the heater circuit enables heater current to be monitored.

NOTES

- (1) Beware of possible high voltages on the shorting links.
- (2) Always ensure correct positioning and security of shorting links especially after replacement following use of circuit breaking facility.
- (3) Loads *other* than resistive must not be used under any circumstances.
- (4) It should be noted that when testing high gain valves, principally pentodes, under dynamic conditions, the measured value of mutual conductance may be inaccurate, dependent upon the operating conditions selected. High values of anode load can introduce errors due to the effect of stray capacitance in the anode circuit. Similarly the effects of anode to grid stray capacitance may become important under any circumstances where high stage gain exists.

CONTROL PANEL

All main controls are front panel mounted and for ease of use, switches associated with test functions have been mounted together and switches associated with electrode supplies are also grouped together. The controls and their functions are listed below:—

FUNCTION CONTROLS

The Circuit Selector switch This is a five position switch which determines the types of test to be undertaken on the instrument. All the necessary internal circuit connections are made automatically to satisfy the test conditions required, whilst internal test circuits unnecessary to the particular test in hand are removed from the valve. The switch positions on the CIRCUIT SELECTOR are:—

CHECK (C). At this position, in conjunction with the LEAKAGE and SET ~ switches (see below) the supply voltage is set to the correct operating value, the valve is also suitably connected for the cold electrode leakage test, and heater continuity.

CHECK (H). At this position, in conjunction with the LEAKAGE switch (see below) the valve under test can be tested for electrode leakage with the valve hot. The supply voltage can also be re-checked as above, without disconnecting the valve heater.

c/h INS: At this position, the valve is automatically checked for cathode to heater insulation with the heater voltage applied.

TEST: When set to this position and in conjunction with the ELECTRODE SELECTOR switch and other relevant controls the valve is tested for its normal characteristics. Also at this position and in conjunction with the appropriate settings of the ELECTRODE SELECTOR switch, signal diodes and rectifying valves can be checked.

GAS: At this position the mA meter is connected in series with the control grid connection, and a direct indication of any gas current flowing will be given on the meter. The 50 μ A meter movement is shunted to provide a full scale deflection of 100 μ A.

Electrode Selector Switch This switch, in conjunction with the CIRCUIT SELECTOR, enables the panel meters to be associated with the anode circuit under test. Triodes, pentodes and multiple grid valves are checked with the ELECTRODE SELECTOR switch set to a', a'', and a''' whilst diodes and rectifiers are checked at positions a_d', a_d'', a_d'', and a_d'''' as required.

Set ~ Switch This switch in conjunction with the ~ position on the LEAKAGE switch enables final mains voltage adjustment to be made, when the CIRCUIT SELECTOR switch is in either the CHECK (C) or CHECK (H) positions.

Leakage Switch This is a twelve position switch, which combined with the CIRCUIT SELECTOR switch enables the SET ~ control to be adjusted with the valve either hot or cold, provides an indication of heater continuity and also enables any electrode, from which leakage occurs to be ascertained. The relative switch positions are as follows:—

~ At this position of the switch and with the CIRCUIT SELECTOR switch set to CHECK (C) or CHECK (H), (see above under 'Set ~ Switch'), the SET ~ control may be adjusted to the correct operating position as indicated by the meter.

h (C). At this position with the CIRCUIT SELECTOR switch set to CHECK (C) heater continuity, with the valve cold, will be indicated by a short on the insulation scale of the meter.

c (C). At this position with the CIRCUIT SELECTOR switch set to CHECK (C), cathode leakage with the valve cold, will be indicated on the meter.

At all remaining nine positions of the LEAKAGE switch, the electrode from which leakage may occur, will be indicated on the meter (with the valve either hot or cold dependent upon the position of the CIRCUIT SELECTOR switch). With the CIRCUIT SELECTOR switch set to CHECK (C) any leakage will be with the valve cold and with the CIRCUIT SELECTOR switch set to CHECK (H) the leakage indicated will be with the heater voltage applied.

ELECTRODE SUPPLIES

Heater Volts Heater voltages are selected by means of three switches, enabling a fine adjustment of heater voltage to be obtained. One, a twelve way rotary switch is scaled from 0 to 110 volts in ten volt steps, the second, a ten way switch, covers 0 to 9 volts in 1 volt steps and the third switch covers 0 to 0.9 volts in 0.1 volt steps. The values of voltage covered by these three switches are additive, thus the heater voltage may be set to any value between 0 and 119.9 volts in increments of 0.1 volts.

Anode and Screen Volts These switches enable the requisite electrode voltage between 12.6 and 400 volts to be applied to screen and anode of valves for the purpose of carrying out valve characteristic measurements.

Grid Volts Control of grid voltage is by means of a variable potentiometer and an associated four position switch which enables the negative grid volts for the valve under test to be set up to any value between 0 and minus 100 volts. Four ranges are provided, 0 to 3, 0 to 10, 0 to 30, and 0 to 100 volts.

OTHER FACILITIES

mA Switch Operation of this switch allows the valve anode current to be measured in milliamps on the ranges covered by the section of the switch marked Ia, i.e. 3, 10, 30 and 100mA f.s.d.

On the ranges covered by the D/R Section of this switch, diodes and rectifiers are loaded for the nominal current in milliamps stated at each position, i.e. 1, 5, 15, 30, 60, 120, and 180 mA. The quality of the diode rectifier is then indicated on the coloured scale of the meter marked 'Diodes and Rectifiers'.

NOTE: The calibration marks on the diode rectifier switch are purely nominal and are approximate test currents only.

At the position of this switch marked with a dot and when the CIRCUIT SELECTOR switch is set to the TEST position, both meters are shorted out. This provides protection for the meter movements during transit.

mA Meter Linear scales calibrated 0 to 100 and 0 to 30 are provided for the measurement of anode and screen current. A further scale calibrated in megohms indicates measurements of insulation resistance. The SET ~ position is also marked on this scale at which position the final mains adjustment is made. A coloured good replace scale indicates the quality of rectifiers and diodes under test.

mA/V Switch The switch selects the appropriate scale of the mA/V meter, i.e. 6, 20 or 60mA V full scale deflection. With this switch set to the position marked 'CAL' a calibration check is provided for the mA/Volt meter. At the 'CAL' position the pointer should lie on the red calibration line marked CAL. Adjustment is provided by potentiometer RV1, which is visible when the plug button is removed from the right hand side panel of the instrument.

mA/V Meter This meter is provided specifically for the continuous monitoring or comparative testing of mutual conductance. Continuous monitoring is provided on the 3½in. main scale of the meter calibrated 0 to 6 and 0 to 20 while a second smaller scale, proportionally related to the main scale, together with a coloured good replace scale provides facilities for the comparative testing of mutual conductance.

With the indicating arrow on the coloured scale set to the nominal mutual conductance figure on the smaller calibrated scale, the dividing line between the red and green sections of the coloured scale will be positioned at half this value on the main scale. Should the value of mutual conductance be less than 50% of the nominal value, the meter pointer will lie in the red zone of the coloured scale and a reject valve will be indicated.

Push Buttons The two push buttons g_2 associated with the mA and mA V switches enable screen parameters to be monitored on the relevant meter. With the mA switch set to a range in the Ia sector, depressing the associated g_2 button monitors screen current. Depressing the push button associated with the mA/V switch, when it is set to any position except the one marked CAL, monitors the screen mutual conductance. Both switches must be held depressed whilst measurements are taken.

Lamps The red SUPPLY lamp will be illuminated when the mains supply is connected to the instrument and the mains switch is set to the ON position. The blue OVERLOAD lamp will be illuminated should the safety relay be operated by a faulty valve or inadvertent overload.

**THE CONNECTION
OF THE
INSTRUMENT TO A
SUPPLY
VOLTAGE**

Ascertain the voltage of the mains supply and set the MAINS VOLTAGE SELECTOR. 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. Ensure that the instrument is switched off whilst the adjustments are made.

Connect the mains lead of the instrument to the power supply. Set the MAINS switch on the panel to its 'ON' position, and observe that the red panel indicator lamp is illuminated. The valve to be tested should NOT be inserted at this stage.

**FINAL SETTING
OF THE MAINS
VOLTAGE SELECTOR
PANEL**

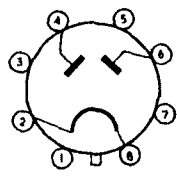
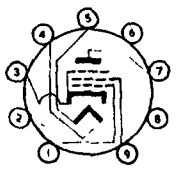
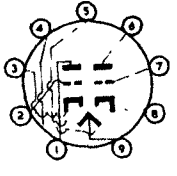
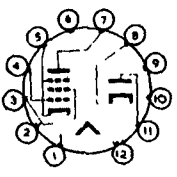
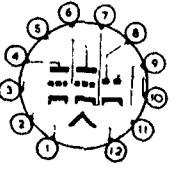
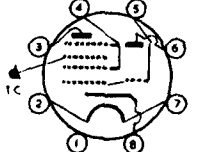
Set the CIRCUIT SELECTOR switch to the position CHECK (C) and the LEAKAGE switch to ~. The mA meter pointer should now move across the scale and come to rest near the black region of the insulation scale denoting zero ohms. Rotate the SET ~ control until the meter pointer is as near as possible to the red line marked ~ in the middle of this black scale marking. 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. 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, the next higher tapping if the pointer is too far right of the ~ mark, and in a similar manner it should be moved to the next lower tapping if the pointer is to the left of the SET ~ mark. Once the mains voltage setting has been correctly set, provided extensive mains fluctuations do not occur, test voltages are automatically correct throughout the instrument.

**PROCEDURE
FOR SETTING
UP VALVE BASE
CONNECTIONS**

The procedure for setting up a valve for test is as follows:—

From some suitable source i.e., the 'AVO' Valve Data Manual, Manufacturers' Valve Data or any other Manual of Valve data, determine the pin connections for the Valve. Rotate the roller of the VALVE PIN SELECTOR switch until the code number or electrode letter combination appears in the window, reading from left to right in accordance with the standard pin numbering sequence. When a valve has less than 13 pins the free rollers on the right of the set up combination correspond to non-existent valve electrodes, and should be set at 0. (See also Chapter 3.)

The accompanying examples show how to correlate the base pin data and the equivalent number for various valves in common use.

VALVE TYPE	VALVE PIN SELECTOR SWITCH CODE				TOP CAP	BASE
Osram U50 Full Wave Rectifier directly heated Octal Base	0 2 0 — h— —	X 0 9 a _d '' — a _d '	0 3 0 — h+ —	0 0 0 0 — — — —	0 0 — —	
Mullard EL84 High Slope Pentode	0 4 1 — g ₁ ' c	2 3 0 h— h+ —	8 0 7 a — g ₂	0 0 0 0 — — — —	0 0 — —	
Mullard ECC 81 Miniature High Slope Double Triode (Heaters wired in parallel)	8 4 1 a g ₁ ' c	2 2 8 h— h— a	5 1 3 g ₁ '' c h+	0 0 0 0 — — — —	0 0 — —	
6 GA7 Compactron Diode Pentode	2 7 7 h— g ₂ g ₂	4 1 0 g ₁ ' c —	8 1 0 a c —	0 9 3 0 — a _d ' h+ —	0 0 — —	
6B10 Compactron Double Diode Twin Triode	2 1 4 h— c g ₁ '	8 5 8 a g ₁ '' a	1 9 1 c a _d ' c	X 0 3 0 a _d '' — h+ —	0 0 — —	
6K8 Triode Hexode frequency Changer	0 2 0 — h— —	0 5 8 — g ₁ '' a	3 1 0 h+ c —	0 0 0 0 — — — —	0 0 — —	
	0 2 8 — h— a	7 4 0 g ₂ g ₁ ' —	3 1 0 h+ c —	0 0 0 0 — — — —	5 0 g ₁ '' —	

**USING THE
AVO VALVE DATA
MANUAL**

The following notes are given to assist users of the Avo Valve Data Manual, particularly when testing multiple electrode valves.

- (a) **Abbreviations** The abbreviations in the Avo Valve Data Manual are as follows:—
- | | | |
|--------------------|---|--|
| V_a | — | Anode Voltage |
| V_{g1} | — | Control Grid Voltage |
| V_{g2} | — | Screen Voltage |
| I_a, mA | — | Anode (plate) Current in milliamps |
| $g_m, \text{mA/V}$ | — | Mutual conductance in milliamps per volt |
| V_f | — | Heater or Filament Voltage |
| R_a | — | External Anode Load Resistance. |
- (b) **Multiple Electrode Valves.** For multiple electrode valves such as rectifier pentodes the first line of data given for any one of these valves refers to the rectifier section of the valve.
- (c) **Double Electrode Valves.** When testing double electrode valves such as triode hexodes, triode pentodes, or dissimilar double pentodes, the upper line of data given for these particular valves, always applies to the triode section of the triode hexode or triode pentode or to section 1 of dissimilar double pentodes. The lower line of data refers to the hexode or pentode section or to section 2 of double pentodes.
- (d) **Dissimilar Treble Pentodes.** For these valves the upper line of data for any particular valve refers to section 1 (and also to section 2 or section 3 if they have the same characteristics as section 1). The lower line of data applies to the remaining section.
- (e) **Quadruple Diodes.** For a small number of these valves, i.e., 6JU8, the anodes of diodes 1 and 3 are coupled internally to the cathodes of diodes 2 and 4. In such cases two Valve Pin Selector switch codings are given in order that each diode may be tested separately.
- (f) **Variations of a Basic Valve Type.** These variations are indicated by a suffix to the basic type designation. These suffixes indicate only mechanical differences and do not affect the basic parameters as measured on the Valve Characteristic Meter. In these cases it is company policy to indicate only the basic type in the Avo Valve Data Manual. For information we give below a list of the suffixes in more general use:—
Basic Type—6L6 included in the Avo Valve Data Manual.
Basic Types with suffixes—6L6A, 6L6B, 6L6G, 6L6GT, 6L6GTA, 6L6W, 6L6WGT, 6L6WGTA. These are not included in the Avo Valve Data Manual.
- (g) **Grid Bias Voltage Not Given.** For some valves a grid bias voltage is not given as manufacturers do not recommend the use of a fixed bias voltage for these valves. This applies particularly in the case of high slope, frame grid valves when a very small change in grid voltage would result in a very great increase in anode current. In these cases it is suggested that the grid voltage is adjusted until the correct value of anode current is obtained.
- (h) **Tuning Indicators.** Valve Data for tuning indicators is now contained in the main section of the Valve Data Manual and not in the appendix as in the Valve Data Manual for the VCM Mk.4. The target volts are given in the V_{g2} column, and the value of load resistor in the Addenda column.
- (i) In the column headed 'Top Cap', figures are inserted in place of electrodes, to conform with the engraving on the roller selectors. For a valve having no top cap the code '00' is used.

