SECTION 12

VALVE TEST PANELS

VALVE TEST PANEL VT/4

General Description

The valve test panel VT/4 is designed for measuring the mutual conductance of the various types of small valves in use in the Corporation. It also includes provision for measuring the cathode to heater insulation of indirectly-heated valves and the emission of power rectifier and diode valves.

The mutual conductance (g_m) of all valves in service should be checked preferably *once a month* but at least every two months. Normally a valve should be rejected when its mutual conductance has fallen to 50 per cent of the average value for the type, as shown in Valve Instructions, although in special circuits a valve may cease to function satisfactorily before this limit has been reached.

Principle of Operation

The amplification factor of a valve (μ) expresses the slope of the anode-volts grid-volts characteristic in terms of the change in anode voltage per volt change in grid potential, i.e.,

$$\mu = \frac{dE_a}{dE_g}$$

But the value of μ is largely dependent upon the mechanical construction of the valve and remains substantially unaltered even though there may have been considerable deterioration in the performance of the valve due to a falling off in the emission. Such deterioration, however, results in a change of anode impedance and is made manifest by a change in the slope of the anode-current grid-volts characteristic. This quantity is termed the mutual conductance (g_m) and expresses the change in anode current measured in milliamperes per volt change of grid potential, i.e.,

$$g_m = \frac{dI_a}{dE_g}$$

Clearly, g_m will decrease as the anode impedance (r_a) increases and therefore an accurate check of the mutual conductance will indicate immediately any deterioration in the performance of the valve.

It is sufficient to measure the conductance at one fixed point of the characteristic and to compare the result with the known conductance of a good valve of the same type at the same point.

A simple method of measuring mutual conductance approximately is to change the grid voltage by, say, 1 volt and to note the change of anode current produced. The definition of mutual conductance given above, however, is only true, provided that (i) the changes in grid potential are small and (ii) the anode external impedance is zero, that is to say, the anode voltage is maintained constant.

The simple method of measurement mentioned is open to serious objection. In the first place a 1-volt change in grid voltage is too great, especially with modern high-gain valves, even approximately to satisfy the first condition, while in the second place, to maintain the anode voltage unchanged under the conditions of test requires either a battery supply or readjustment of the anode volts on changing the grid voltage. A mains-operated equipment was, however, desired, preferably direct reading and simple to adjust.

Another method of measuring mutual conductance, based on the application to the grid of a 50 c/s voltage is illustrated in Fig. 12.1 and is that adopted in VT/4.

The valve is connected in the test circuit as shown and the values of h.t. and of d.c. grid bias are adjusted to obtain the particular point on the characteristic at which the measurement is to be made. A.C. at approximately 0·2 volt, 50 c/s, is then applied to the grid of the valve under test, and an equal voltage in opposite phase is applied to a calibrated slide-wire resistor, by means of which a portion of this voltage is applied to the valve anode through a resistance of 100 ohms. A galvanometer circuit is connected, via a capacitor between the anode of the valve and the slider of the slide-wire, which is adjusted so as to obtain no a.c. in the measuring circuit.

If the a.c. exciter voltage $= E_g$,

the a.c. anode current, $I_a = \dfrac{g_m \times E_g}{1{,}000}$

then the voltage developed across the 100-ohm

$$\text{resistor} = 100I_a = \frac{g_m \times E_g}{10}$$

If the condition of balance is obtained with a portion x of the slide-wire included in the anode circuit, the value of the balancing voltage applied to the anode will be $x \times E_g$.

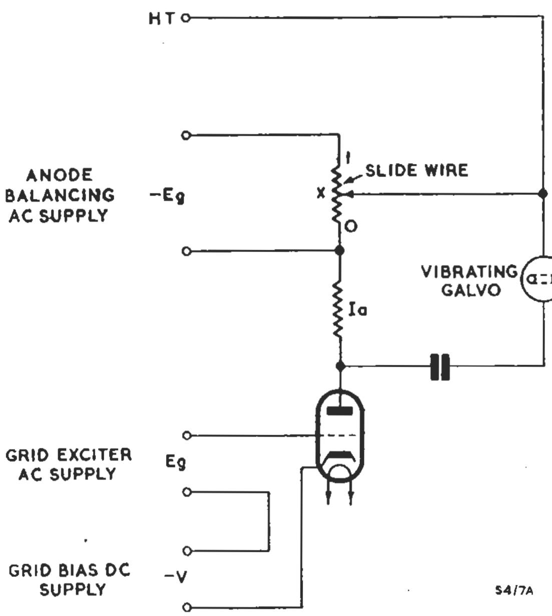


Fig. 12.1. Method of Measuring Mutual Conductance employed in VT/4

Equating these two expressions we have

$$x \, . \, E_g = \frac{g_m \times E_g}{10}$$

whence $$g_m = 10x$$

That is to say, g_m is directly proportional to the length of the portion of the slide-wire included in the anode circuit. The slide-wire scale can thus be calibrated to enable the mutual conductance to be directly read as soon as the balanced condition obtains.

It will be obvious that a high degree of accuracy can only be assured if the resistance of the slide-wire is made small compared with that of the anode resistance so that it will have practically no effect on the operating conditions of the valve. The actual value is unimportant so long as it is of the correct order of magnitude. Similarly the actual value of the anode resistance is unimportant, but obviously if the value is increased the voltage applied to the slide-wire must also be increased in the same proportion in order to make the condition of balance obtainable. In order to make negligible any variation of the voltage across the slide-wire during the test, the impedance of the anode-balancing supply must be kept small relative to the resistance of the slide-wire. Similarly, since the test is normally carried out at zero bias, the impedance of the a.c. grid-voltage supply also must be kept low in order to prevent fluctuation of the voltage due to grid current. Furthermore, to prevent the voltage of the h.t. supply from varying at 50 c/s, the fundamental frequency of the anode current, the supply circuit must be arranged to have a very low impedance at this frequency.

Circuit Description

The assembly consists of two panels, mounted either on a rack or on a trolley. The larger panel incorporates all the essential parts such as meters, slide-wire, galvanometer and operating keys. The smaller panel contains valveholders for accommodating the various types of valves which may be required to be tested and switches for establishing the appropriate connections to their sockets.

