

TESTERS, VALVE, AVO

TECHNICAL HANDBOOK - TECHNICAL DESCRIPTION

Note: This Part 1, together with the Part 2, supersedes Tels Y 802, Issue 1, dated 19 Aug 44.

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INTRODUCTION

1. The complete testing of a thermionic valve is a complex procedure involving a range of apparatus that cannot be conveniently embodied in a single instrument. However, in workshops it is not necessary to carry out a complete range of tests as testing is normally confined to valves which have been previously and thoroughly checked at the manufacturers prior to issue.
2. The Testers valve are self-contained, mains-operated instruments for the simple testing of general purpose Service and commercial types.
3. The results obtained can be directly compared with the data as published in Table 6 of Tels Y 811, Issue 1. This gives details of ROLLER SELECTOR switch settings, test voltages and specification figures. Reference should be made to Tels Y 812 Part 2 for component values, circuit and layout diagrams.

TESTER, VALVE, AVO, NO 1

BRIEF TECHNICAL DESCRIPTION

Electrical

4. The instrument uses an a.c. testing method which eliminates the need for elaborate d.c. power packs. Full wave a.c. voltages are applied to the valve electrodes in a manner such that, when anode current and changes of anode current are measured in terms of d.c. currents, the general function of a static d.c. valve characteristic is maintained.
5. Valve holders are provided on the valve holder panel which is on the subsidiary unit. These holders cater for valves in current use and a nine-way rotary switch allows any one of the valve base sockets to be connected to any one of the electrode test circuits in the instrument.
6. Valve electrode test voltages are obtained from three multi-tapped transformers and unsmoothed half-wave rectified a.c. is used to 'back off' anode current when making mutual conductance measurements.

Power requirements

7. The power supply required is 200 - 250V at 50 - 60c/s. The consumption is approximately 20VA.

Mechanical

8. The complete instrument consists of two units, the main and the subsidiary. The main unit consists of a bakelite front panel on which are mounted all the components including the meter. The subsidiary unit consists of an aluminium front panel on which are mounted the valve holders and the nine-way rotary selector switch. A pressed aluminium case completes each unit.

DETAILED TECHNICAL DESCRIPTIONMethod of characteristic testing (Fig 2001)

9. The manner of operation is shown in Fig 2001. The electrode voltage controls are directly calibrated in terms of d.c. voltages and provide the indicated test voltages.
10. With no backing-off voltage applied by the SET ZERO control, RV2 to the meter circuit, this meter indicates the standing anode current.
11. A direct reading of mutual conductance is obtained by backing-off the standing anode current to zero and applying a 1V a.c. positive charge to the grid. The meter deflection is a direct measurement of the valves mutual conductance, it being a change in anode current (milliamps) for a grid potential change of 1V
12. The grid potential is obtained from the 1V winding L1 on transformer T1, which is centre-tapped to chassis. The ends of this winding are connected to the key switch SF. When the switch is in its central position one end of the winding is connected to the grid, making it 0.5V negative with respect to cathode. On pressing the switch to the mA/V position the other end of the winding is connected to the grid, making the grid 0.5V positive with respect to the cathode, ie, a 1V change in all. The resulting change in anode current is therefore a direct reading of mutual conductance.
13. For quick batch testing in terms of mutual conductance a GOOD/BAD scale is provided on the meter. By adjusting the SET mA/V control, RV1, to a pre-determined mutual conductance figure, a shunt value is obtained for the meter, such that full scale deflection of the meter corresponds to this predetermined figure of mutual conductance. Then, on pressing the key switch to the mA/V position, the meter will give a reading which, after being multiplied by 10, gives the percentage efficiency of the valve (f.s.d. = 100%).

Method of rectifier and diode testing (Fig 2001)

14. Rectifiers are tested with 30V applied to the anodes via a limiting resistance R4. Full scale deflection indicates anode current of 100mA.
15. Signal diodes are tested in a similar manner but with 12V applied to anodes via R5. Full scale deflection indicates anode current of 10mA.