**SETTING UP
THE INSTRUMENT
FROM
MANUFACTURERS
DATA**

The following notes are given to assist users of data other than the Avo Valve Data Manual.

- (a) For valves with pins which are internally connected, the appropriate roller of the valve Pin Selector switch should be set at 0.
- (b) If using data issued by United States or other manufacturers the term 'transconductance' replaces 'mutual conductance'. Transconductance (given in micromhos) divided by 1000, gives mutual conductance in mA/V, i.e.,

$$\text{mA/V} = \frac{\text{Transconductance (micromhos)}}{1.000}$$

- (c) When testing triode hexode valves which have the grid of the triode section internally connected to the injector grid of the hexode, the valve Pin Selector switch should be set up normally for the triode section. However, when setting up the hexode section, the grid of the triode section should be strapped to the grid of the hexode section, (i.e. set to position 5). This removes the 50V bias from the injector grid of the hexode section. Since the bias has now been removed from the triode grid, the triode anode must be disconnected by setting the roller to 0. Failure to do this will result in excessive anode current and will modify the anode current reading for the hexode section.
- (d) When the grid voltage is not stated, but a value of cathode bias resistor is given, one of two methods should be used,
- (i) Calculate the voltage drop across the resistor using the formula:—

$$V_{g1} = \frac{(I_a + I_{g2}) R_k}{1,000}$$
 where I_a , I_{g2} are in mA and R_k is in ohms
 - (ii) Set the grid voltage to zero and connect the cathode bias across the cathode link on the valveholder panel. On completion of the test, the cathode resistor should be removed from the link.
- (e) Some manufacturers quote a positive grid voltage together with a cathode bias resistor value. It will be found that if the voltage developed across the resistor is subtracted from the positive voltage, a negative voltage will result. It is this negative voltage which should be set on the Negative Grid Volts control.
- (f) Heater current should be limited to 5A for heater voltages of up to 9.9V. For voltages above this, heater current should be limited to 3A. When valves with substantially high heater currents are under test, the volt drop in the test circuit may be appreciable. This may be compensated for by increasing the heater volts by 0.1 to 0.2 volts per ampere of the nominal heater current. If desired, heater volts may be monitored with a sub-standard a.c. voltmeter, by tapping the appropriate pins of the valveholder adjacent to the valve under test.

SETTING ELECTRODE VOLTAGES

From the Avo Valve Data Manual or Manufacturers' data, ascertain the electrode voltages for the valve under test. Set the heater, grid, anode and screen voltage switches to the correct value for the valve under test and insert the valve in the appropriate valveholder.

INSULATION CHECKS WITH THE VALVE COLD

With the CIRCUIT SELECTOR switch at CHECK (C) rotate the LEAKAGE switch clockwise through its various electrode positions starting at position h (C). At this position the meter should indicate a short on the insulation resistance scale confirming heater continuity. At any other position any reading obtained on the insulation scale of the meter will indicate an electrode insulation breakdown.

INSULATION CHECKS WITH THE VALVE HOT

Set the CIRCUIT SELECTOR switch to CHECK (H). Allow sufficient time for the valve heater to warm up. Rotate the LEAKAGE switch clockwise through the grid and anode positions. Any reading on the insulation scale of the meter will denote an electrode insulation breakdown in megohms.

CATHODE TO HEATER INSULATION CHECK

Set the CIRCUIT SELECTOR to c'h INS. At this position the cathode to heater insulation figure with the valve heater hot will be directly indicated on the insulation resistance scale of the mA meter. It is not possible to state a rejection figure for a valve under test, for such a fault will be of considerable importance in some circuits, whilst in other cases its presence has virtually no consequence at all.

Where an appreciable potential exists between heater and cathode such as for instance, in cathode follower circuits, or d.c. valve amplifiers, the presence of a heater to cathode breakdown of the order of megohms, can often give rise to quite serious trouble. Heater to cathode insulation breakdown, either permanent or variable, can also give rise to noise in valve amplifier circuits. If, on the other hand, the value of the external cathode to heater circuit resistance is only of the order of a few hundred ohms, then a cathode to heater insulation breakdown of the order of fractions of a megohm or greater need not give rise to serious trouble.

MEASUREMENT OF MUTUAL CONDUCTANCE

Having completed the inter-electrode insulation checks, some or all of the valve mutual conductance characteristics would normally be measured. This may take the form of the complete plotting of one or all of its characteristics, or the measurement of its mutual conductance. All these require operation of the main voltage and meter controls and it is essential to ensure that all the requisite controls are correctly set. This applies to the setting of the Grid, Screen and Anode voltage controls, the mA switch and the ELECTRODE SELECTOR switch. In particular, where the probable

anode current of a valve is unknown, the mA switch should be set to 100mA, to avoid possible damage to the meter movement if the current flowing exceeds the mA switch setting. The mA switch may be set subsequently to lower full scale current if required. A silicon diode connected in the shunt across the meter terminals provides some degree of protection against overloading the meter movement.

For mutual conductance testing the instrument should be set up as follows:—

Set Grid, Screen and Anode voltage to the value indicated in the Valve Data Manual. Set the ELECTRODE SELECTOR to the desired anode, the mA switch to the appropriate Ia range, and the CIRCUIT SELECTOR switch to TEST. This last switching operation applies electrode voltages to the valve. Anode current will be indicated on the appropriate mA meter scale and the value of mutual conductance will be displayed on the mA Volt meter. Further sections of the valve may be tested with the ELECTRODE SELECTOR set to other appropriate anode positions.

By depressing the g_2 button, screen current or screen mutual conductance will be displayed. The push buttons must be held depressed whilst measurements are taken.

NOTE: Should the overload relay operate, (indicated by lighting of the blue OVERLOAD lamp), 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 (gassy) and the test should proceed no further. Switch off and remove the valve under test. When switched on again the instrument should function normally.

To check the relative goodness of the valve, using the coloured comparison scale ascertain the rated value of valve mutual conductance from the Avo Valve Data Manual or manufacturers' data and set the arrow of the coloured scale on the mA V meter to this figure on the smaller scale. This will automatically set the dividing line between the red and green sections of the coloured scale, at 50% of this value on the main scale, i.e., if the arrow is set to three on the smaller scale the dividing line between the red and green sections will lie at '1.5' on the main scale. If the measured mutual conductance is less than 50% of the rated figure the meter pointer will lie in the red or reject section of the scale. If however, the measured value of mutual conductance is greater than 50% of the rated value the meter pointer will lie in the 'GOOD' section of the coloured scale.

VALVE CHARACTERISTIC MEASUREMENTS

To provide more comprehensive information, the plotting of one, or a family of mutual characteristics, can be readily undertaken with this Valve Characteristic Meter. The CIRCUIT SELECTOR should be set to position TEST when the value of the appropriate electrode currents can be plotted relative to the setting of the associated electrode voltage switches. I_a, V_g curves will be taken at predetermined setting of anode and/or screen volts, the reading of the anode current obtained being plotted against the setting on the variable grid bias controls. Similarly I_a, V_a curves will require a fixed setting of grid bias, anode current being plotted against the setting of the anode voltage switch. For characteristic curves for the screen g_2 of the valve the push button associated with the mA switch will need to be operated.

Dynamic characteristics may be plotted similarly using selected anode and cathode loads connected at the appropriate links on the Valve Panel. When setting up for these tests the following points should be noted:—

- (a) A capacitor should not be included in the cathode load as this could result in smoothing of the cathode waveform, and resultant errors in measurements.
- (b) When setting V_g it may be necessary to make allowance for the voltage dropped across the cathode load.
 e.g. From the Avo Valve Data Manual the test data for a Valve Type ECC 34 is:—
 $V_g = 16$ volts, $I_a = 10$ ma
 Assuming an R_k of $500\ \Omega$, the voltage dropped across R_k would be 5V. In this instance the GRID VOLTS control should be set to 11V to provide the required V_g of 16 volts.
- (c) For the tetrode and pentode testing the circuit is arranged such that the screen is not decoupled and this should not be attempted.

Additional information for multiple or special types of valve will be found in subsequent notes.

**MEASUREMENT
OF GRID
CURRENT**

The measurement of grid current may be made after measuring the mutual conductance. This measurement should not be made where an apparent fault in the valve has previously caused the protective relay to operate (probably due to softness).

With the CIRCUIT SELECTOR switch set to GAS, the meter will indicate grid current directly in μA . The meter reads a maximum of $100\mu\text{A}$ f.s.d. but it is not possible to state the value at which a valve becomes useless due to presence of gas. This will depend entirely upon the circuit in which it is to be used.

**INSTRUCTIONS
FOR TESTING
SPECIFIC
TYPES**

The function of a valve, as distinct from the type number given to it by its manufacturer is indicated by a symbol in the form of letters appearing at the right of the test data given in the 'AVO' publications, e.g., a half wave rectifier is marked 'R' whilst a full wave rectifier is designated by 'RR'. In a similar manner, diode valves are shown by the letter 'D', the number of the diode elements being indicated by the number of 'Ds'. e.g., 'DDD' refers to a triple diode.

**CHECKING
POWER
RECTIFIERS**

The testing of rectifying valves should ideally be associated with the requirements of the circuit in which they are to operate. In most cases throughout the 'AVO' Valve Data Manual, the figure quoted denotes the standard emission per anode to be expected from the type of valve under test.

Insulation checks may be made as already described. The mA switch has a number of positions grouped together and labelled D/R, the figure marked in these positions being the emission in mA expected per anode of the valve under test. To check load current the mA switch should be set to the load current given for the valve in the Valve Data Manual. Set CIRCUIT SELECTOR to TEST and the ELECTRODE SELECTOR either to a_d' in the case of a half wave rectifier, or a_d'' then a_d''' for a full wave rectifier. The quality of the valve will then be indicated directly on the replace good scale of the mA meter.

The setting of the mA switch can either be determined from the tabulated data given, or can alternatively, be related, to the total current that the valve is required to deliver. Thus, on a piece of equipment where the total h.t. drain on the rectifier is 50mA, then a rectifier load setting of 60 will be an adequate test of the valve's emissive state, assuming that it is a half wave rectifier. Alternatively, if the valve is a new one, the maker's rating for maximum load current can be used as the basis for setting the mA switch.

In the case of full wave rectifiers, each anode of the valve is rated independently and the setting of the mA switch should indicate half the total value of the current which the valve should be expected to deliver in a full wave rectifier circuit, e.g., a valve rated at maximum of 120mA would be tested with each anode at the 60mA position. The load rating given in the Valve Data Manual is the load per anode.

**CHECKING SIGNAL
DIODES**

Signal diodes are checked in exactly the same manner as rectifiers, except that the mA switch is always set to 1 or 5 according to the anode current figures given in the data. (Where 'AVO' Valve Data does not give a current figure for a diode, it is always checked with the meter switch set to its 1mA position).

**MULTIPLE DIODES
AND RECTIFIERS
(D, DD, DDD, DDDD, R, RR)**

The testing of multiple diodes and rectifiers is carried out in the manner already explained, the ELECTRODE SELECTOR being used to select the particular diode or rectifier section, the emission of which is indicated on the mA meter replace/good scale.

**DIODES AND
RECTIFIERS
COMBINED WITH
OTHER
ELECTRODE
ASSEMBLIES
(DT, DDT, DDDT, DP, DDP,
DTP)**

Combined diodes and amplifying valves are represented in the type column of the Data by 'DT', 'DDT' and 'DDDT' for diode triodes, double diode triodes and triple diode triodes, whilst 'DP' and 'DDP' indicates diode pentodes and double diode pentodes and 'DTP' diode triode pentodes.

The testing of the separate sections of each valve is carried out in rotation with the CIRCUIT SELECTOR at TEST and the ELECTRODE SELECTOR at position a' , a'' , or a''' as required.

The rotation of the ELECTRODE SELECTOR to the a_d' , a_d'' , a_d''' or a_d'''' position will automatically set the instrument in readiness for testing the selected diode with the mA switch set to 1 on the D/R scale.

An indication of failing emission will probably give the most useful results. As a subsequent test, therefore, it is helpful to note the anode current at the rated test figures with the nominal heater voltage applied, and then to decrease the heater voltage by approximately 15% for a short period. In the case of a valve with a failing emission, the decrease in cathode temperature will result in an excessive decrease in the anode current, considerably greater than the percentage decrease in heater voltage.

**CHECKING
COLD
CATHODE
RECTIFIERS (CCR)**

Cold cathode rectifiers, designated by the symbol 'CCR' can be tested in a similar manner, but in this instance, a limiting resistance is required in the anode circuit. Values of anode voltage, approximate anode current and load resistance are given in the Valve Data Manual. The anode shorting link should be removed and the recommended value of load resistor should be connected across the terminals.

**DOUBLE TRIODES
AND
DOUBLE PENTODES
(TT, PP)**

Double triodes and double pentodes are indicated by the letters 'TT' and 'PP', each section being tested in the normal manner. Selection of each assembly is made by the rotation of the ELECTRODE SELECTOR switch to a' and a'' (section under test). When double valves are used in class 'B' or 'balanced' circuits, a close match of the characteristics of both halves is essential.

When measuring the screen current of double pentodes having either common or separate screen grids and separate control grids, it is necessary to switch from a' to a'' in order to transpose the bias and cut-off voltages from the control grids. When testing valves having a common control grid but separate screen grids, it is necessary to open circuit the anode and screen not being tested, otherwise the measured current will apply to both sections.

**FREQUENCY
CHANGERS
(H, TH, O, TP.)**

These valves are tested as two separate assemblies, separate data being given for each assembly in the Valve Data Manual.

The ELECTRODE SELECTOR should be set to a' when checking the triode section and to a'' when checking the pentode section.

**CHECKING
TUNING
INDICATORS
(TI)**

Tuning indicators (magic eyes) are tested with the controls set to the figures given in the data table, the SCREEN VOLTS switch being used to obtain target volts (V_{g2} in the Avo Valve Data Manual) and the appropriate anode load inserted in accordance with the value shown in the addenda column. At the approximate bias given in the table the triode section should be at 'cut-off' and the eye fully closed. Reducing the grid bias to zero, the eye should open fully and the value of the anode current should approximate to that appearing in the table (where given). In the case of double sensitivity indicators giving multiple images responding to different sensitivities, two sets of data (where possible) are given, the first set referring to the more sensitive indication.