The apparatus is suitable only for operation on 50-c/s controlled a.c. supply mains of 200-250 volts. For operation from a 110-volt supply an additional auto-transformer is required. The standard model is not designed for operation on frequencies other than 50 c/s nor directly from d.c. mains, nor is provision made for the use of battery supplies. Where only a d.c. supply is available a motor alternator must be used.

The standard apparatus is arranged for the measurement of mutual conductance only at the fixed point on the valve characteristic corresponding to 100 or 110 volts on the anode and zero grid bias. In special cases, however, e.g. for testing variable-mu valves, it may be desirable for a small negative potential to be applied to the grid so that measurements can be made at more than one point on the characteristic. For this purpose a special grid-bias supply unit with a very low impedance has been developed which provides a continuously variable bias from zero to 10 volts negative. It should be particularly noted that no other source of grid bias should be used for the purpose otherwise the readings obtained may be inaccurate.

The arrangement of the circuit of the mutual conductance valve tester is shown in Fig. 15, and that of the associated valve socket panel in Fig. 16.

Referring to Fig. 15, the filament-supply circuit consists of a mains transformer with a secondary winding having taps at 2, 4, 6, 13, 26 and 40 volts and capable of giving an output of 12 watts. In series with the primary winding of the transformer, a variable resistance, designated *Adjust Filament Volts* is provided and is of such a value as to give nearly complete coverage between the tappings. A link, accessible when the back cover of the panel is removed, is provided in series with the filament supply. This can be withdrawn to permit the connection of an external variable resistance, on the rare occasions when the value of filament voltage required proves to be unobtainable with the normal adjustment provided. A rectifier-type voltmeter is used with separate leads which are taken back to the valveholder pins so that the actual voltage applied across them can be read. The voltmeter has two scales reading 0-6 and 0-40 and the range is automatically changed by the tap switch, which is designated *Set Filament Volts*. An ammeter is provided for measuring the filament current and takes the form of a rectifier-type millivoltmeter actuated by a current transformer so that the load introduced into the filament circuit is negligible. The meter has two ranges reading 0-5A and 0-0·5A, the lower range being obtained by depressing a plunger key which increases the transformer ratio.

For the h.t. a conventional mains-supply unit is used capable of delivering 100 volts d.c. at any load up to 60 milliamps. Very efficient smoothing is provided and immunity from 50 c/s variation is secured by the connection across the d.c. supply of an approximately tuned reactor and series capacitor in order to make the impedance of the supply very low at this frequency. This also serves to eliminate hum from the galvanometer circuit which is connected between the h.t. supply and the anode of the valve. The supply is controlled by a potentiometer, designated *Adjust Anode Volts*, and the anode connection is made via the slide-wire and a 100-ohm resistor. The anode current is read on a moving-coil milliammeter which actually requires only 1 milliamp for full-scale deflection but is normally shunted to read up to 100 milliamps. The voltage is measured by means of an extra high resistance voltmeter connected between the anode and cathode of the valve under test and passing only 100 microamps at 100 volts.

A separate potentiometer connected between cathode and h.t. positive and designated *Adjust Screen Volts* controls the screen grid voltage supply, which is decoupled in the normal manner by a capacitor connected between the slider and the cathode lead. The voltage can be measured by depressing a plunger key designated *Press to Read Screen Volts*, which transfers the voltmeter from the anode to the screened grid circuit.

The exciter and anode balancing voltages are provided by a common mains transformer. The voltages in the two cases are equal but the anode balancing winding is connected so as to apply its voltage across the slide-wire in such a sense as to oppose the voltage developed in the anode circuit due to the exciter voltage applied to the grid. The secondary impedance for both windings is approximately 0·1 ohm and the voltage available in each case approximately 0·2 volt. The exact value is unimportant and obviously any variation in the mains voltage will cause both supply voltages to vary equally. A link designated *XY* is provided in the grid-cathode lead in series with the exciter winding and is removed for the connection of the grid bias unit when the latter is required.

The slide-wire has a resistance of about 0·5 ohm and the full voltage of the transformer would correspond to a mutual conductance of 10 milliamp/volts. A small resistance in series with the slide-wire, which is used for the initial calibration, reduces the maximum slide-wire reading to 8·5 milliamp/volts. However, a key designated $G_m \times 2$ is provided by means of which a short-circuit is placed across half of the anode resistance and the range of measurement thus increased to 17 milliamp/volts. A circular scale with a diameter of about 5 inches and a slow-motion control is used for making the readings and permits of an accuracy better than 1 per cent over the whole range of measurement from 0-17 milliamp/volts.

The measuring device consists of a sensitive vibration galvanometer of the permanent-magnet type sharply tuned to 50 c/s. The reading is provided by a mirror mounted at the centre of the vibrating element which projects a spot of light on to a ground-glass screen. When the instrument is passing a.c. the spot sweeps over the screen, tracing out a beam of illumination extending an equal distance on either side of the centre line, the amplitude of the ' spread ' being proportional to the current. When the condition of balance is achieved a circular spot of light is obtained on the centre line. The galvanometer may, however, be tuned to any frequency between about 45-52 c/s. Therefore, where the frequency of the supply mains is not accurately controlled, or where a motor alternator is used to provide an a.c. supply from d.c. mains, the instrument can be tuned to the precise frequency of the supply available and, provided the supply frequency does not ' hunt ' by more than $\pm$ 1 c/s, the apparatus will work satisfactorily. The sensitivity of the apparatus at other frequencies is less than at 50 c/s due to the fact that the transformers in the power supply circuits and the tuned a.c. shunt across the H.T. supply circuit have been designed to have a maximum efficiency at 50 c/s. The sensitivity of the instrument is, however, much greater than that necessary to give the required accuracy of measurement and is accordingly reduced by placing a heavy shunt across it. The shunt has been made variable in order to permit of calibration and compensation where the galvanometer is tuned to a frequency other than 50 c/s.