Continuity and insulation test circuits

16. The input to the h.t. transformer T1 is used as a means of testing insulation. Across this supply are two resistors, the neon lamp, and a switch. When prods are inserted in the sockets on the front panel of the main unit this switch is opened and the circuit broken. If the two prods are touched together the circuit is again completed. The insulation test takes the form of a comparison test between the glow obtained from the lamp when the prods are shorted together and the glow obtained when the prods are connected to the electrodes of a valve, between which it is desired to check the insulation. The brighter the glow, the less the insulation.

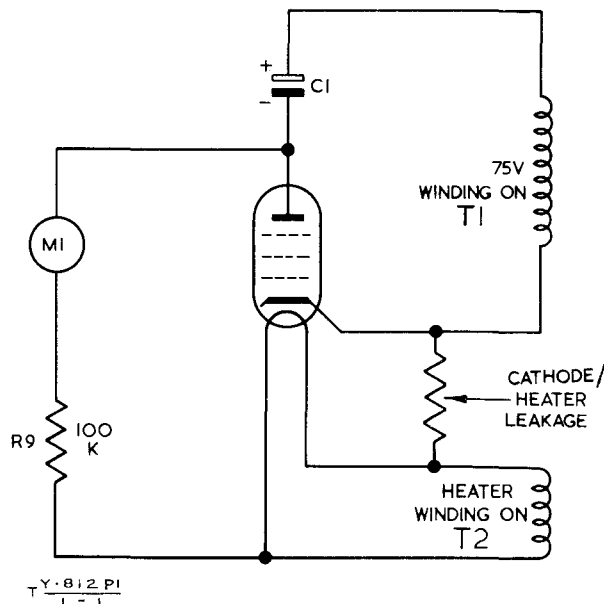


Fig 1 - Heater/cathode insulation test
Tester No 1

17. To test the cathode/heater insulation, however, this method is not used. From Fig 1 it will be seen that the valve under test is being made to act as a rectifier and the 0.05µF condenser C1 will charge up from the 75V tapping on the h.t. transformer. Any breakdown between cathode and heater will allow this charge to leak away through the meter, which will indicate the value of discharge current. Thus this leakage may be directly calibrated in megohms. This has been done on the lower black scale and the cathode/heater insulation is read directly from this scale.

Transformer assemblies (Fig 2001)

18. All supplies for the instrument are derived from the transformer assemblies consisting of the heater transformer T2, and the h.t. transformer T1. The normal mains supply tapplings enable the input to T1 to be controlled by an auto-transformer arrangement.

19. T1 has three secondary windings which supply:-
 - (a) 1V for the direct readings of mutual conductance.
 - (b) 20V for the SET ZERO control.
 - (c) Eleven tapplings to provide anode and screen voltages.
20. T2 has two secondary windings which supply:-
 - (a) The heater voltages in the range 0-40V as selected by switch SB.
 - (b) 30 and 100V fed to the ANODE VOLTS switch at REC and 100 respectively.
21. It will be seen from the circuit diagram, Fig 2001, that the 200V tapping on the SCREEN VOLTS control is the same as the 150V tapping on the ANODE VOLTS control. If measurements are taken of the various voltages they will correspond to the figures on the transformer. In fact, the SCREEN VOLTS are substantially the same as the positions of the switch denote whilst the actual voltage at the positions of the ANODE VOLTS control is somewhat higher. The reason for this is that when the instrument was designed the relationship that does exist between these voltages was empirically found to be the correct one to test valves on the straight portion of the characteristic.

Set zero

22. To obtain a direct reading of mutual conductance a backing-off circuit is used to balance out any deflection due to the standing anode current at the desired test conditions. The 20V winding on T1 feeds a potentiometer which forms part of the SET ZERO control. The other part of the control is a series resistor, ganged in such a manner that the backing-off potential network presents an approximately constant shunt across the meter circuit. By use of the SET ZERO control any potential up to 20V a.c. may be selected, rectified and fed to the meter circuit in opposition to the valve anode current.