THYRATRONS

Small thyratrons can be checked by comparison, if set up as a normal triode, but with a limiting resistor included in the anode link, the control ratio being indicated by a comparison between the peak value of the applied anode voltage and the setting of the grid bias control which will prevent the valve striking and passing anode current. It must be emphasised, however, that the main value of such a test is in comparison only, as the hold-off grid bias value shown on the grid bias control is only approximately half that of the bias which would normally be required to hold off the anode current of the valve at the peak anode voltage in question. In the data columns where information is given on the common thyratrons, it will be seen that this comprises a VALVE PIN SELECTOR switch number, Heater voltage, Anode voltage, expected Anode current, and the value of the limiting resistor required which will be found in the addenda column. The resistor should be of suitable wattage and connected across the link terminals before the valve is inserted in its holder. Grid volts should be at their maximum setting. With the mA switch set to '100' on the Ia section, the ELECTRODE SELECTOR at a' and the CIRCUIT SELECTOR at TEST, the bias on the valve should be reduced until the valve strikes and anode current flows. A good valve will pass, approximately the anode current given in the data. (If necessary reduce setting of mA switch.) This test is suitable as an emission check on thyratrons used in television and commercial radio equipment.

**NEON
INDICATING
LAMPS**

Neon indicators may be tested for striking, by setting up the VALVE PIN SELECTOR switch so that anode and cathode pins of the tube are set to 8 and 1 respectively, all other rollers being connected to 0. A suitable load resistor (normally between 5,000 and 15,000 ohms) should be included in the anode circuit link and the anode voltage switch should be set to a peak value as near as possible to (and in no cases lower than) the striking voltage of the neon in question. The striking of the neon will of course be indicated by a passage of anode current. The mA switch should be set to '100' on the Ia section. It should be noted that where the anode voltage refers to the peak applied voltage, as in the case of thyratrons and neons, the actual peak voltage applied to the valve is higher than the indication on the anode voltage switch. To obtain the peak voltage equivalent to a given setting of the anode voltage switch the figure shown on the switch should be multiplied by approximately 1.5: thus with the anode voltage switch set to represent a d.c. voltage of 100V the peak applied voltage is approximately 150V.

NOTE: It is not recommended that Neon reference or stabiliser tubes are tested on this instrument as the valve manufacturers' state that the application of a.c. potentials may damage the valve under test.

**GENERAL
PRECAUTIONS
TO BE OBSERVED
WHEN USING
THE VALVE
CHARACTERISTIC
METER**

It will be realised that when dealing with an instrument such as the Valve Characteristic Meter with such flexibility of control, it is almost impossible to protect the instrument to such an extent that the operator cannot cause damage to either the valve or the instrument by some combination or wrong setting of the controls or incorrect use of the instrument. It is, therefore, important that the correct procedure, as previously outlined should be used in the sequence of the tests applied. Valves should be tested for insulation or breakdown before full voltages are applied for characteristic tests. Where any doubt whatever exists as to the probable electrode current likely to be passed, the mA switch, should always be set to its highest current range and then gradually reduced in order to facilitate reading of the electrode current.

In experimental work where a variable voltage is required to be applied to the anode or screen electrodes of the valve, always start with the lower voltage tappings and increase only after correct adjustments have been made to the mA switch to ensure that the meter circuit is not overloaded by an unknown current. Always make sure that the VOLTAGE SELECTOR switches have been correctly set for the valve before the instrument is switched on again. In this respect it is good practice to return the VOLTAGE SELECTOR switches to their minimum position (particularly HEATER VOLTAGE switches) after a test has been applied and before a new valve is inserted.

Take care in setting the VALVE PIN SELECTOR switch to avoid wrongly connecting the electrodes of the valve under test. In this respect the automatic cut-out is advantageous in that it will usually protect a valve if high tension voltage is inadvertently applied to the heater by incorrect setting of the switch but it must be pointed out that after the switch is correctly set, nothing can save the heater from being burnt out if an overload heater voltage is applied by incorrect setting of the heater voltage switches.

Do not apply test voltage to the valve without ensuring, that where necessary, top cap connections have been correctly made, as a valve can often be irreparably damaged by running it with its grid or anode wrongly connected.

Where a valve appears to be performing abnormally, as indicated for instance by a continuously rising or falling anode current which does not attain a condition of stability, do not leave the valve on test for a long period to see what will ultimately happen, as this will in all probability result in the damaging of the valve due to excessive currents in the anode or screen circuits. In general it is not necessary or helpful to leave a valve on test for a considerably longer period than is necessary to complete the test in question.

Finally it must be stressed that whilst every care has been taken in the compilation of this publication and the 'AVO' Valve Data Manual, to ensure that all data given is correct as far as is known at the time of going to press, it is not impossible that with the many thousands of figures involved, errors will have crept in. The manufacturers' cannot hold themselves responsible for any damage that might occur to a valve or to the instrument from such a cause.

For convenience, we give below an abbreviated list of instructions but before switching ON the full operating instructions should be read and always be used for reference when testing unusual types of valves.

- (1) Check mains adjustment tap and connect mains lead to supply.
- (2) Set CIRCUIT SELECTOR to CHECK (C) and ELECTRODE SELECTOR to a'.
- (3) Set HEATER VOLTS to value indicated in Valve Data.
- (4) Set GRID, SCREEN and ANODE VOLTS to values indicated in Valve Data.
- (5) Set VALVE PIN SELECTOR switch as indicated in Valve Data and ensure that the links are tight.
- (6) With LEAKAGE switch set to ~, switch on and adjust pointer to position by means of SET ~ switch.

ALL VALVES

- (1) Insert valve and make any top cap connections if required.
- (2) Fully rotate LEAKAGE switch. Check heater continuity at h(C) and insulation on all other positions.
- (3) Set CIRCUIT SELECTOR to CHECK (H) to measure leakage with valve hot.
- (4) Turn CIRCUIT SELECTOR to c h INS to measure leakage between heater and cathode with the valve hot. (If valve is indirectly heated.)

TRIODES, DOUBLE TRIODES, DOUBLE TRIODE PENTODES, DOUBLE PENTODES, DIODE PENTODES, AND TETRODES IN SIMILAR COMBINATION.

ANODE CURRENT. Set ELECTRODE SELECTOR to a' and CIRCUIT SELECTOR to TEST. The mA meter should then indicate 'Anode Current'. Reduce mA switch setting if required. NOTE: If the blue OVERLOAD lamp is illuminated, switch off and check for incorrect setting of VALVE PIN SELECTOR switch or panel controls. If all controls are correct and lamp continues to light when instrument is switched on again, the valve is probably soft and the test should be discontinued.

MUTUAL CONDUCTANCE

With all controls set as for anode current measurement, the mutual conductance will be indicated on the special mA V meter. To use the comparison scale, set the Nominal mA/V calibrated scale to the mutual conductance figure given in the Valve Data. If the measured mutual conductance is less than 50% of this figure the meter pointer will lie in the red portion of the scale and a reject valve will be indicated.

For multiple valves check data if different for other sections. Set the CIRCUIT SELECTOR switch back to c,h INS and set up appropriate voltages for the next section. Set the ELECTRODE SELECTOR to a'' and then repeat for a''' if applicable.

GAS TEST

To measure grid current set CIRCUIT SELECTOR to position GAS. Meter will now indicate gas current, full scale indication being 100 μ A.

DIODES

To check diodes turn the ELECTRODE SELECTOR to a_d' and mA switch to 1mA on D/R scale (unless otherwise indicated in Valve Data). Turn CIRCUIT SELECTOR to TEST. The condition of the valve will now be given on the REPLACE/GOOD scale of the meter. For multiple diodes check as required at a_d'', a_d''' and a_d'''' positions of the ELECTRODE SELECTOR.

RECTIFIERS

To check rectifiers, set ELECTRODE SELECTOR to a_d' and set anode loading given in Valve Data on D/R section of the mA switch. Turn CIRCUIT SELECTOR to TEST. The condition of the valve will now be indicated on REPLACE/GOOD scale of the mA meter. Load reading is per anode. Check full wave rectifiers at position a_d' and a_d'' of ELECTRODE SELECTOR switch.

At the completion of tests all switches should be set to their lowest value.