With directly-heated valves the h.t. negative return is to the centre point of the filament and it is, therefore, necessary to determine this accurately, otherwise hum will be introduced from the filament into the anode circuit and will result in a false reading of the mutual conductance. A variable potentiometer, designated *Adjust Zero*, is therefore provided across the filament supply with its slider connected to the cathode lead. To determine the true electrical centre of the filament, the conductance dial is set at zero, so that there will be no a.c. applied to the anode from the balancing winding, the h.t. is applied, and the plunger key, designated *Press to Set Zero*, is depressed. The latter operation isolates the grid from the a.c. exciter winding and connects it via 50 ohms to the cathode. Any a.c. present in the anode circuit under these conditions will be due to excitation from the filament circuit. The potentiometer, designated *Adjust Zero*, is therefore rotated until there ceases to be any deflection on the galvanometer, in which condition the true electrical centre of the filament will have been found. The release of the plunger key restores the grid voltage connection.

The anode current meter is also used for measuring the insulation resistance between cathode and heater of indirectly-heated valves. The plunger key, designated *Press for Cathode Insulation*, when depressed, connects the voltmeter as an ohmmeter in series with the h.t. + supply lead and the heater filament via the potentiometer designated *Adjust Zero*, the cathode being connected to h.t. negative. The insulation resistance at 100 volts can then be read directly on the auxiliary scale provided on the meter.

In the *Normal* position of the 3-position switch, the anode circuit is arranged for the measurement of mutual conductance. If the switch is moved to the position marked *Power Rectifiers Only* a resistor is connected in the anode circuit, such that normal rectifying valves in good condition will pass at least 50 milliamps of anode current per anode at 100 volts. In the position marked *Diodes Only* a much higher resistance is provided and the shunt removed from the anode current meter. Diodes in good condition will pass at least 0·8 milliamp at 100 volts.

Referring to Fig. 16, a set of valveholders for 5-pin, 7-pin, 9-pin and octal based valves is provided on the *valveholder panel*. Connectors are also provided for making the top-cap or side-terminal connections required with some valves. The anode, screened grid, control grid, and cathode or suppressor connections from the main panel are brought down to the movable arms of a set of rotary switches, by means of which the appropriate connections to the pins of the valveholders, and to the top-cap or side-terminal, where fitted, can be made. The filament or heater pins of each valveholder are permanently wired, except for octal-based valves, some of which have the heater connected between pins 2 and 7 and some between pins 2 and 8. An additional switch is therefore provided for making the appropriate connection to this valveholder. It is only with valves having 5-pin bases that the pin to which the cathode is connected may vary; in all other valves the cathode is always connected to one particular pin. Except in the case of the 5-pin valveholders, therefore, the cathode connection is permanently wired. The switch marked *Cathode or Suppressor* controls the cathode connection only for the 5-pin holder; with other valveholders it controls only the suppressor connection. Very complete screening of the control grid circuits is carried out so as to prevent oscillation due to feedback. This is extremely important in view of the high mutual conductance of many of the valves which have to be tested. The low value of the grid-circuit impedance assists considerably in overcoming errors due to capacity currents and thus enables a very high degree of screening to be obtained fairly simply. The main panel and the valveholder panel are interconnected by terminal blocks so that any new valveholders that may be required in future can be added to the valveholder panel without disturbing the main panel.

Setting-up the Apparatus for Use

Insert the mains plug to correspond with the voltage of the incoming supply and insert a UU/5 or equivalent rectifier valve in position at the back of the panel. Then operate the switch marked *Mains*.

Power is thereby applied to the primary windings of the h.t. exciter, and filament transformers. A voltage will be developed across the output of the h.t. supply circuit, but since there is no valve in any of the valveholders and the h.t. switch is open, there will be no current in either anode or screened grid circuits. A voltage also appears in the filament circuit and the filament voltmeter will read a value near that indicated by the position of the selector switch. The indicator lamp associated with the mains switch and the lamp in the telescope of the galvanometer will both light from the 6-volt winding of the exciter transformer. The lamps used are Osram 8-volt, 1·6 watts, MEX Reference OS.7588. A.C. from the anode-balancing winding of the exciter transformer will be applied across the slide-wire and thus across the galvanometer input in series with the anode resistance. The galvanometer should therefore read and, if the conductance dial is set at zero, a spot should appear at the centre of the ground-glass screen.

If no spot is formed it may be due either to failure of the lamp in the telescope or to displacement of the telescope so that the light is not directed on to the mirror.

Remove the cover from the back of the panel, the mains switch first being placed in the *Off* position and the mains plug withdrawn, in order to obviate all possibility of accidental short-circuits. Replace the mains plug and operate the mains switch. The conductance dial should remain set at zero. Assuming that the telescope lamp is found to be alight, the position of the telescope, the base of which is fitted with a universal joint, should be adjusted so as to direct the light on to the mirror.

An adjustment is provided whereby the lens in the telescope can be moved longitudinally in the outer housing in order to focus the lamp. When the lamp is correctly focused a sharp image of the filament will be obtained on the mirror of the galvanometer. A well-defined spot should then be obtained on the screen.

If the spot does not fall on the screen, or is not central on the screen, the galvanometer itself must be adjusted. Adjustment in the vertical direction can be made by rotating the galvanometer body in its trunnions, and adjustment in the horizontal direction by altering the angle of the mirror by means of an adjusting screw at one end of it. Whenever any adjustment is made the position of the telescope will, of course, also need to be re-adjusted so as to obtain maximum illumination on the screen.

The sensitivity and tuning of the galvanometer should then be checked. The tuning should be such that the ‘ spread ’ is a maximum for any particular setting of the sensitivity, and the sensitivity should be such that when the conductance dial is set at 8·5 milliamp/volts the ‘ spread ’ just covers the full width of the screen. The tuning can be adjusted by slightly turning a screw which will be found on the body of the galvanometer at the opposite end to that controlling the angle of the mirror, and the sensitivity is adjusted by the potentiometer located near the galvanometer which controls the value of the shunt.

Some of the early types of galvanometer have been found to exhibit slight stretching of the phosphor-bronze wire, and in some cases the stretch has sent the tuning range of the galvanometer beyond the normal range of the adjusting screw. If, therefore, it should be found impossible with the adjusting screw to tune the galvanometer correctly on either side of the resonant point, the galvanometer complete with its magnet should be removed from the apparatus, carefully packed, and returned to Equipment Department for re-tuning. It is inadvisable to attempt to repair galvanometers on site, as special wire and special solder for making off the end have to be used and the wire has to be heat-treated after assembly.