Operation of key switch SF

23. This key is used to apply the 1V change to the grid of the valve when in the mA/V position and to apply 75V a.c. to the valve for testing the cathode/heater insulation when in the C.INS. position. In addition it disconnects the anode voltage. Table 1 gives the contacts on this switch and their functions.

Contacts	Position of centre key			Function of contacts
	C.INS	Central position	mA/V	
AB	closed	open	open) Metering circuit
BC	open	closed	closed	
DE	open	closed	closed) Cathode circuit return
FG	closed	open	open) Anode volts
GH	open	closed	closed	
JK	closed	open	open) Grid voltage
KL	open	closed	closed	
MN	closed	closed	open) Grid voltage
NP	open	open	closed	

Table 1 - Contacts of key switch SF

Valve holder panel and roller selector switch

24. On the subsidiary unit are mounted the valve holder panel which contains 17 valve holders when fully modified, the ROLLER SELECTOR SWITCH, three sockets for top cap or side terminal connections, and the NORMAL/ ÷ BY 7 switch, (SH). The valve holders are of the following types:-

- (a) British 4/5 pin, 7 pin, and 9 pin

- (b) B3G, B5A, B7G, B8A, B9A, B9G
- (c) B8B or B8G (American loctal)
- (d) British octal, International octal
- (e) American 4 pin, 5 pin, 6 pin, small 7 pin UX
- (f) Flying lead

These valve holders have the corresponding pin numbers wired in parallel. The three sockets are connected to anode, screen and grid circuits.

25. The ROLLER SELECTOR switch carries nine spring contacts, each of which can be rotated to make connection to any one of ten busbars arranged co-axially in the barrel of the switch. Thus any valve pin number can be connected to any one of the instrument circuits, as may be necessary. The rollers are held in their selected positions by leaf springs acting on the moulding escapement. The particular connection made for any one of the pin rotating contacts is indicated in the escutcheon window by suitably engraved position markers as under:-

1	2	3	4	5	6	7	8	9	0
C	H-	H+	G	S	A	A ₂	D ₁	D ₂	E

26. The NORMAL/ ÷ BY 7 switch is for use with valves using lower heater voltages than can be obtained direct from the HEATER VOLTS selector switch. For example, to test a valve with a 1.4V filament, set the HEATER VOLTS selector switch to 10 volts and the NORMAL/ ÷ BY 7 switch to ÷ BY 7 and the resultant heater voltage will be approximately 1.4 volts.

TESTER, VALVE, AVO, NO 3

INTRODUCTION

27. The Tester, valve, Avo, No 3 is a self-contained, mains-operated instrument for the simple testing of general purpose Service and commercial type valves. Heater continuity, inter-electrode insulation, electrode currents and mutual conductance can be quickly measured. The instrument design enables static and dynamic characteristic curves to be obtained if required.

28. Two forms of the valve tester, designated by the manufacturers as the Valve characteristic meter Mk 1 and Mk 2 respectively are held by the Service under common nomenclature, Tester, valve, Avo, No 3. The differences between the two forms are minor. Identification of the two types is a simple matter. The Mk 2 version has two base runners, handles on either side of the front panel and a small compartment for the manual, whilst these are not provided on the Mk 1. It should be noted that circuit or positional changes may occur which have not been detailed in this regulation. This is due to the fact that the instrument was not designed solely for Service use and hence changes may occur without prior Service consultation.

BRIEF TECHNICAL DESCRIPTIONElectrical

29. The instrument uses an a.c. testing method which eliminates the need for elaborate d.c. power packs. Full-wave and half-wave unsmoothed a.c. voltages are applied to the valve electrodes in a manner such that, when anode current and changes of anode current are measured in terms of d.c. currents, the general function of a static d.c. valve characteristic is maintained.

30. Valve electrode voltages to establish the test conditions are derived from multi-tapped transformers via calibrated selector switches. One transformer provides heater voltages, the other h.t., g.b. and backing-off voltages. Unsmoothed 50c/s a.c. is applied direct to the anode and screen of a valve under test. Unsmoothed, half-wave rectified a.c. is used to fix the grid working point, to provide a grid swing and the anode current backing-off voltage to facilitate the measurement of mutual conductance.