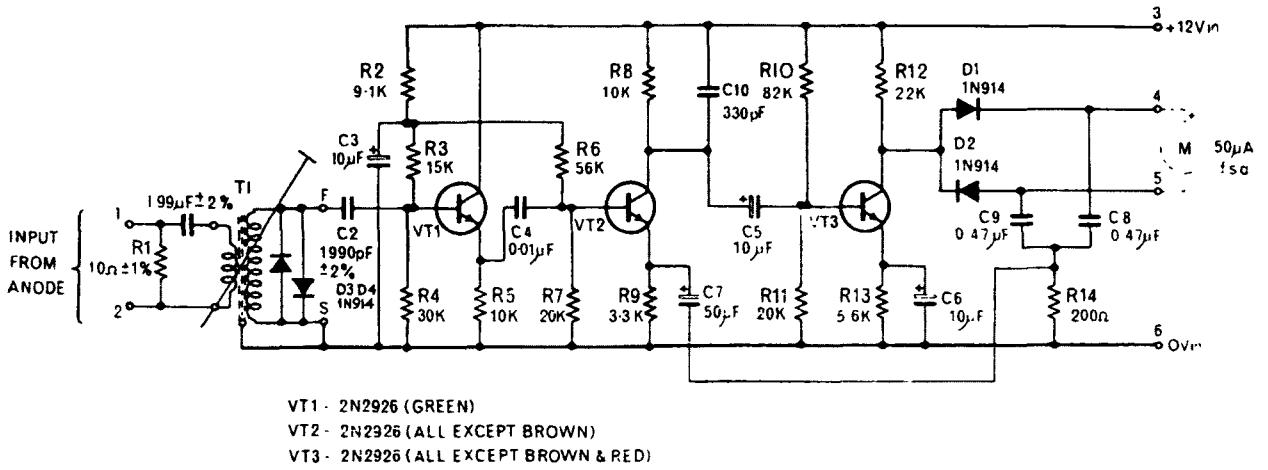


FIG. 4 AMPLIFIER CIRCUIT DIAGRAM

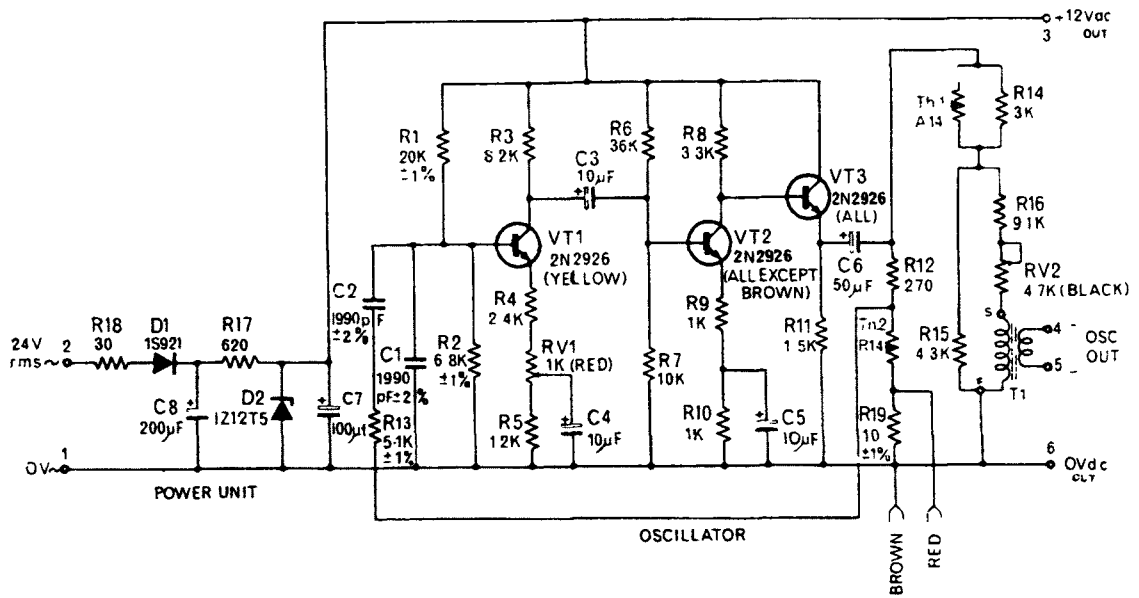


FIG. 5 OSCILLATOR AND POWER UNIT CIRCUIT DIAGRAM

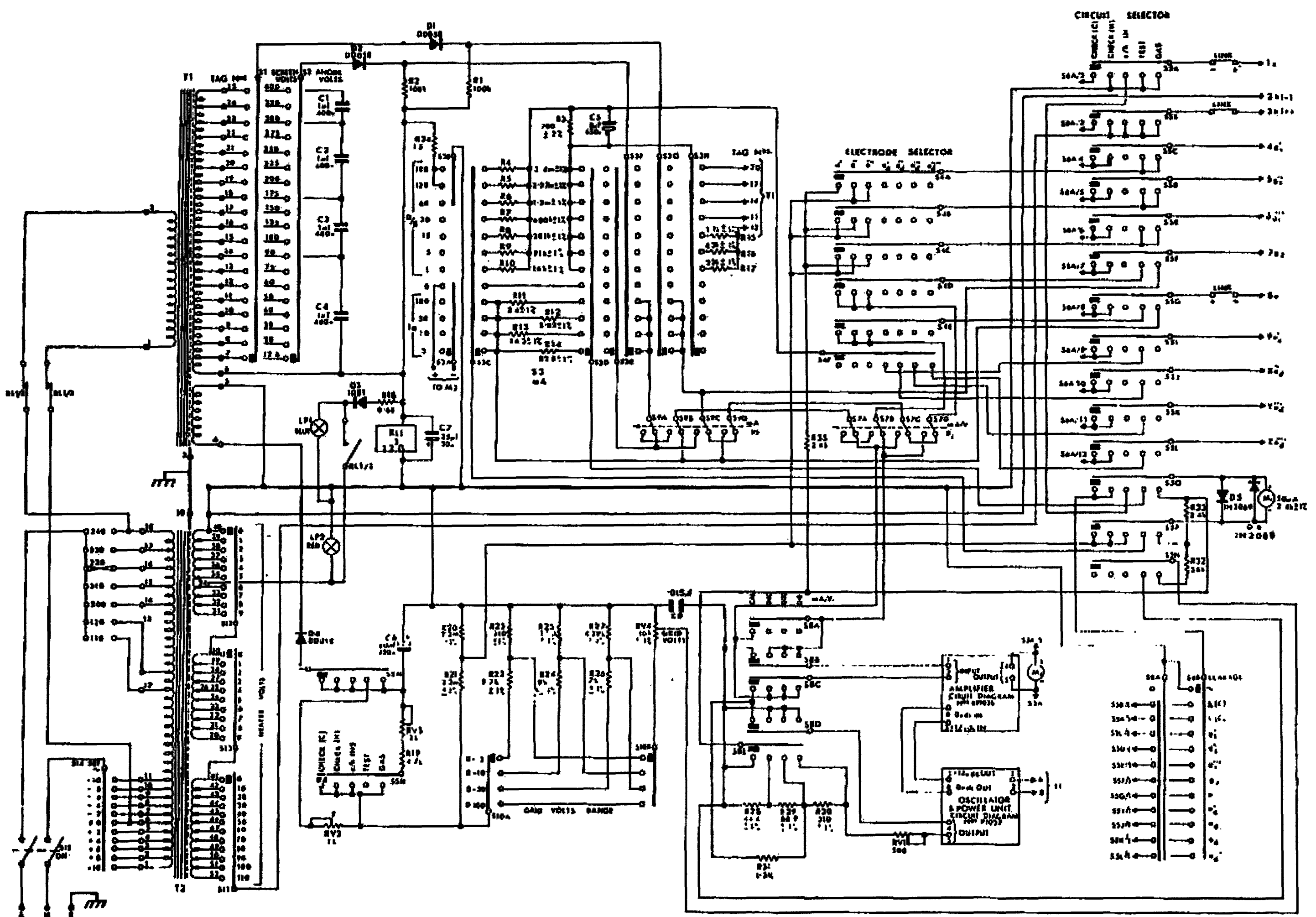
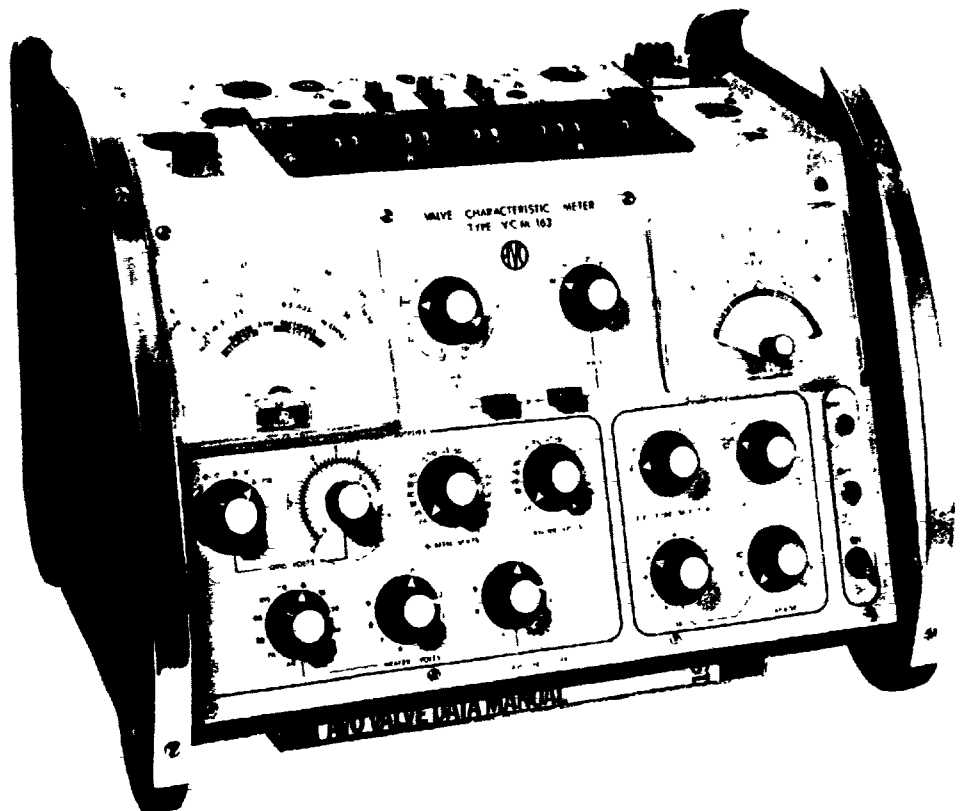


Fig 12 Circuit Diagram; Valve Characteristic Meter Type VCM 163



Service Manual

Type V.C.M. 163 Valve Characteristic Meter



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Service Manual

Type V.C.M. 163 Valve Characteristic Meter

These instructions have been written to provide a general guide to the servicing of the Valve Characteristic Meter Type VCM 163.

No attempt should be made to service this Valve Characteristic Meter Type VCM 163 unless the full range of recommended test equipment (see Page 1) is available.

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)
 - (d) Resistors various, $1M\Omega \pm 5\%$, $1k\Omega$ 3W variable, $3.9k\Omega \pm 5\%$ 4.5W,
 $960\Omega \pm 5\%$ with a rating of greater than 30W,
 $150\Omega \pm 1\%$ 5W
 - (e) 500V Megger
 - (f) Valve 12AT7 and Rectifier Valve U52
 - (g) Silicon Diode DD058
-

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 I_a/V_g curve must be plotted at recommended V_a (See Valve Data Book). From the curve obtain the Mutual Conductance at a point (I_a/V_g) preferably given by the Valve Data Book, if it is on the linear portion of the characteristic.

$$\text{Mutual Conductance} = \frac{I_a}{V_g}$$

Adequately smoothed dc supplies should be used and Model 8 Avometers to monitor V_a , I_a and V_g . 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 \sim . 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 \sim control until the meter pointer is as near as possible to the red line marked \sim 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 \sim control.
- (g) If this is not possible and rotation of the SET \sim control does not enable the pointer to reach the \sim 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 \sim 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 \sim 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 $\pm 5\%$ of range value $+0.25V$ and g_m is within $\pm 5\%$ f.s.d. of standardised value.
- (k) Check the 'Gas' position of the CIRCUIT SELECTOR switch. Insert a $1M\Omega$ 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.

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 \sim . 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 \sim control until the meter pointer is as near as possible to the red line marked \sim 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 \sim control.
- (g) If this is not possible and rotation of the SET \sim control does not enable the pointer to reach the \sim 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 \sim 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 \sim 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 $\pm 5\%$ of range value $+0.25V$ and g_m is within $\pm 5\%$ f.s.d. of standardised value.
- (k) Check the 'Gas' position of the CIRCUIT SELECTOR switch. Insert a $1M\Omega$ 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.

<u>Symptoms</u>	<u>Possible Fault</u>	<u>Action</u>
No red panel lamp indication	No mains input Indicator bulb burnt out	Check mains connector 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 $960\Omega \pm 5\%$ 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. Ferroxcube 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 $\pm 0.5\%$ 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 \sim at mid-point, Leakage at \sim , 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 $I_a = 100$ 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 correctappings 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 100M Ω).

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

- (g) With the instrument switched on, set switches as follows:
 SET \sim at mid-point, LEAKAGE at \sim , CIRCUIT SELECTOR at CHECK (H) or CHECK (C).
- (h) Set the mA meter to the red line marked \sim by adjusting RV3 and ensuring that the ac voltmeter reads exactly 240V at this point.
- (j) Rotate the SET \sim 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 $\pm 0.5\%$ at 52V dc and the sensitivity 20,000 Ω /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 $\pm 3\%$ 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 tapplings, 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 $\pm 5\%$.
- (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^o and 22^oC.
- (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 1k Ω variable 3W resistor and 3.9k $\Omega \pm 5\%$, 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 $1.5\text{mA} \pm 2.5\%$. Repeat this test for the following switch settings:

<u>Ia</u>	<u>Va</u>	<u>Sub-standard meter reading</u>
10	40	$5\text{mA} \pm 2.5\%$
*30	12.6	$15\text{mA} \pm 2.5\%$
*100	50	$50\text{mA} \pm 4\%$

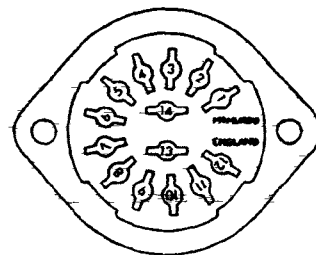
*For these settings short the $3.9\text{k}\Omega$ resistor.

FINAL TEST PROCEDURE

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

- Apply a 500V Megger test between the mains input and frame.
- Apply 240V via a variac to the instrument and adjust the meter pointer to the \sim mark on the scaleplate. (For full details see Rapid Performance Checks (d) to (g)).
- Set the VALVE PIN SELECTOR switch to 133 456 789 XYZ0
- Set the CIRCUIT SELECTOR switch to CHECK (C)
- Using the SP14S valveholder on the valve panel, connect a $1\text{M}\Omega \pm 5\%$ 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 $1\text{M}\Omega \pm 10\%$. For convenience, the pin numbering of the SP14S valveholder is given in the diagram.

<u>Pins</u>	<u>Leakage switch setting</u>
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'''' d



- (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 $1M\Omega$ resistor between cathode and heater. The meter should again read $1M\Omega \pm 10\%$.
- (h) Set the Anode Volts to 12.6, the mA switch to Ia 100 and CIRCUIT SELECTOR to Test.
- (j) Connect a resistor of $960\Omega \pm 5\%$ 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 E55L 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

817 231 151
817 231 161

Electrode Selector

a"
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 $\pm 5\%$ of range value + 0.25V and that g_m is within $\pm 5\%$ 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 $1M\Omega$ 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 $\pm 1\%$, 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:

<u>D/R Range</u>	<u>Reading on 100 scale</u>
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 500 Ω	27133-326
RV2	Potentiometer 1k Ω	27133-331
RV3	Potentiometer 2k Ω	27133-341
T1	H.T. Transformer Assembly	45185
T2	L.T. Transformer Assembly	45197
RL1	Relay	45211
C1-C4	Capacitors 1 μ F 400V	27538-318
D4	Diode DD058	28461-501
D5, D6	Diode IN2069	28462-696

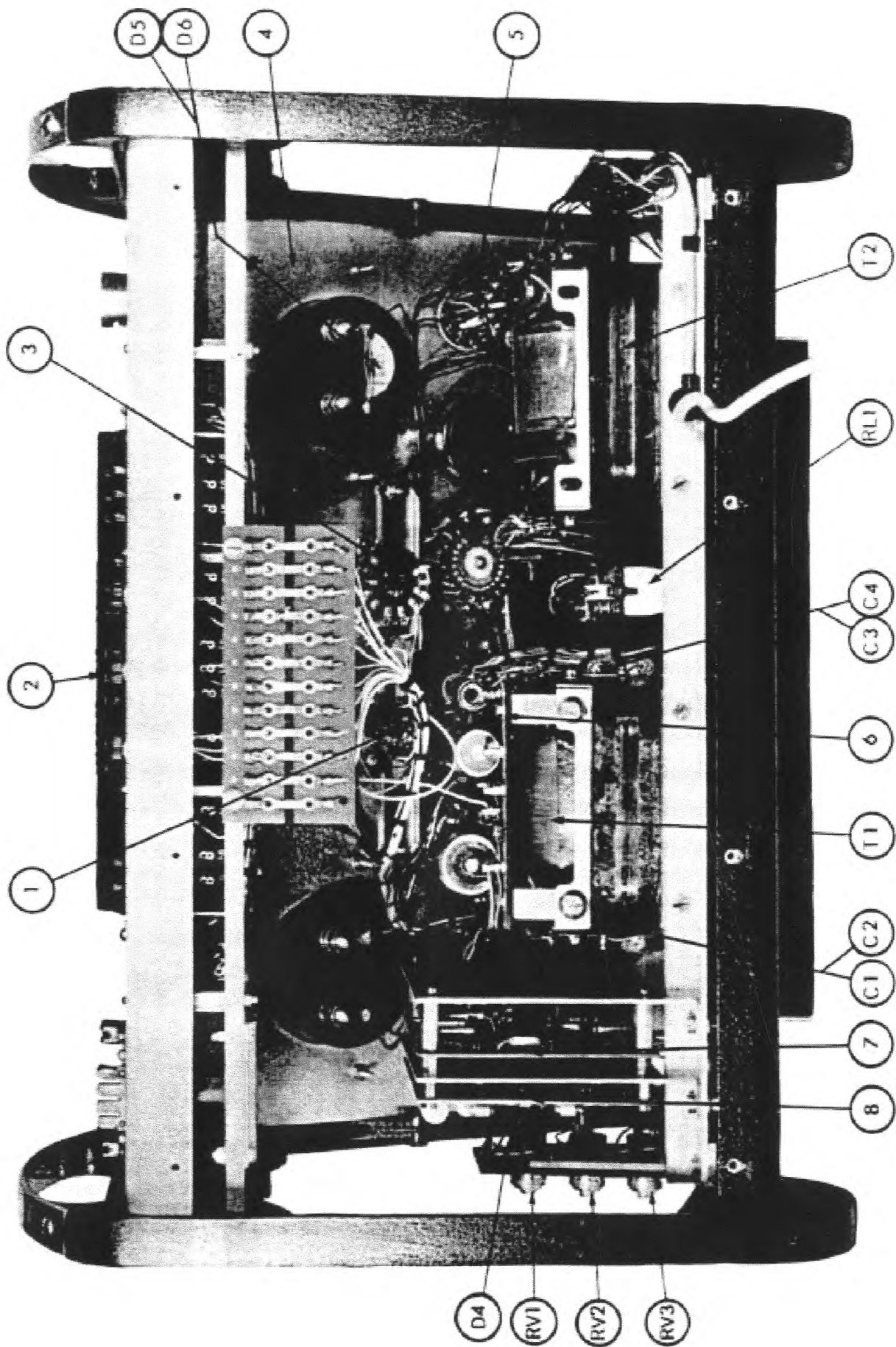


Fig1. Chassis Assembly

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 M1	45206
31	Meter Assembly mA M2	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 \pm 1% (R33)	26232-382
43	Resistor 56k \pm 2% (R32)	26834-497