Mutual Conductance Test

Look up the valve to be tested in the BBC Valve Instructions Manual. The code number of the valve will be found in the left-hand column of the appropriate table, and against it, in the third column. appears the class of base with which it is fitted. The sixth and seventh columns show the manner in which the various pins are connected.

Put the *Set Filament Volts* switch to the range nearest the value of filament voltage quoted for the valve in column 4 of the table and insert the valve in the appropriate socket. Close the mains switch and adjust the voltage applied to the filament accurately to the value listed, by means of the *Adjust Filament Volts* rheostat. The filament current can be read on the ammeter provided. If the current is less than 0·5 amps the lower range of the meter may be used by depressing the press-key provided on the panel by the side of the meter. The filament voltage selecting switch automatically changes the range of the voltmeter when 6 volts is exceeded.

By means of the rotary switches on the valveholder panel the anode, screened grid, control grid and cathode or suppressor grid connections to the various pins of the valveholder in use should be set up in accordance with the connections listed for the particular class of valve base. Any switch not in use, e.g. the *Screened Grid* switch when testing a triode, should be placed in the *Off* position. (The filament connections in the case of all the valveholders except that for octal-based valves, of which they are completed via an auxiliary switch, and the cathode connection in the case of all except the 5-pin valveholder, are permanently wired.)

Set the conductance dial at zero and then make the h.t. switch. The anode voltage and anode current can be read on the appropriate meters, and the screen volts on the anode-current meter by depressing the press-key located alongside it. Individual potentiometers are provided for adjusting the two voltages but since the anode current depends upon the screen-grid voltage, and the adjustment of either alters the load on the rectifier, the two adjustments cannot be made independently of one another. The correct settings are fairly quickly obtained by the process of trial and error, involving the checking and resetting of the anode voltage after each adjustment of the screen-grid voltage and the subsequent rechecking and readjustment of the latter.

For all valves requiring an anode current of less than 60 milliamps, the testing conditions for the various types of valves are as follows, E_g in every case being zero.

Triodes	$E_a = 100$
Tetrodes (other than KT types)	$E_a = 100$, $E_{sg} = 80$
Pentodes and KT type Tetrodes	$E_a = 110$, $E_{sg} = 100$, $E_{sup} = 0$

Some of the larger valves take an anode current greater than 60 milliamps at 100 volts on anode or screen, consequently, since the rectifier will not supply 100 volts at currents greater than 60 milliamps, the conductance must be measured at a lower voltage. The valves to which this applies are suitably indicated in the tables.

For valves with directly-heated filaments it is necessary before attempting to measure the conductance, first to return the h.t. negative to the centre point of the filament. This is done by retaining the conductance dial at zero, operating the press-key marked *Press to Set Zero*, and by slowly rotating the control marked *Adjust Zero* until a clear-cut spot is obtained on the galvanometer screen. The press switch should then be released. Since the electrical centre may vary even for valves of the same type and make, this adjustment must be made afresh for each valve with a directly-heated filament.

Rotate the conductance dial until a clear-cut spot of light is formed at the centre of the screen. The conductance can then be directly read on the scale. If the conductance is greater than 8·5 milliamp/volts it will not be possible to obtain a clear-cut spot unless the press-key, designated $G_m \times 2$, located alongside the conductance dial, is operated. In this case the mutual conductance will be double the figure indicated on the scale when a clear-cut spot of light is formed.

Certain high-conductance pentodes or tetrodes are liable to oscillate when being tested in the bridge. The purpose of the 0·0001-microfarad capacitors shown in Fig. 15 is to suppress this oscillation. It has been found, however, that these capacitors are not always successful. They are therefore now omitted and instead distributed capacitance is introduced by cutting back the screening of the cable and connecting some of these cables to the cathode. In practically every case this has been found to be a complete cure, but it is not impossible that oscillation may still occur in some isolated instances. In order to detect whether a valve being tested is free from oscillation, the control-grid terminal of the valve should be lightly touched with the finger. If the light spot on the galvanometer screen does not move, then no oscillation is present. If, however, a movement of more than about 1 millimeter is detected, then it is possible that the valve is oscillating. A cure can usually be effected by connecting a 0·0001-microfarad capacitor from either the anode, control-grid or screen-grid terminal direct to the cathode pin by very short leads. Should this not effect a cure the Valve Section should be notified.

Heater-cathode Insulation

By operating the press-key marked *Press for Cathode Insulation*, the anode voltmeter becomes an ohmmeter connected for reading the insulation resistance at the anode voltage between filament and cathode of indirectly-heated valves, the cathode being made negative with respect to the heater. The resistance is indicated on the lower scale of the voltmeter. Good valves should have a resistance greater than 3 megohms.

With some valves, however the heater-cathode insulation may be as low as 1 megohm without the performance of the valve being affected. No hard and fast rule can be laid down as to the lowest value of heater-cathode resistance which can be tolerated in practice. Valves should not, therefore, be rejected because they have a heater-cathode insulation resistance lower than 3 megohms unless some other factor influencing the performance of the valve has been noted, or unless a number of other valves of similar type have indicated a much higher resistance.

The heater-cathode insulation test will be non-operative with directly-heated valves.

Testing Power Rectifiers

For testing power rectifiers, whether directly or indirectly-heated, all switches on the valveholder panel should be set at *Off*. The 3-position switch should be operated to the position designated *Power Rectifiers Only*. The filament-voltage switch should be set to the appropriate range and the valve inserted in the valveholder and the filament voltage adjusted to the correct value by means of the *Adjust Filament Volts* control. Each of the anodes is tested in turn. The anode switch on the valveholder panel should be set to make connection with the anode to be tested, the h.t. should then be switched on and the anode volts adjusted to 100. (For some high-voltage filament indirectly-heated rectifiers, it is also necessary to make the cathode connection.) The anode current will be indicated on the anode current meter. The h.t. should then be switched off and the anode switch on the valveholder panel, moved to make connection with another of the anodes which should then be similarly tested. For normal rectifiers the anode current should be of the order of *50 milliamps* per anode. *On the completion of the test restore the 3-position key to the normal position.*

Testing Diodes

Diodes are tested in the same manner as power rectifiers except that the test is made with the 3-position switch in the position designated *Diodes Only*. In this position the anode current meter is unshunted and reads 1 milliamp full scale. Most diodes in good condition will show a current exceeding 0·8 milliamps at 100 volts h.t. (The diode elements of complex valves, e.g. double-diode triodes, may be similarly tested by suitable connection of the valveholder switches.) *Upon the completion of the test return the 3-position key to Normal.*

Valves with Non-standard Bases

Some valves, for example special diodes, are fitted with non-standard bases and certain other valves, for instance a 2-volt double pentode, although fitted with a standard base, have non-standard connections. Should it become necessary to test any number of these valves, Valve Section should be communicated with and an adaptor will be provided.