31. A single 3.1/2 inch scale moving-coil meter, used in conjunction with three selector switches in combination, provides direct readings of inter-electrode insulation or electrode currents or mutual conductance.

32. A cut-cut in the form of a double-circuit polarized electro-magnetic relay with its windings energized by the anode and screen currents provides protection against inadvertent or deliberate shorting of the supply voltages.

33. Valve holders are provided on the valve holder panel. These holders cater for valves in current use and a nine-way rotary switch enables any one of the valve base standard pin numbers to be connected to any one of the electrode test circuits in the instrument.

Power requirements

34. The power supply required is 95-125V or 185-255V at 50-60c/s. The consumption is approximately 60VA.

Mechanical

35. The instrument consists of 3 major assemblies as follows:-

- (a) Front panel assembly
- (b) Transformer assembly
- (c) Valve panel assembly

These assemblies are mounted on a sand-cast aluminium framework of two main vertical side frames, bolted and screwed to four horizontal members consisting of 1/4 in. dia cross rod, two angled 1/2 in. x 1/2 in. strips and the top valve holder panel casting.

36. A pressed aluminium pedestal cabinet, complete with hinged lid, houses the instrument.

DETAILED TECHNICAL DESCRIPTION

Method of characteristic testing (Fig 2)

37. The general function for a d.c. static valve characteristic is

$$I_a = \frac{f (V_a + \mu_1 V_{g1} + \mu_2 V_{g2})}{R_a} \quad (1)$$

where I_a = anode current

V_a = anode volts

R_a = anode slope resistance

V_{g1} = control grid voltage

V_{g2} = screen grid voltage

μ_1 = amplification factor grid/anode

μ_2 = amplification factor grid/screen

The relationship only holds under the conditions that μ_1 , μ_2 and R_a are constant over the operating region.

38. In the instrument a patented a.c. method of operation is used whereby raw 50c/s a.c. voltages are applied to the anode and screen electrodes. The grid conditions are established with unsmoothed half-wave rectified a.c. but the I_a is measured in terms of d.c. current. Co-relation between the a.c. and d.c. test conditions is arranged in the instrument design by maintaining the following relationships:-

$$V_a \text{ r.m.s.} = 1.1 \text{ indicated d.c. } V_a$$

$$V_{g2} \text{ r.m.s.} = 1.1 \text{ indicated d.c. } V_{g2}$$

$$V_{g1} \text{ (mean unsmoothed)} = 0.52 \text{ indicated d.c. } V_{g1}$$

$$I_a \text{ (mean d.c.)} = 0.5 \text{ indicated } I_a$$

The manner of operation is shown in Fig 2. Included are voltage waveforms at various points in the circuit, as is the current waveform in the anode circuit.

39. The electrode voltage controls are directly calibrated in terms of d.c. voltages and provide the indicated test voltages; for example, with the ANODE VOLTS switch set at 200V we have 220V r.m.s. applied to the anode and with NEG GRID VOLTS at -3V the mean d.c. voltage at the control grid is -1.56V. The factor of two has been introduced into the meter circuit by the shunt element RV7 and the actual mean d.c. I_a flowing in the anode circuit will be found to be half that indicated by the instrument meter.