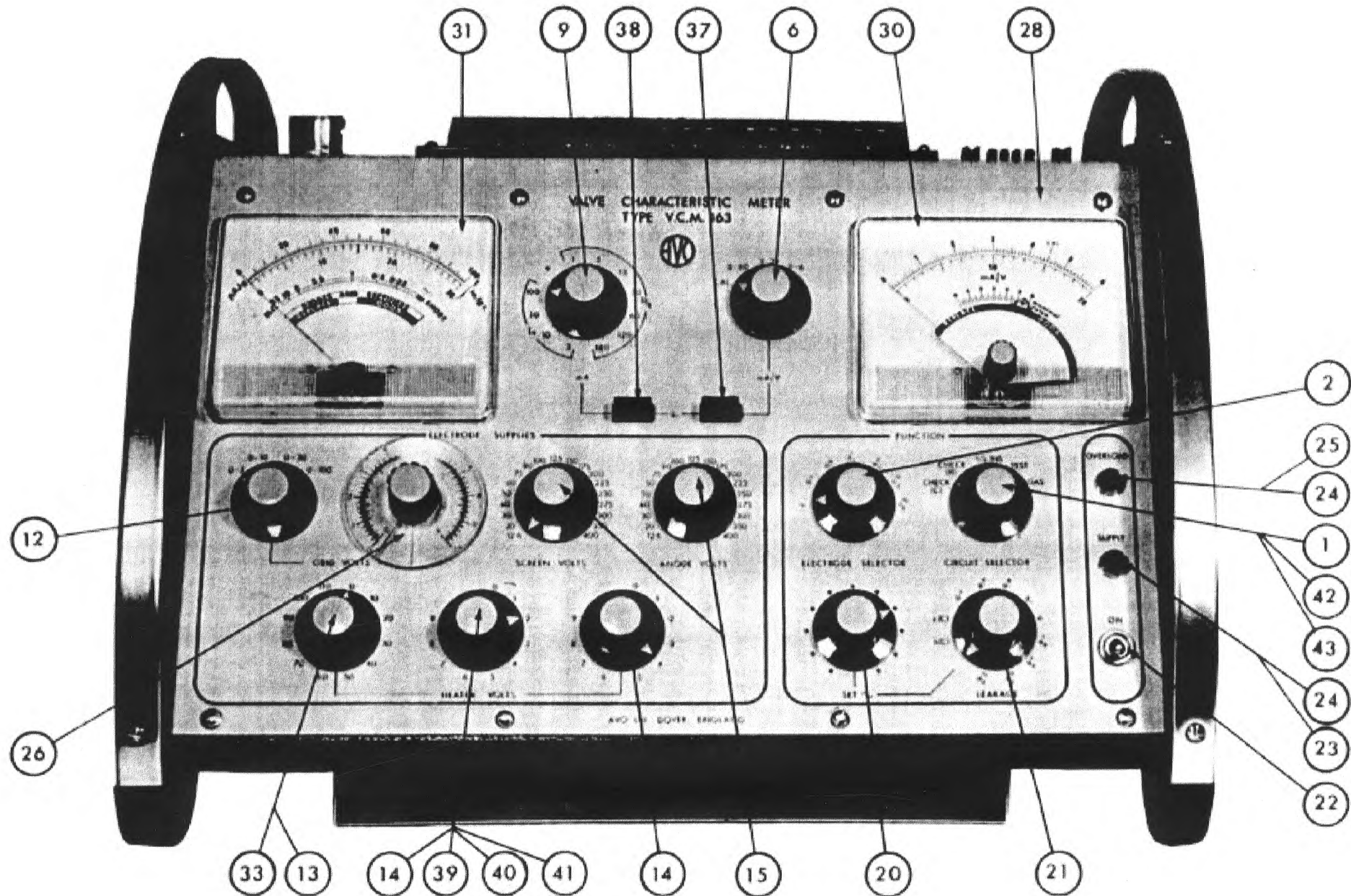


Fig 2. Front Panel Assembly 45193

FIG.3-AMPLIFIER BOARD ASSEMBLY 45001

Item No.	Description	Avo Part No.
1	Printed Circuit Board	3218-326
2	Transistors 2N2926 (VT1, 2 & 3)	28552-601
3	Resistor 9.1k \pm 2% (R2)	26834-478
4	Capacitor 0.01 μ F \pm 20% 160V dc (C4)	27532-125
5	Resistor 56k \pm 2% (R6)	26834-497
6	Resistor 10k \pm 2% (R5, R8)	26834-479
7	Resistor 20k \pm 2% (R7, R11)	26834-486
8	Capacitor 330pF \pm 20% 400V dc (C10)	27532-106
9	Resistor 3.3k \pm 2% (R9)	26834-467
10	Capacitor 10 μ F 15V dc (C3, 5 & 6)	27462-405
11	Resistor 82k \pm 2% (R10)	26834-501
12	Resistor 5.6k \pm 2% (R13)	26834-473
13	Resistor 22k \pm 2% (R12)	26834-487
14	Capacitor 50 μ F 15V dc (C7)	27462-413
15	Resistor 200 Ω \pm 1% (R14)	26232-356
16	Capacitor 0.47 μ F \pm 10% 160V dc (C8,C9)	27537-161
17	Diode IN 914 (D1, 2, 3 & 4)	28433-801
19	Printed Circuit Tags	25255-372
20	Capacitor 1 μ F \pm 2% 150V dc (C1)	27533-845
21	Resistor 10 Ω \pm 1% (R1)	26232-325
22	Transformer	45003
23	Capacitor 1990pF \pm 2% 125V dc (C2)	27522-133
24	Resistor 15k \pm 1% (R3)	26232-401
25	Resistor 30k \pm 1% (R4)	26232-408

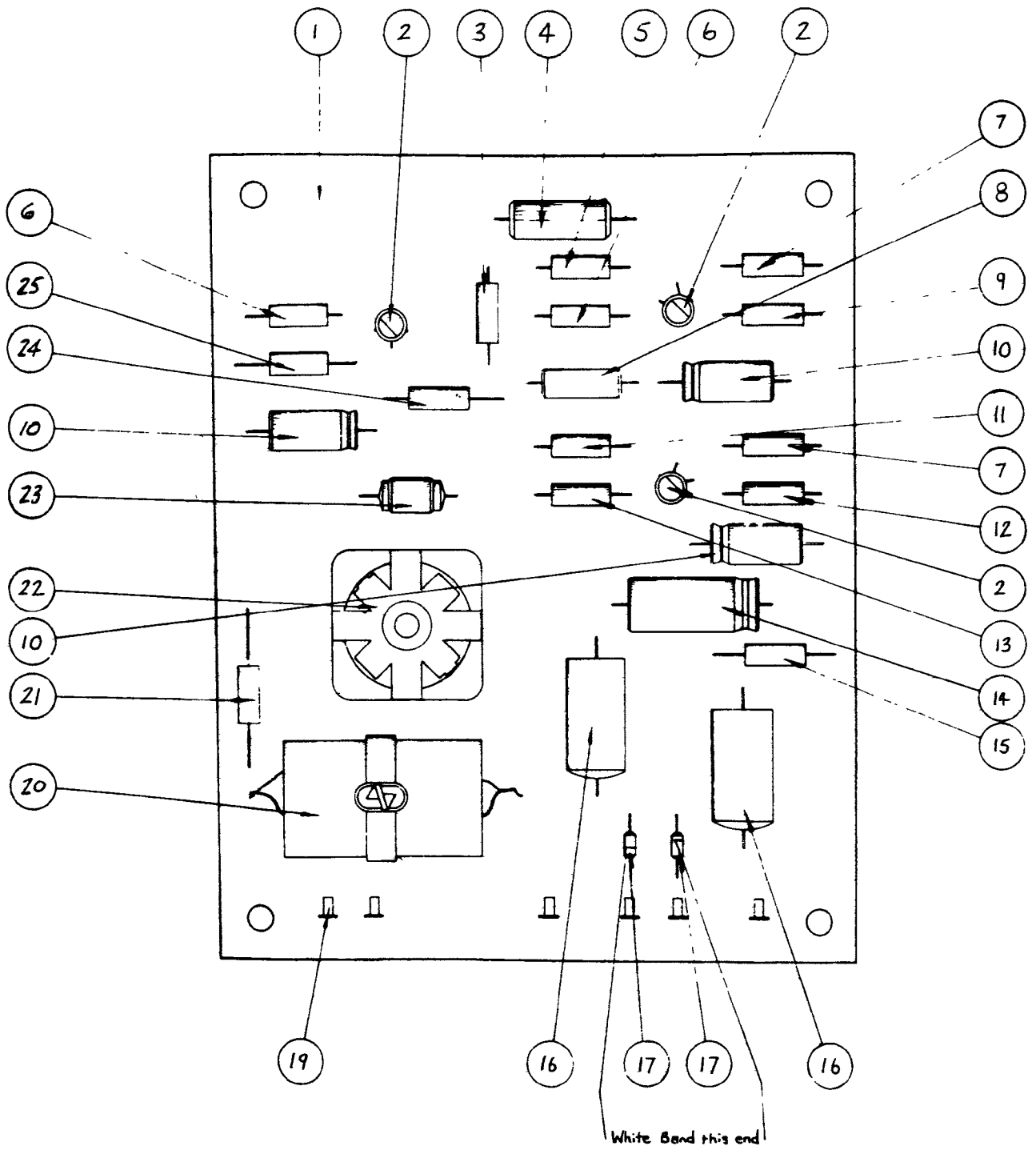


Fig3. Amplifier Board Assembly 45001

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 \pm 20% @ 20 ⁰ C (TH2)	27284-318
3	Heat Sink	3565-615
4	Resistor 1k \pm 2% (R9, R10)	26834-455
5	Capacitor 50 μ F 15V dc (C6)	27462-413
6	Thermistor Type A14 10k \pm 20% @ 20 ⁰ C (TH1)	27284-330
7	Resistor 3k \pm 2% (R14)	26834-466
8	Transistor 2N2926 (VT1, 2 & 3)	28552-601
9	Resistor 4.3k \pm 2% (R15)	26834-470
10	Oscillator Output transformer (T1)	45004
11	Printed Circuit Tags	25255-372
12	Potentiometer 4.7k \pm 20% (RV2)	27113-712
13	Resistor 30 Ω \pm 2% (R18)	26834-418
14	Resistor 1.5k \pm 2% (R11)	26834-459
15	Resistor 3.3k \pm 2% (R8)	26834-467
16	Diode IS 921 (D1)	28461-824
17	Diode IZ125T5 (D2)	28475-281
18	Resistor 620 Ω \pm 2% (R17)	26834-450
19	Resistor 36k \pm 2% (R6)	26834-492
20	Capacitor 100 μ F 15V dc (C7)	27462-417
21	Capacitor 200 μ F 30V dc (C8)	27462-421
22	Resistor 8.2k \pm 2% (R3)	26834-477
23	Resistor 20k \pm 1% (R1)	26232-404
24	Resistor 6.8k \pm 1% (R2)	26232-393
25	Capacitor 1990pF \pm 2% 125V dc (C1, C2)	27522-133
26	Capacitor 10 μ F 15V dc (C3, 4 & 5)	27462-405
27	Resistor 5.1k \pm 1% (R13)	26232-390
28	Resistor 1.2k \pm 2% (R5)	26834-457
29	Resistor 2.4k \pm 2% (R4)	26834-464
30	Potentiometer 1k \pm 20% (RV1)	27113-749
31	Resistor 10k \pm 2% (R7)	26834-479
32	Resistor 270 Ω \pm 2% (R12)	26834-441
33	Resistor 10 Ω \pm 1% (R19)	26232-325
34	Printed Circuit Socket	45052
35	Printed Circuit Socket	45085
40	Resistor 9.1k \pm 2% (R16)	26834-478

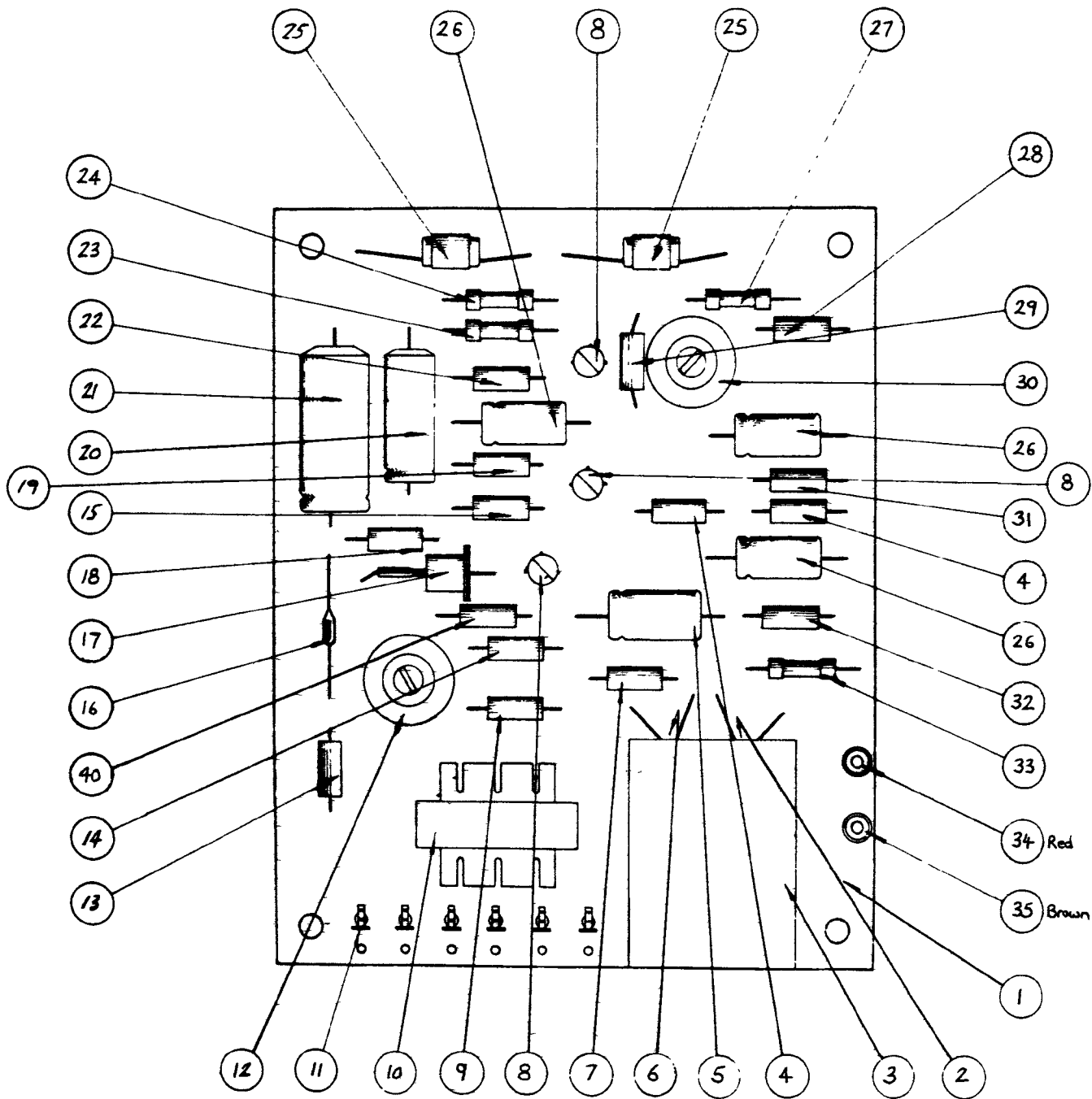


Fig 4. Oscillator and Power Unit Board Assembly 45002

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	25428-283
15	Valveholder B9G	28281-163
16	Valveholder B4/5 SP5E	28281-122
17	Valveholder B10B	28281-738
18	Valveholder B9A	28281-709
19	Valveholder B9D	28281-736
20	Valveholder I.O	28281-154
21	Valveholder Compactron	28281-757
22	Valveholder B8G	28281-676
23	Valveholder B7G	28281-632
24	Valveholder B8A	28281-663
42	Ferroxcube Bead (Not illustrated)	27888-321