Precautions

(1) Always see that the filament voltmeter switch is correctly set before inserting a valve or switching on the mains.
(2) See that the switch marked *Normal*, *Power Rectifiers*, and *Diodes* is in the correct position. *Never measure conductance unless the switch is at Normal.*
(3) Before making the h.t. switch, see that the correct connections are made by means of the switches on the valveholder panel.
(4) Never move the valveholder switches unless the h.t. switch is off.
(5) Never remove the back cover unless the mains plug is pulled out.
(6) Do not interfere with the galvanometer more than is absolutely necessary. Once it has been set up it should require no adjustment unless the frequency of the supply is changed.
(7) Owing to its high sensitivity, the anode voltmeter may sometimes 'stick' slightly. If this

occurs it will be desirable to tap the meter gently when setting the anode volts or measuring the heater-cathode resistance.

(8) At the commencement of the test some valves may not give a clear-cut spot but generally this will gradually improve if the valve is left in circuit for a few minutes with the filament and h.t. supplies switched on. If, however, after some minutes the spot still remains out of focus, primary emission from the grid should be suspected, but if everything else be normal this will not as a rule be sufficiently serious to warrant rejection of the valve.

VALVE TESTER VT/5

General Description

The valve tester VT/5 is a portable instrument operated from 200/250 volts a.c. supply and designed to test, by direct measurement, the mutual conductance (g_m) of most types of small valves in current use.

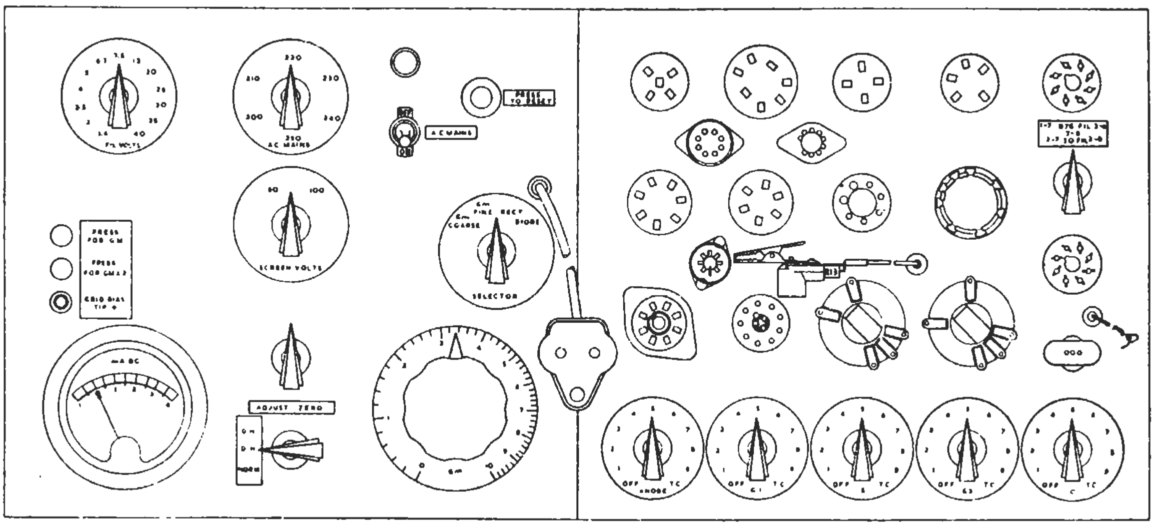


Fig. 12.2. Face Panel VT/5

The instrument incorporates new principles of g_m measurement in that no d.c. potentials are applied to the electrodes of the valve under test. This simplifies design by eliminating the necessity for valve rectifiers and smoothing circuits. The degree of accuracy is slightly below that of the VT/4 but the error does not exceed $\pm$ 3 per cent.

g_m Tests for Multi-electrode Valves

A simplified circuit showing the conditions when testing a triode is given in Fig. 12.3. Similar principles apply for pentodes. An a.c. voltage is applied to the anode from L1 and rectified by the valve under test, the anode current I_a, averaged over one half-cycle, being indicated on the milliammeter. (It should be understood that this current bears no direct relation to the current which would be obtained by the application of a comparable d.c. voltage, and cannot be regarded as the E_a-I_a characteristic of the valve.)

This rectified I_a is balanced off to zero by a second rectified a.c. voltage $-E_{a_1}$ applied in opposite sense from the coil L2, the potentiometer R1 and rectifier MR 1. If, under these conditions, an a.c. voltage E_g is applied to the grid of the valve in phase with the anode voltage, the mean anode current will increase and a reading appear on the meter. This change in anode current (due to the application of a voltage to the grid) is a measurement of the g_m of the valve. The higher the mutual conductance, the greater will be the reading. This voltage is applied by depressing the switch S1. It will be seen that in the 'release' position of S1, voltage is applied to the grid from the coil L4, this voltage being in anti-phase to the anode voltage, and that when the key is depressed an equal voltage of opposite phase is applied.

Let it be assumed that the first condition represents an E_g of $-\cdot 5$ volt peak and the second an E_g of $+\cdot 5$ volt peak. Then the change in anode current resulting from depressing and releasing the key would be equivalent to the change obtained by the application of $\pm$ 1 volt d.c. to the grid of a valve normally having zero bias.

It now remains to measure this change in terms of milliamps per volt; this is done by applying a rectified a.c. voltage $-Ea_2$ to the anode from the circuit comprising L3, R2 and rectifier MR2. This calibrating voltage, which is in opposite sense to the anode voltage, is adjusted by the potentiometer R2 until the anode current resulting from the applied Eg is reduced to zero. The g_m is then read off direct from the potentiometer scale.