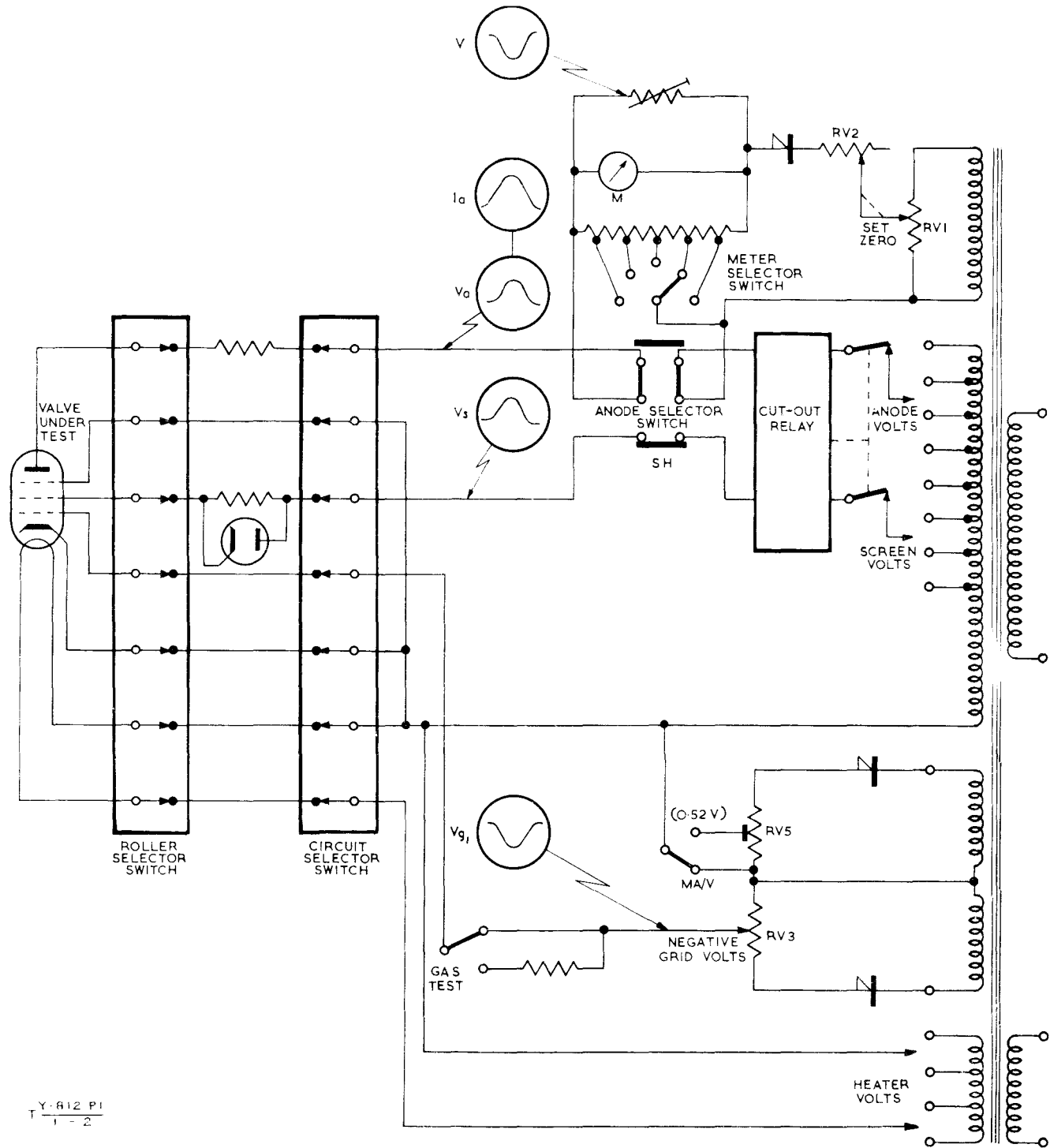


Fig 2 - Method of characteristic testing. Tester No 3

40. With no backing-off voltage applied by RV1 to the meter circuit, this meter indicates the standing anode or screen current according to the setting of the ANODE SELECTOR switch SH.

41. A direct reading of mutual conductance is obtained by backing off the standing anode current of the valve to zero and applying a 0.52V d.c. positive voltage change to the grid, which is obtained from the half-wave rectifier circuit when the mA/V button SM is pressed. The meter deflection is a direct measurement of the valve's mutual conductance, it being a change equivalent to 1V d.c.