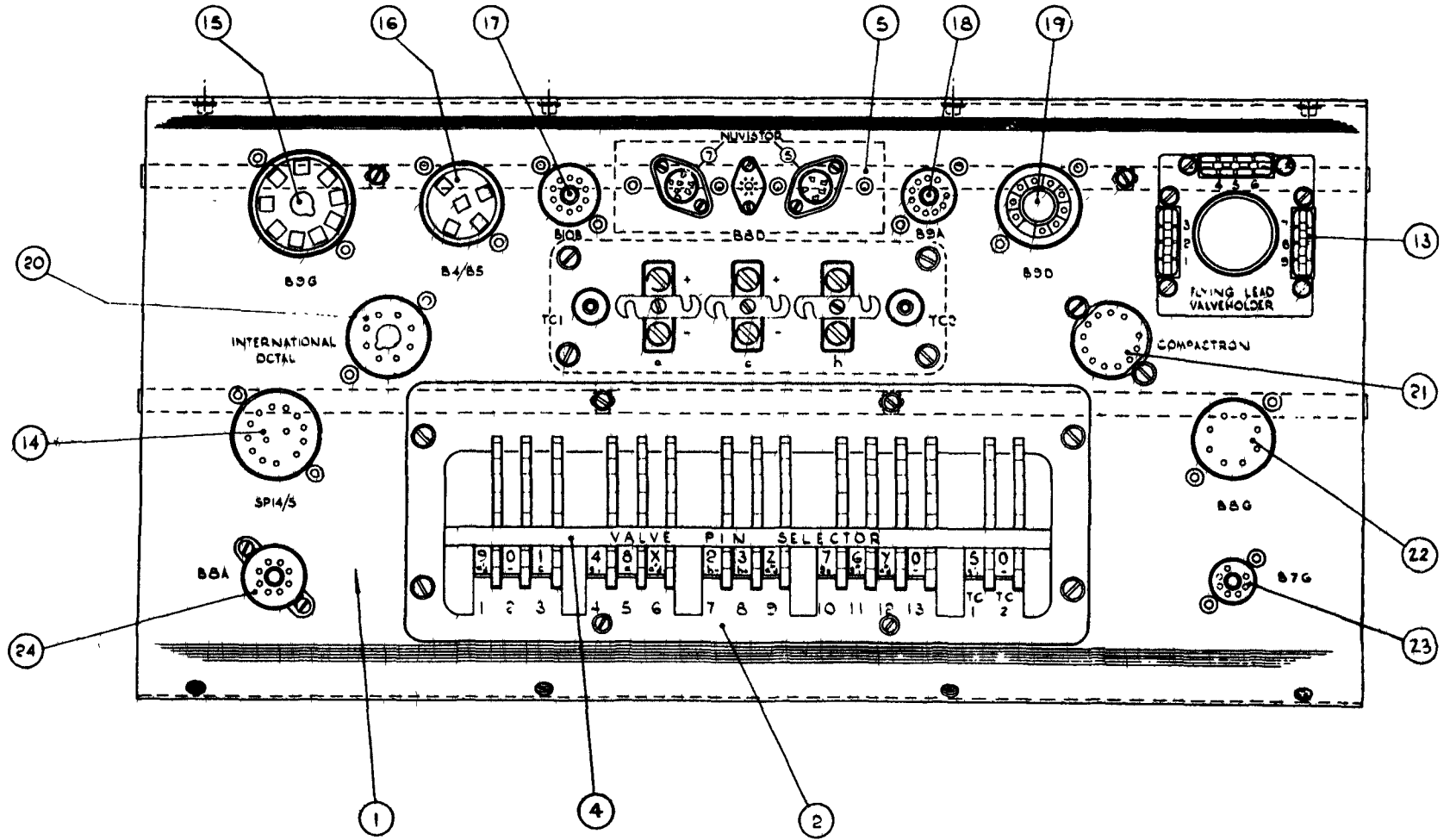


Fig 5. Valve Panel Assembly 45215

FIG.6- mA VOLT SWITCH ASSEMBLY 45190

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

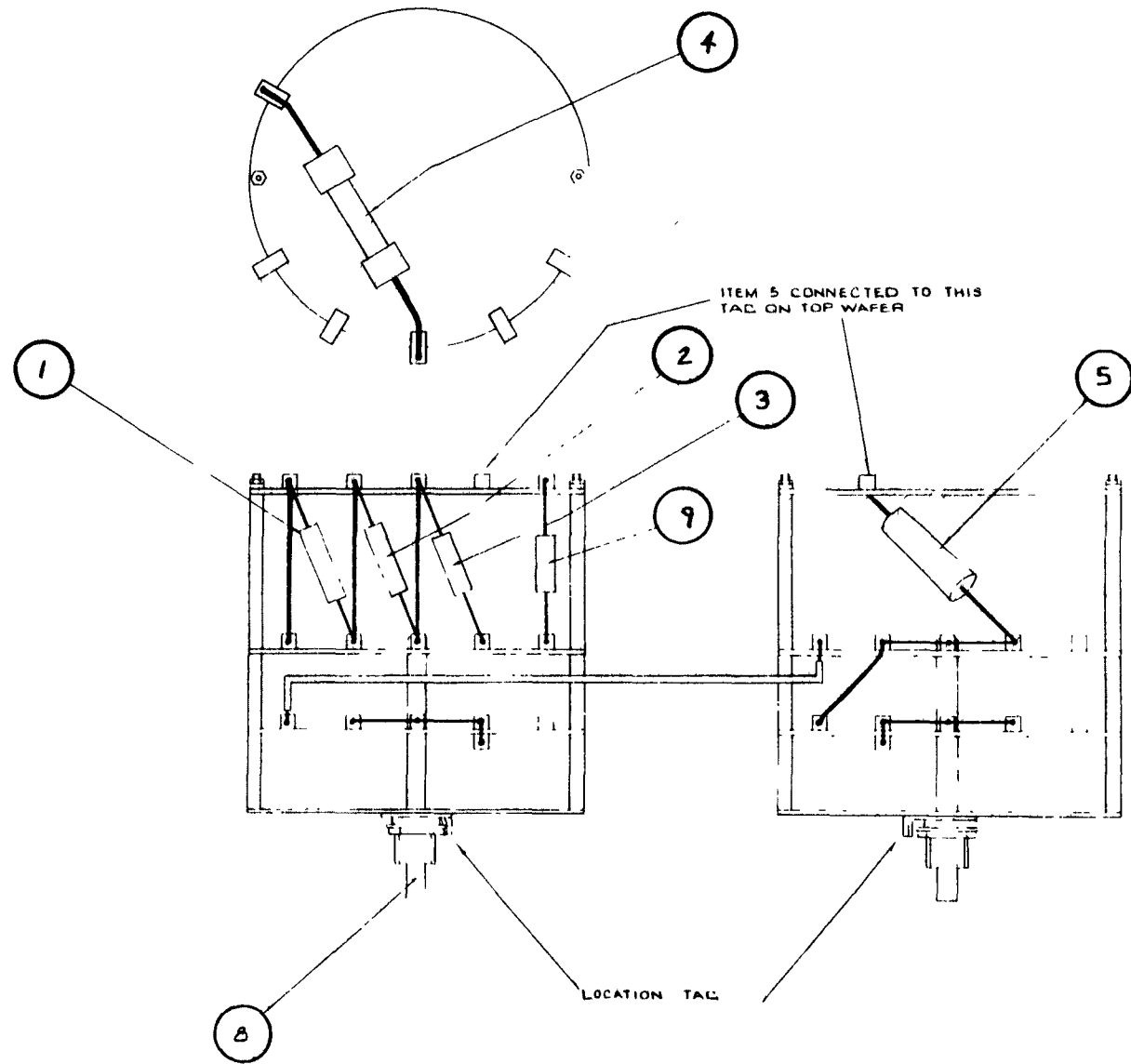


Fig 6. mA Volt Switch Assembly 45190

FIG.7- mA SWITCH ASSEMBLY 45189

Item No.	Description	Avo Part No.
1	mA Switch	45815
2	Resistor $3.4M\Omega \pm 1\%$ (R4)	26236-666
3	Resistor $82.8\Omega \pm 1\%$ (R14)	26444-232
4	Resistor $24.3\Omega \pm 1\%$ (R13)	26441-632
5	Resistor $8.02\Omega \pm 1\%$ (R12)	26437-372
6	Resistor $2.4\Omega \pm 0.05\Omega$ (R11)	26434-830
7	Resistor $16k\Omega \pm 1\%$ (R10)	26232-402
8	Resistor $281k\Omega \pm 1\%$ (R8)	26235-911
9	Resistor $680k\Omega \pm 1\%$ (R7)	26232-441
10	Resistor $1.3M\Omega \pm 1\%$ (R6)	26232-448
11	Resistor $2.27M\Omega \pm 1\%$ (R5)	26236-660
12	Resistor $1.1k\Omega \pm 1\%$ (R15)	26233-574
13	Resistor $4.3k\Omega \pm 1\%$ (R16)	26232-388
14	Resistor $22k\Omega \pm 1\%$ (R17)	26232-405
15	Resistor $91k\Omega \pm 1\%$ (R9)	26232-420

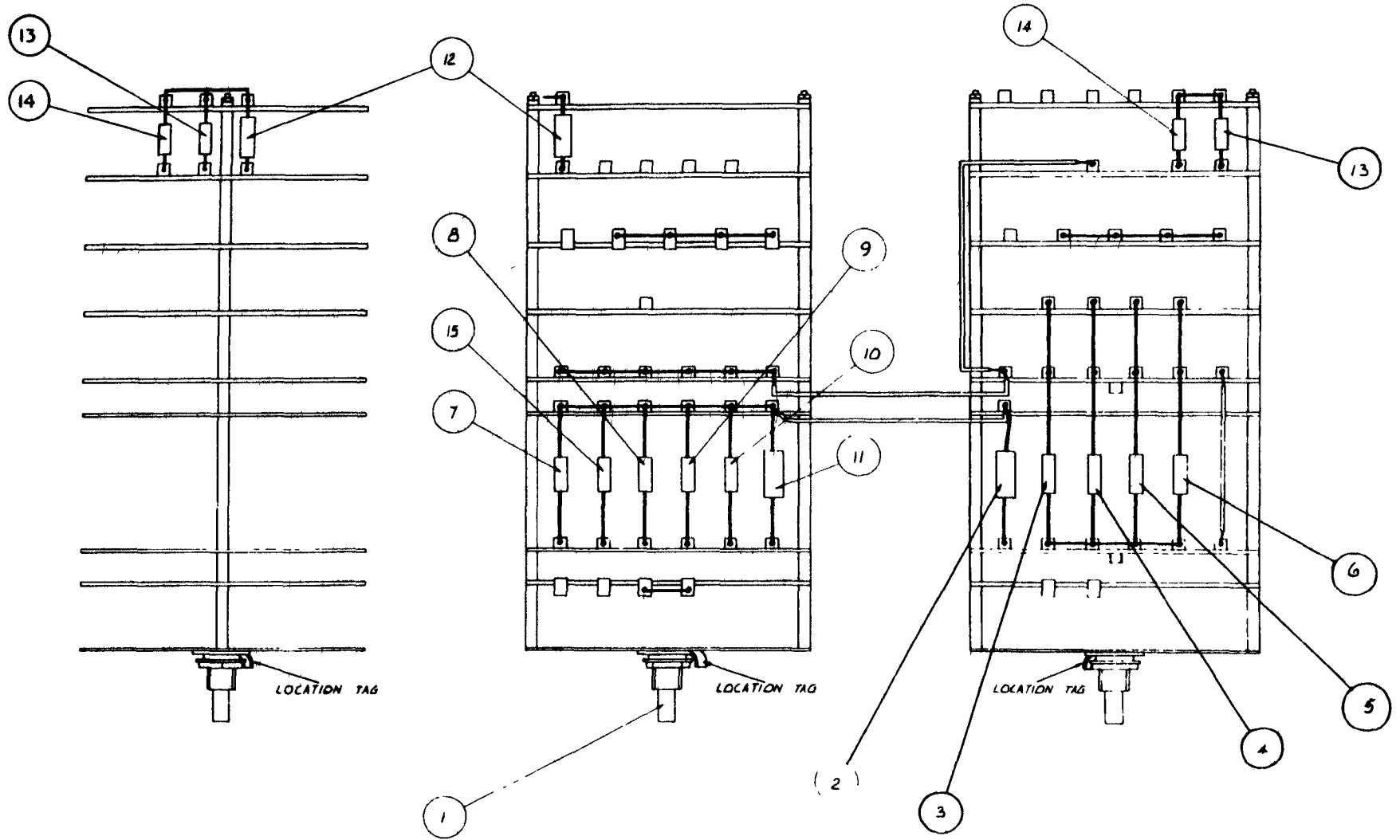


Fig 7. mA Switch Assembly 45189

FIG.8- GRID VOLTS SWITCH ASSEMBLY 45188

Item No.	Description	Avo Part No.
1	Grid Volts Switch	45817
2	Resistor $310\Omega \pm 1\%$ (R23)	26235-736
3	Resistor $1.11k\Omega \pm 1\%$ (R25)	26235-767
4	Resistor $4.29k\Omega \pm 1\%$ (R27)	26235-793
5	Resistor $9.7k\Omega \pm 1\%$ (R22)	26338-327
6	Resistor $9k\Omega \pm 1\%$ (R24)	26338-325
7	Resistor $7k\Omega \pm 1\%$ (R26)	26338-322
8	Resistor $2.2M\Omega \pm 1\%$ (R20, R21)	26233-653
9	Resistor $4.7k\Omega \pm 2\%$ (R19)	26834-471