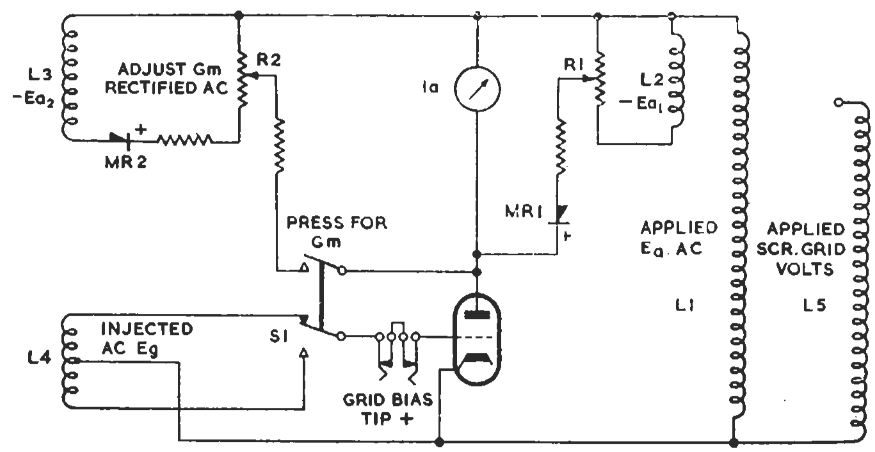


Fig. 12.3. Schematic for g_m Tests VT/5

Emission Tests for Diodes and Rectifiers

In this test, 100 volts r.m.s. is applied to the anode through the meter and a loading resistance as indicated in Fig. 12.4. A reading of more than 3·5 on the meter indicates that the valve is functioning normally, although it should be understood that this does not represent the anode current which would be obtained if the valve were tested by applying 100 volts d.c.

Circuit Description (Fig. 17)

Filament Supplies

The various tappings from the transformer filament winding are taken to the *Filament Volts* switch, from which the supply is wired direct to the filament sockets of all valveholders except those for octal and B7G bases. The filament sockets of octal valves are wired via the *Octal Filament* switch. This is necessary because, whereas most octal valves have their filaments wired to pins 2 and 7, a few types have them wired to pins 2 and 8, or 7 and 8. Comparable considerations apply to B 7G Valves in relation to the *B7G Filament* switch. The switch labelled *Normal, DH, DH,* is provided to enable directly-heated valves to be tested with either leg of the filament earthed. (See under Operation.)

Anode Supply

The normal anode h.t. supply is taken from the 70·7-volts tapping L6-L8 of the transformer,

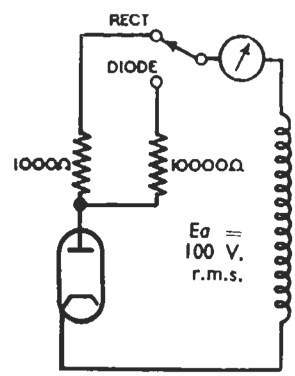


Fig. 12.4. Schematic for Diode Tests VT/5

via the selector switch and the meter to the traveller of the anode electrode switch. (It should be noted that 70·7 represents the r.m.s. voltage, hence the peak voltage supply to the anodes is equal to $70{\cdot}7 \times \sqrt{2} = 100$ volts.) The return lead of the h.t. winding is taken through an overload circuit-breaker relay which, in the event of the anode supply being connected to an earthed electrode, causes the main supply to be interrupted.

Screen-grid Supply

This is taken from the transformer tapping L7-L8 for 80 volts or L6-L8 for 100 volts.

Zero Adjusting Circuit

This circuit, which supplies the backing-off voltage $-E_{a_1}$ for setting the meter to zero, comprises the transformer winding L3-L4, the *Adjust Zero* potentiometer, R6, and rectifier MR 1.

Calibrating Circuit

This includes the transformer winding L1-L2, rectifier MR 2 and potentiometer R5, calibrated for reading off the g_m of the valve under test. There are four variations of this circuit, controlled by the *Selector* switch.

(i) g_m *Coarse*. In this position of the switch the circuit is completed to the anode via section 3 of the selector switch, the meter being shunted on section 2 by the 2·22-ohm resistor R8. The purpose of this circuit is to permit an approximate adjustment of the backing-off voltage $-Ea$ (by means of R6) when lining up the meter.

(ii) g_m *Fine*. In this position of the selector switch the circuit is similar to (1) but with the meter shunt removed. This circuit permits a fine adjustment of the backing-off voltage and, with the g_m key depressed, for testing all valves other than diodes and rectifiers. If the normal g_m of the valve is known to be above 10, the key $g_m \times 2$ must be pressed simultaneously with the g_m key. This shorts out half the series resistance in the calibrating circuit and, in effect, doubles the calibrating voltage $-Ea_2$. The actual g_m will thus be twice that indicated on the scale.

(iii) *Rectifier*. With this circuit, the anode supply voltage is taken from the tapping L5-L8 (100 volts r.m.s.) and a 1-kilohm loading resistor R9, is switched in series with the anode circuit. The meter shunt is also connected. Measurements are taken with the *Adjust Zero* potentiometer fully clockwise, and indicated readings should in all cases be more than 3·5 milliamps. (See under Operation.)

(iv) *Diode*. The same conditions apply as in (iii) except that the 1-kilohm loading resistor R9 is replaced by 10 kilohms R10, and the meter shunt removed.

The Grid Circuit

Grid voltage is obtained from the transformer centre-tapped winding L9-L11. The application has already been explained. The actual voltage from the winding is 0·35 r.m.s., i.e. 0·5 volts peak on either side of the centre tap, the circuit being connected to the grid electrode switch *G1* via the g_m switch and a jack which may be used to provide grid bias.

Operation

1. *Mutual Conductance Tests*

(i) Before connecting the instrument to the mains supply, make sure that the green lead on the main flexible cord is properly earthed.

(ii) Set the *A.C.* Mains switch to the correct stud for the local supply voltage. This step is important since the instrument is not provided with a variable potentiometer for adjusting filament voltage. (The filament voltage is selected by the *Filament Volts* switch, and will lie within the limits necessary for valve testing only when the mains transformer is set on the right tapping.)