42. For quick batch testing in terms of mutual conductance, a GOOD/BAD scale is provided on the meter. With the METER SELECTOR switch SG at mA/V - position 5, a variable shunt element consisting of R5 and RV4 is connected across the meter. By adjusting the SET mA/V resistor RV4 to a predetermined mutual conductance figure, a shunt value is obtained for the meter, such that half scale deflection occurs when the effective current change due to the grid potential change on pressing the SET mA/V button, SM, is equal to the pre-set mutual conductance figure. A good valve should give a reading of half the full scale deflection, or above.

Method of rectifier and diode testing (Fig 3)

43. Rectifiers can be tested to ensure that each section will produce sufficient current under suitable load conditions. A voltage of 150V r.m.s. from tapping (j) on T2 is applied to the anode of the rectifier under test which supplies the reservoir condenser C1. The resistors R21 to R25 provide six d.c. load conditions of 1mA, 5mA, 15mA, 30mA, 60mA and 120mA. Current in the load circuit is indicated by the meter, shunted to correspond with the selected load current. Each half of a full-wave rectifier can be individually tested by the selection of anode 1 or anode 2, as selected by the ANODE SELECTOR switch.

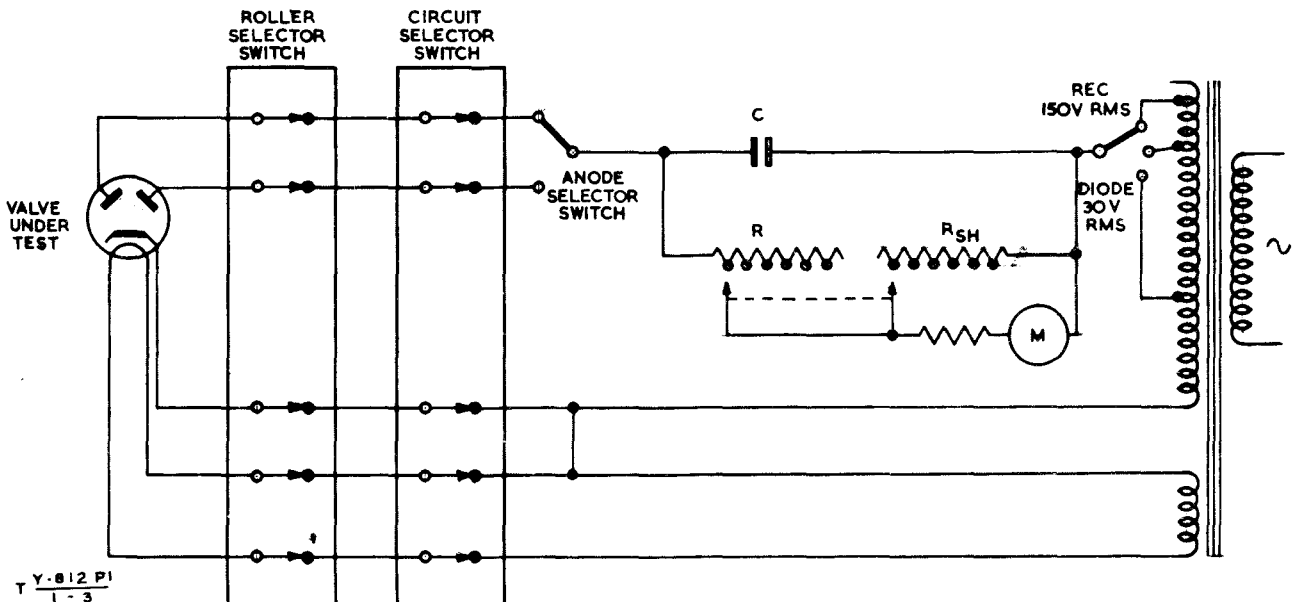
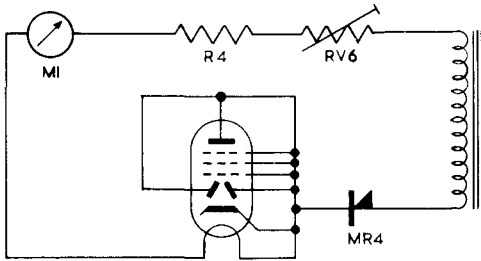
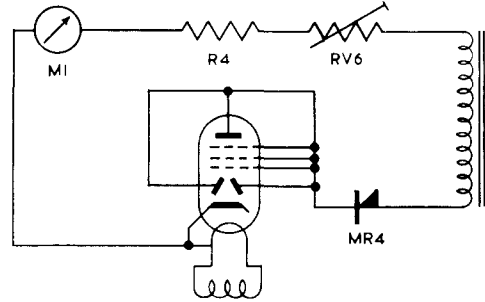