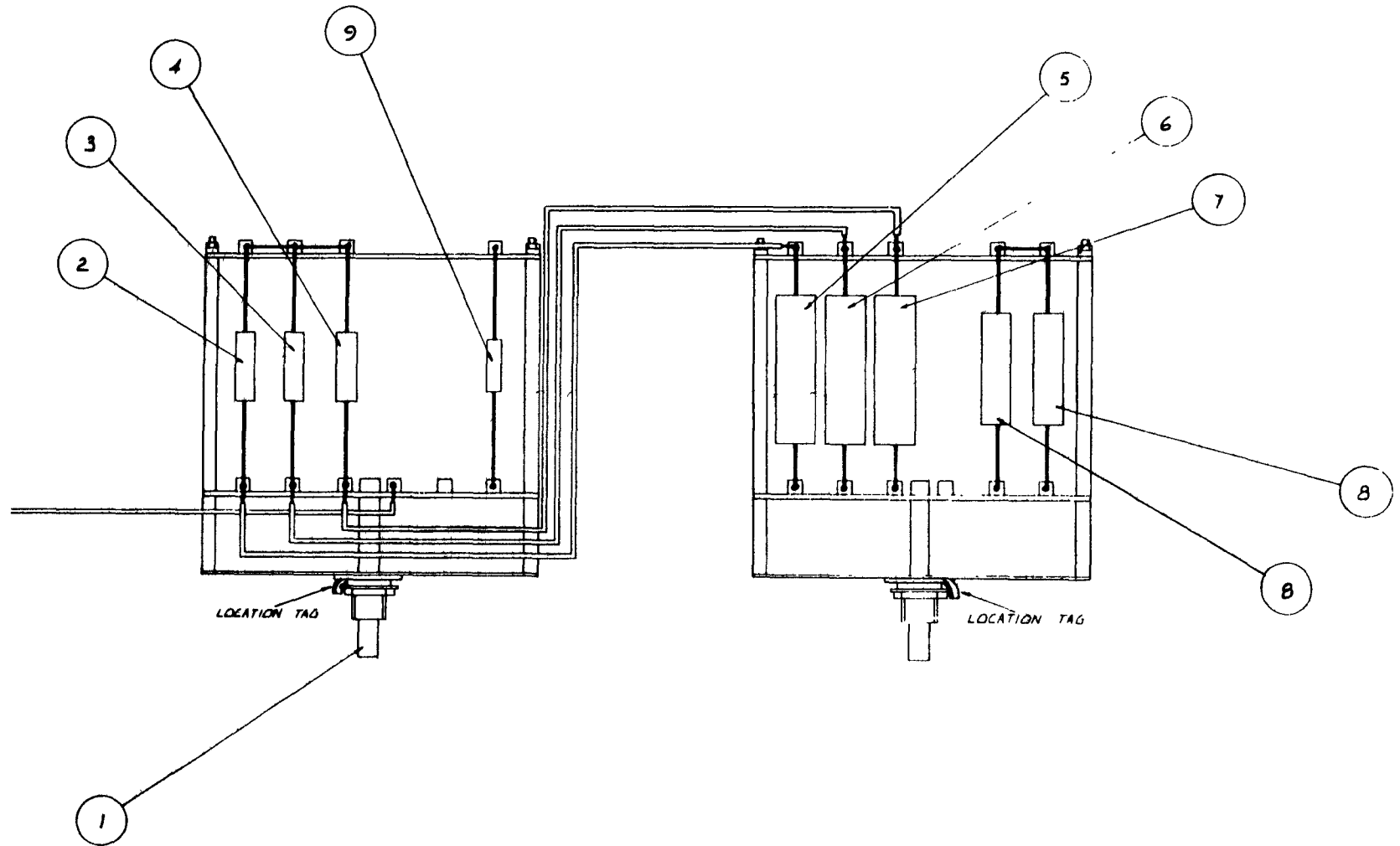


Fig 8. Grid Volts Switch Assembly 45188

FIG.9- COMPONENT BOARD ASSEMBLY 45194

Item No.	Description	Avo Part No.
1	Component Board	3836-452
2	Diode DD058 (D1, D2)	28468-501
3	Resistor $1.5\Omega \pm 5\%$ (R34)	26713-105
6	Resistor $100k\Omega \pm 20\%$ (R1, R2)	26136-221
7	Resistor $700\Omega \pm 2\%$ (R3)	26782-267
9	Capacitor $8\mu\text{F}$ 450V Electrolytic (C5)	27461-214
10	Capacitor $25\mu\text{F}$ 30V (C7)	27463-410
11	Capacitor $60\mu\text{F}$ 250V (C6)	27463-560
12	Resistor $0.68\Omega \pm 10\%$ (R18)	26711-253
13	Diode 10B1 (D3)	28461-841

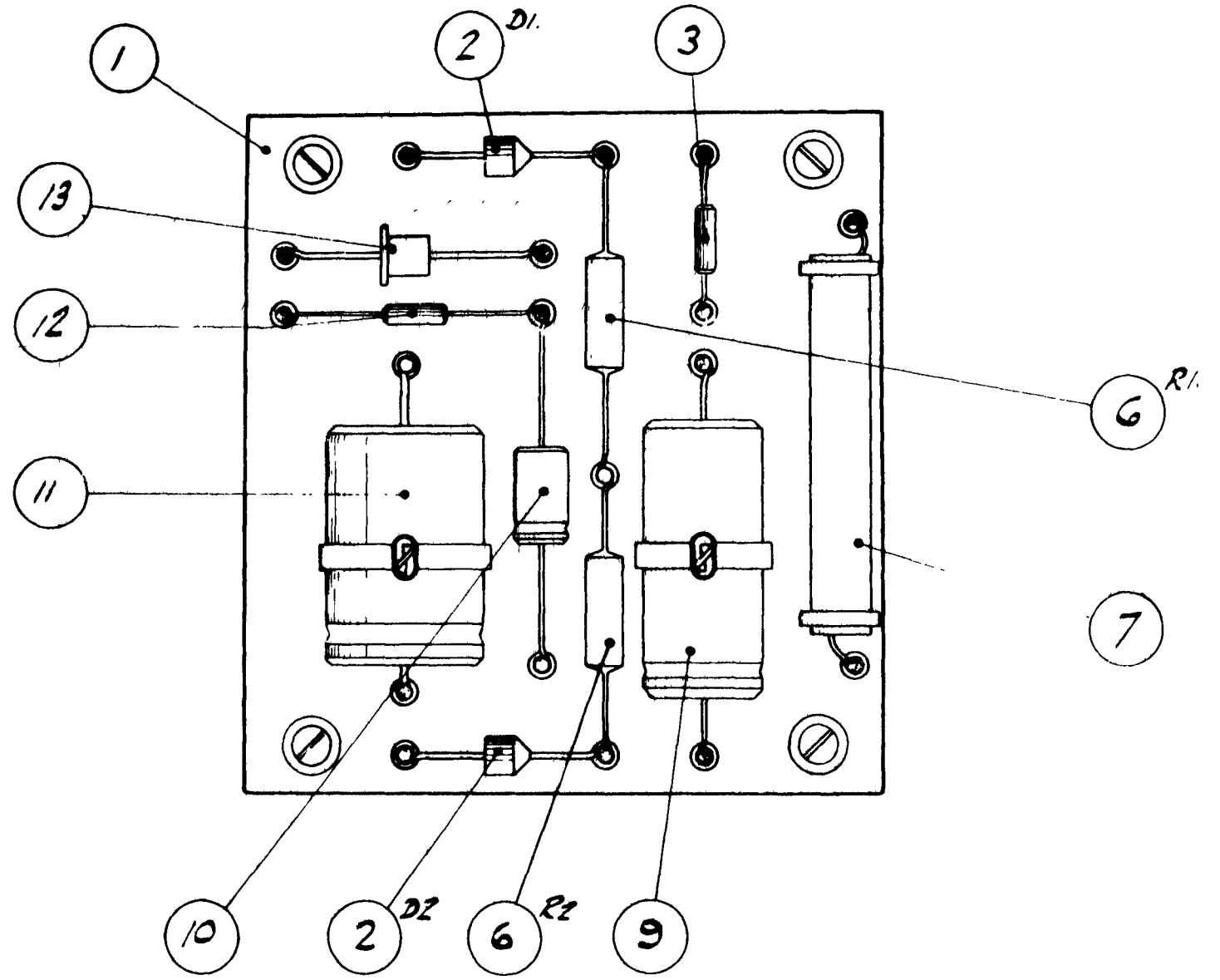


Fig 9. Component Board Assembly 45194

FIG. 10 - AMPLIFIER CIRCUIT DIAGRAM

Circuit Ref.	Assy Fig. No.	Item No.	Description	Qty	AVO Part No.
R1	3	21	Resistor $10\Omega \pm 1\%$	1	26232-325*
R2	3	3	Resistor $9.1k \pm 2\%$	1	26834-478*
R3	3	24	Resistor $15k \pm 1\%$	1	26232-401
R4	3	25	Resistor $30k \pm 1\%$	1	26232-408
R5	3	6	Resistor $10k \pm 2\%$	2	26834-479*
R6	3	5	Resistor $56k \pm 2\%$	1	26834-497
R7	3	7	Resistor $20k \pm 2\%$	2	26834-486
R8	3	6	Resistor $10k \pm 2\%$	2	26834-479*
R9	3	9	Resistor $3.3k \pm 2\%$	1	26834-467*
R10	3	11	Resistor $82k \pm 2\%$	1	26834-501
R11	3	7	Resistor $20k \pm 2\%$	2	26834-486
R12	3	13	Resistor $22k \pm 2\%$	1	26834-487
R13	3	12	Resistor $5.6k \pm 2\%$	1	26834-473
R14	3	15	Resistor $200\Omega \pm 1\%$	1	26232-356
C1	3	20	Cap. $1\mu F \pm 2\%$ 150V dc	1	27533-845
C2	3	23	Cap. $1990pF \pm 2\%$ 125V dc	1	27522-133*(
C3	3	10	Cap. $10\mu F$ 15V dc	3	27462-405*
C4	3	4	Cap. $0.01\mu F \pm 20\%$ 160V dc	1	27532-125
C5	3	10	Cap. $10\mu F$ 15V dc	3	27462-405*
C6	3	10	Cap. $10\mu F$ 15V dc	3	27462-405*
C7	3	14	Cap. $50\mu F$ 15V dc	1	27462-413*
C8	3	16	Cap. $0.47\mu F \pm 10\%$ 160V dc)	2	27537-161
C9	3	16	Cap. $0.47\mu F \pm 10\%$ 160V dc)		
C10	3	8	Cap. $330pF \pm 20\%$ 400V dc	1	27532-106
VT1-VT3	3	2	Transistor 2N 926	3	28552-601*
D1-D4	3	17	Diode IN 914	4	28433-801
T1	3	22	Transformer	1	45003
-	3	1	Printed Circuit Board	1	3218-326
-	3	19	Printed Circuit Tags	6	25255-372*