(iii) Set the *Selector Switch* to g_m *Coarse*.

(iv) Set the *Filaments Volts* switch to the right value.

(v) Set the individual electrode switches to the appropriate pin numbers. Check the *Octal* or *B7G Filament* switch against the condition required.

(vi) Set the *Screen Volts* switch to the voltage required.

(vii) Switch on the mains supply. The neon lamp will glow and a reading should appear on the meter after approximately 30 seconds. If there is no meter reading, operate the *Press to Reset* button. This restores the overload relay contacts (manually) to the *make* position, thus completing the mains supply circuit. If, on pressing this button a loud buzzing is heard, *release the button immediately* as this indicates a short-circuit across the main transformer winding, probably due to faulty setting of the electrode switches.

(viii) Move the *Adjust Zero* control until the meter reads approximately zero.

(ix) Set the *Selector* switch to g_m *Fine* and adjust for accurate zero if necessary.

(x) Press the g_m key and adjust the meter reading to zero by means of the calibrating

g_m dial. The reading of the dial will indicate the mutual conductance in milliamps per volt. In order to obtain an accuracy of within 2 to 3 per cent, repeat the operation rapidly, alternately pressing and releasing the g_m key until the zero adjustment and the calibrated g_m dial adjustment give the same meter reading.

For valves whose conductances are over 10 milliamp/volts, the key $g_m \times 2$ should be depressed simultaneously with the g_m key and balancing carried out as above. The g_m will be twice the scale reading.

2. *Directly-heated Valves*

The instructions given under 1 apply equally to directly-heated valves, but an additional operation is necessary to eliminate errors due to unbalanced filaments. This consists of taking a reading on both *D.H.* positions of the special key, and obtaining a mean g_m from the two results.

3. *Emission Tests for Diodes and Power Rectifiers.*

This test gives the relative emission capabilities of the cathodes and hence the d.c. impedance of the anode-cathode path. In each case, the test consists of applying a.c. voltage to the anode through a load and noting the feed shown on the meter.

(i) Carry out tests (i) to (viii) as indicated under the heading 1.

(ii) Set the *Selector* switch to *Rectifier* or *Diode*, according to the type being tested.

(iii) Set the *Adjust Zero* control fully anti-clockwise. A reading of 3·5 or above indicates normal emission.

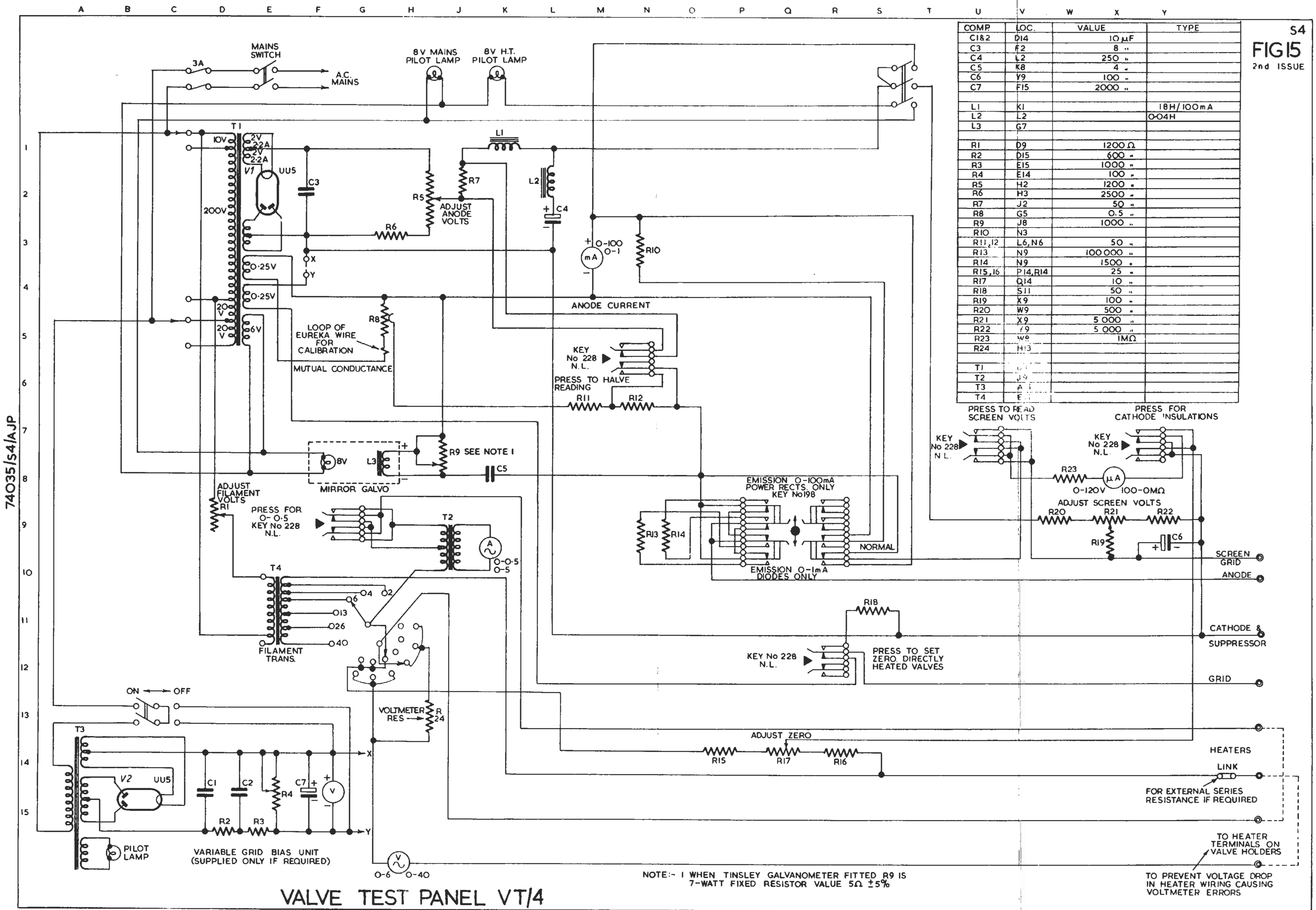
Note :—It must be emphasised that this reading has no ordinary relation to the current which will be drawn if 100 volts d.c. were applied to the anode, as in the case of the test panel VT/4.