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

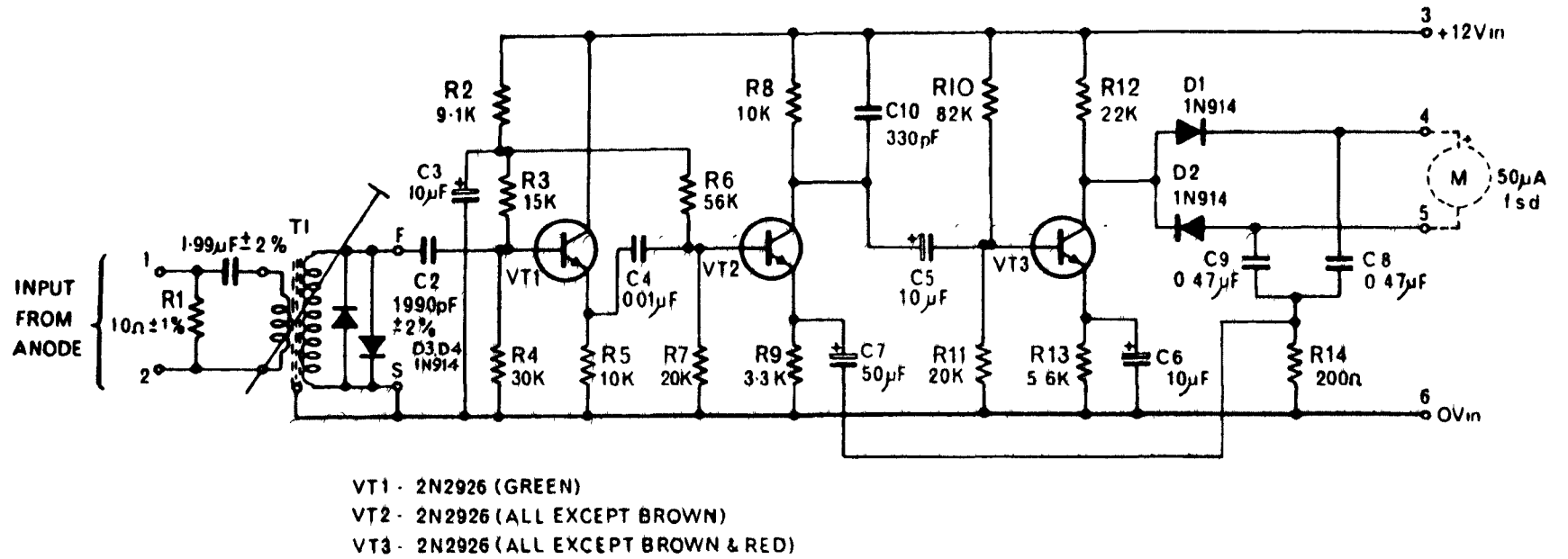


Fig 10. Amplifier Circuit Diagram

FIG. 11 - OSCILLATOR & POWER UNIT CIRCUIT DIAGRAM

Circuit Ref.	Assy Fig. No.	Item No.	Description	Qty	AVO Part No.
R1	4	23	Resistor 20k \pm 1%	1	26232-404
R2	4	24	Resistor 6.8k \pm 1%	1	26232-393
R3	4	22	Resistor 8.2k \pm 2%	1	26834-477
R4	4	29	Resistor 2.4k \pm 2%	1	26834-464
R5	4	28	Resistor 1.2k \pm 2%	1	26834-457
R6	4	19	Resistor 36k \pm 2%	1	26834-492
R7	4	31	Resistor 10k \pm 2%	1	26834-279*
R8	4	15	Resistor 3.3k \pm 2%	1	26834-467*
R9	4	4	Resistor 1k \pm 2%)	2	26834-455
R10	4	4	Resistor 1k \pm 2%)		
R11	4	14	Resistor 1.5k \pm 2%	1	26834-459
R12	4	32	Resistor 270 Ω \pm 2%	1	26834-441
R13	4	27	Resistor 5.1k \pm 1%	1	26232-390
R14	4	7	Resistor 3k \pm 2%	1	26834-466
R15	4	9	Resistor 4.3k \pm 2%	1	26834-470 (
R16	4	40	Resistor 9.1k \pm 2%	1	26834-478*
R17	4	18	Resistor 620 Ω \pm 2%	1	26834-450
R18	4	13	Resistor 30 Ω \pm 2%	1	26834-418
R19	4	33	Resistor 10 Ω \pm 1%	1	26232-325*
RV1	4	30	Potentiometer 1k \pm 20%	1	27113-749
RV2	4	12	Potentiometer 4.7k \pm 20%	1	27113-712
C1	4	25	Cap. 1990pF \pm 2% 125V dc)	2	27522-133*
C2	4	25	Cap. 1990pF \pm 2% 125V dc)		
C3	4	26	Cap. 10 μ F 15V dc)	3	27462-405
C4	4	26	Cap. 10 μ F 15V dc)		
C5	4	26	Cap. 10 μ F 15V dc)		
C6	4	5	Cap. 50 μ F 15V dc	1	27462-413*
C7	4	20	Cap. 100 μ F 15V dc	1	27462-417
C8	4	21	Cap. 200 μ F 30V dc	1	27462-421 (
VT1-VT3	4	8	Transistors 2N 2926	3	28552-601
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 \pm 20%	1	27284-330
TH2	4	2	Thermistor Type R14 10k \pm 20%	1	27284-318
-	4	1	Printed Circuit Board	1	3218-328
-	4	3	Heat Sink	1	3565-615
-	4	11	Printed Circuit Tags	6	25255-372*
-	4	34	Printed Circuit Socket	1	45052
-	4	35	Printed Circuit Socket	1	45085

* Additional quantities on Amplifier Board Fig. 3

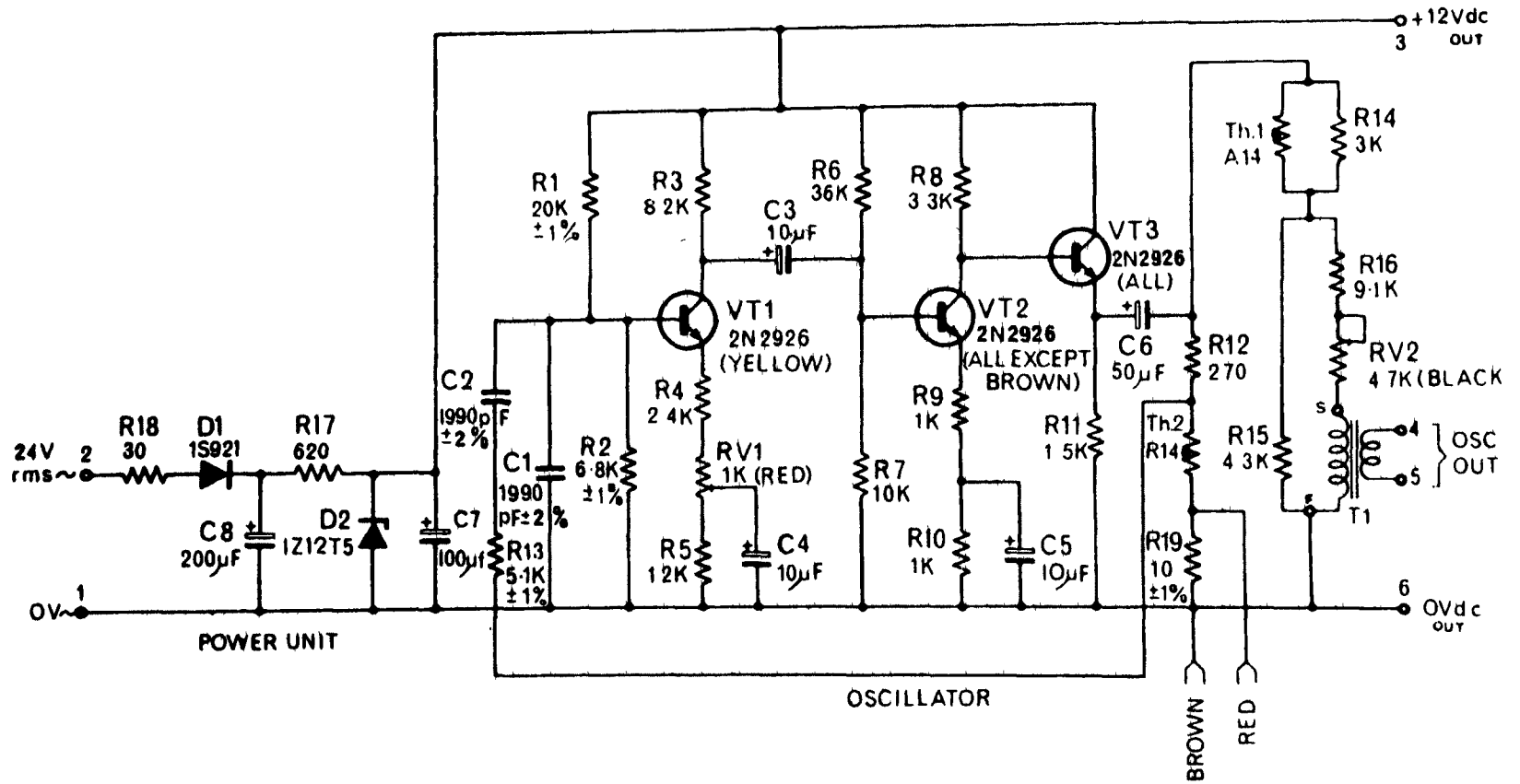


Fig 11. Oscillator and Power Unit Circuit Diagram

FIG. 12 - VCM 163 CIRCUIT DIAGRAM

Circuit Ref.	Assy Fig. No.	Item No.	Description	Qty	AVO Part No.
R1	9	6	Resistor 100k \pm 20%)	2	26136-221
R2	9	6	Resistor 100k \pm 20%)		
R3	9	7	Resistor 700 Ω \pm 2%	1	26782-267
R4	7	2	Resistor 3.4M \pm 1%	1	26232-666
R5	7	11	Resistor 2.27M \pm 1%	1	26236-660
R6	7	10	Resistor 1.3M \pm 1%	1	26232-448
R7	7	9	Resistor 680k \pm 1%	1	26232-441
R8	7	8	Resistor 281k \pm 1%	1	26235-911
R9	7	15	Resistor 91k \pm 1%	1	26232-420
R10	7	7	Resistor 16k \pm 1%	1	26232-402
R11	7	6	Resistor 2.4 Ω \pm 0.05%	1	26434-830
R12	7	5	Resistor 8.02 Ω \pm 1%	1	26437-372
R13	7	4	Resistor 24.3 Ω \pm 1%	1	26441-632
R14	7	3	Resistor 82.8 Ω \pm 1%	1	26444-232
R15	7	12	Resistor 1.1k \pm 1%	1	26233-574
R16	7	13	Resistor 4.3k \pm 1%	1	26232-388
R17	7	14	Resistor 22k \pm 1%	1	26232-405
R18	9	12	Resistor 0.68 Ω \pm 10%	1	26711-253
R19	8	9	Resistor 4.7k \pm 2%	1	26834-471
R20	8	8	Resistor 2.2M \pm 1%)	2	26233-653
R21	8	8	Resistor 2.2M \pm 1%)		
R22	8	5	Resistor 9.7k \pm 1%	1	26338-327
R23	8	2	Resistor 310 Ω \pm 1%	1	26235-736
R24	8	6	Resistor 9k \pm 1%	1	26338-325
R25	8	3	Resistor 1.11k \pm 1%	1	26235-767
R26	8	7	Resistor 7k \pm 1%	1	26338-322
R27	8	4	Resistor 4.29k \pm 1%	1	26235-793
R28	6	1	Resistor 44.4 Ω \pm 1%	1	26235-710
R29	6	2	Resistor 88.9 Ω \pm 1%	1	26235-717
R30	6	3	Resistor 310 Ω \pm 1%	1	26235-736
R31	6	4	Resistor 1.3k \pm 2%	1	26834-458
R32	2	43	Resistor 56k \pm 2%	1	26834-497
R33	2	42	Resistor 2.4k \pm 1%	1	26232-382
R34	9	3	Resistor 1.5 Ω \pm 5%	1	26713-105
R35	6	9	Resistor 2.4k \pm 2%	1	26834-464
RV1	1	-	Potentiometer 500 Ω	1	27133-326
RV2	1	-	Potentiometer 1k	1	27133-331
RV3	1	-	Potentiometer 2k	1	27133-341
RV4	2	26	Potentiometer 10k \pm 1%	1	27238-232
C1-C4	1	-	Capacitors 1 μ F 400V	4	27538-318
C5	9	9	Cap. 8 μ F 450V Electrolytic	1	27461-214
C6	9	11	Cap. 60 μ F 250V	1	27463-560
C7	9	10	Cap. 25 μ F 30V	1	27463-410
C8	6	5	Cap. 0.015 μ F +0-20%	1	27532-393
D1,D2	9	2	Diode DD058	2	28461-501
D3	9	13	Diode 10B1	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	45185
T2	1	-	L.T. Transformer Assembly	1	45197
RL1	1	-	Relay	1	45211
LP1	2	25	Indicator Lamp (Blue)	1	25517-235
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

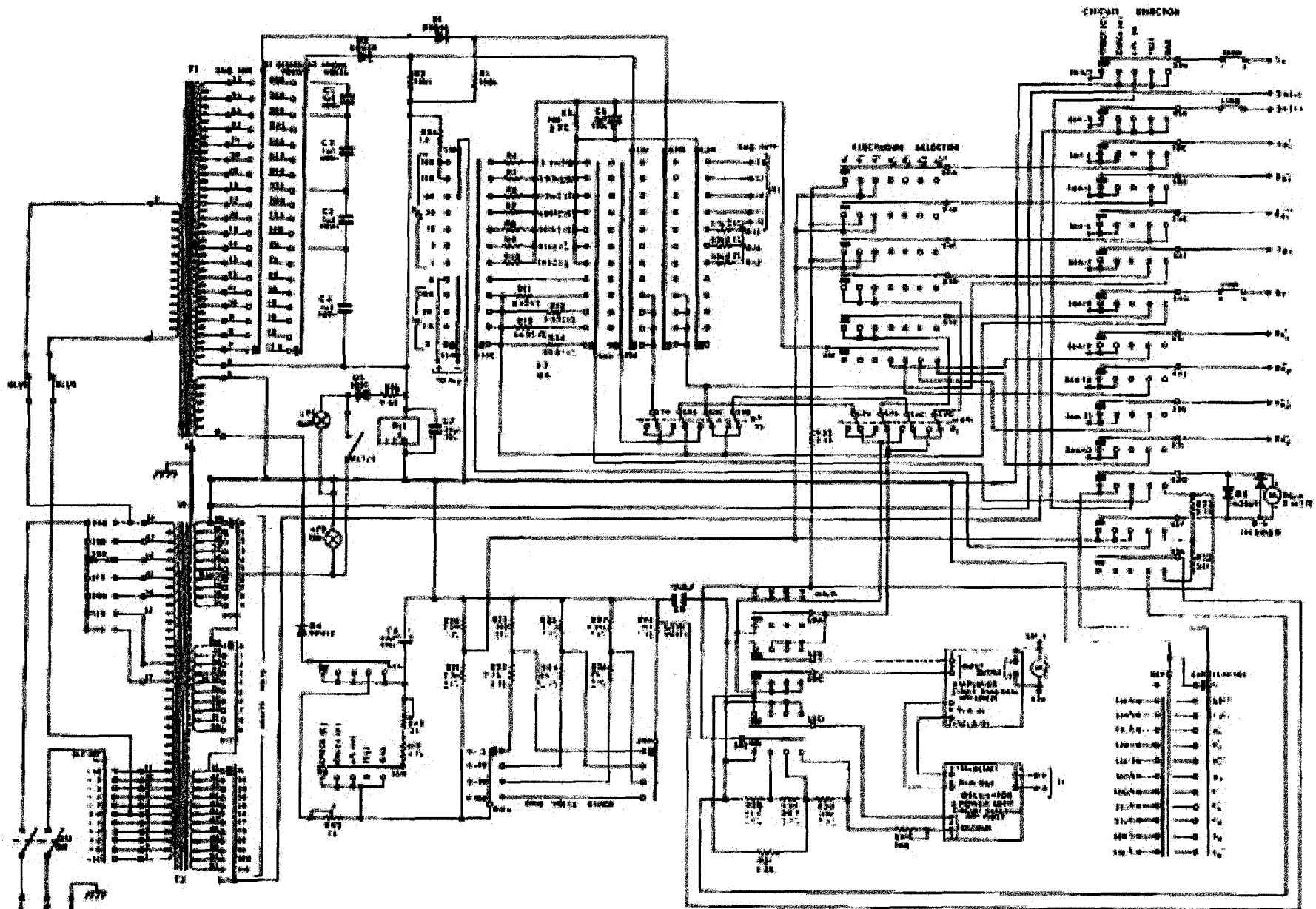


Fig 12 Circuit Diagram; Valve Characteristic Meter Type VCM 163