VT4/5

S4

FIG 15

2nd ISSUE

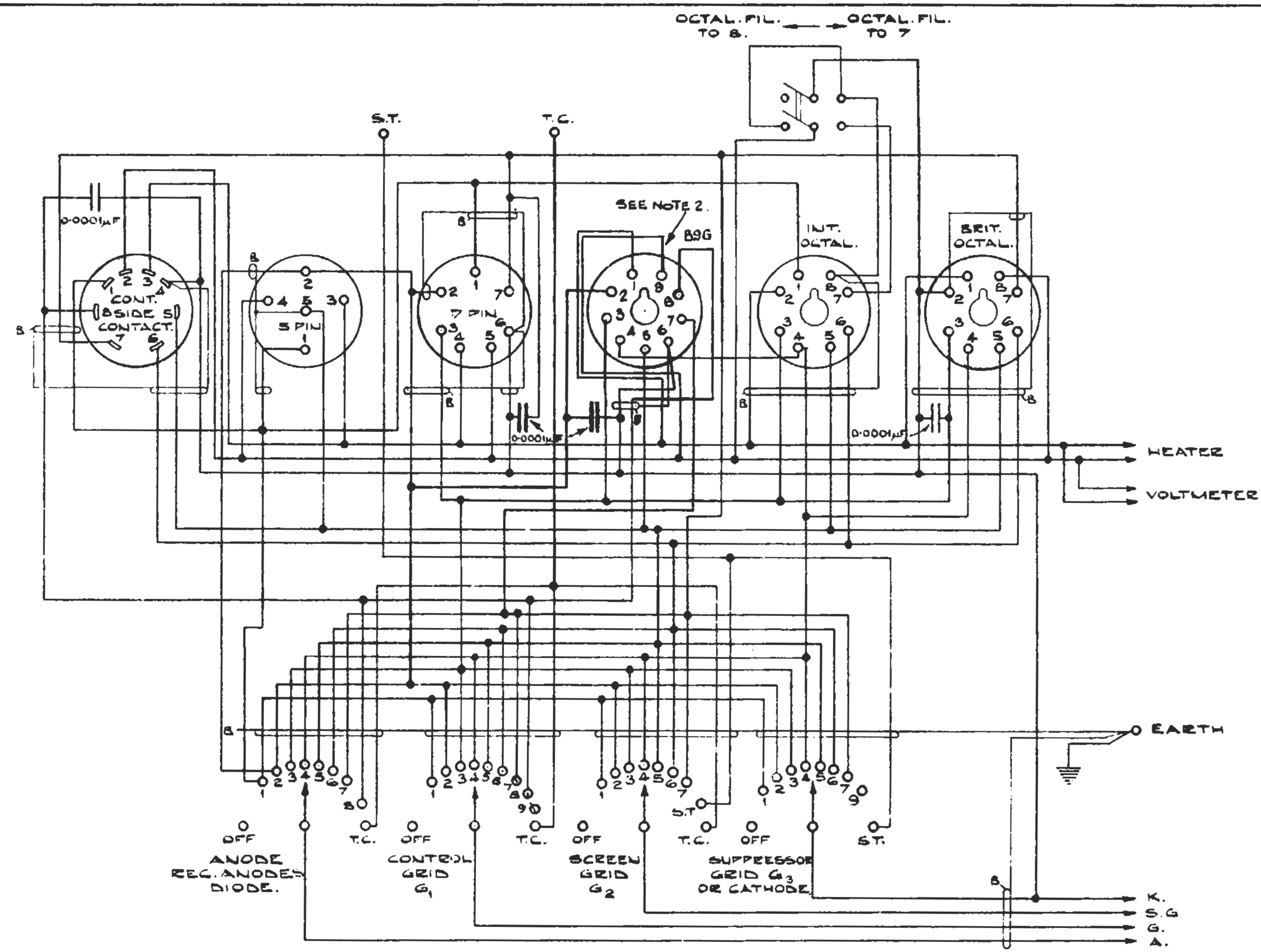


COMP.	LOC.	VALUE	TYPE
C1&2	D14	10 μF	
C3	F2	8 "	
C4	L2	250 "	
C5	K8	4 "	
C6	Y9	100 "	
C7	F15	2000 "	
L1	K1		18H/100mA
L2	L2		0·04H
L3	G7		
R1	D9	1200 Ω	
R2	D15	600 "	
R3	E15	1000 "	
R4	E14	100 "	
R5	H2	1200 "	
R6	H3	2500 "	
R7	J2	50 "	
R8	G5	0.5 "	
R9	J8	1000 "	
R10	N3		
R11,12	L6,N6	50 "	
R13	N9	100 000 "	
R14	N9	1500 "	
R15,16	P14,R14	25 "	
R17	Q14	10 "	
R18	S11	50 "	
R19	X9	100 "	
R20	W9	500 "	
R21	X9	5 000 "	
R22	Y9	5 000 "	
R23	W9	1MΩ	
R24	H13		
T1	[illegible]		
T2	J9		
T3	[illegible]		
T4	[illegible]		

NOTE:- 1 WHEN TINSLEY GALVANOMETER FITTED R9 IS 7-WATT FIXED RESISTOR VALUE 5Ω ±5%

VALVE TEST PANEL VT/4

51/JWG/004
B5376



NOTE. 1. THE 0·0001µF CONDENSERS ARE OMITTED ON LATER MODELS, DUE TO REARRANGEMENT OF SCREENING.

NOTE 2. WHEN A BRITISH STANDARD 9 PIN HOLDER IS FITTED IN PLACE OF RING SEAL HOLDER TYPE B9G, THE FOLLOWING CONNS. REQUIRE MODIFICATION:- PINS 4 & 5 TO HEATER SUPPLY, PIN 9 TO 9 OF SEL'R SW'S G1 & G3, PIN 1 TO 1 OF SEL'R SWITCHES.

B - BONDING OF SCREENS.

S.T. - SIDE TERMINAL.

T.C. - VALVE TOP CAP.

FIG 16
3rd ISSUE

VT/4 VALVEHOLDER PANEL

S4

VT4/5