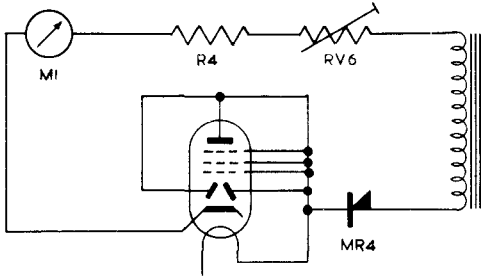
Fig 3 - Method of rectifier and diode testing. Tester No 3



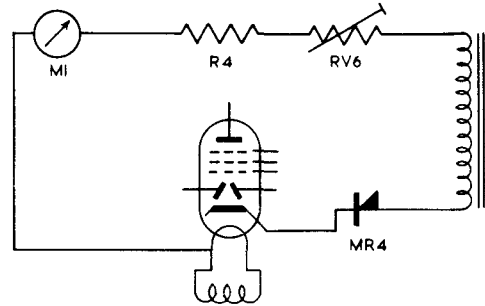
(a) HEATER CONTINUITY TEST — VALVE COLD
CIRCUIT SELECTOR SWITCH SET TO CHECK (C)
ELECTRODE LEAKAGE SWITCH SET TO H



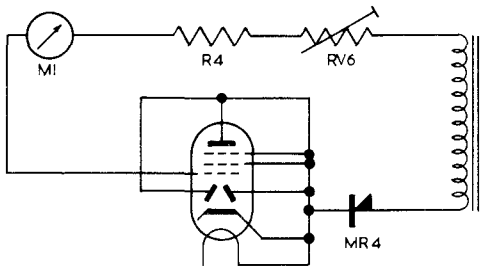
(d) INSULATION TEST — VALVE HOT
CIRCUIT SELECTOR SWITCH SET TO CHECK (H)



(b) INSULATION TEST — VALVE COLD
CIRCUIT SELECTOR SWITCH SET TO CHECK (C)
ELECTRODE LEAKAGE SWITCH SET TO C



(c) CATHODE TO HEATER TEST (INDIRECTLY HEATED VALVE)
CIRCUIT SELECTOR SWITCH SET TO C/H in



(e) INSULATION TEST — VALVE COLD
CIRCUIT SELECTOR SWITCH SET TO CHECK (C)
ELECTRODE LEAKAGE SWITCH SET TO G

Y-812 P1
1-4

Fig 4 - Continuity and insulation test circuits. Tester No 3

44. The load figures are chosen to correspond with the maximum emission specified by the valve manufacturers. The meter indicates the efficiency of the valve on the basis of the required d.c. load.

45. Signal diodes are tested in a similar manner but with the 30V r.m.s. from tapping (b) on T2 applied to the anode and with a d.c. loading of 1mA.

Continuity and insulation test circuits (Fig 4)

46. The output of rectifier MR4 is used as an unsmoothed d.c. supply for the continuity and insulation tests. The three circuits are established by the setting of the CIRCUIT SELECTOR switch SI and the ELECTRODE LEAKAGE switch SJ (paras 53 and 54 refer). The three positions are shown in Fig 4. There is the example for heater continuity (a), two examples of insulation test with valve cold, (b) and (c), and two examples of insulation test with valve hot, (d) and (e).

Transformer assembly (Fig 2005)

47. All supplies for the instrument are derived from the transformer assembly, consisting of the heater transformer T1 and the h.t. and g.b. transformer T2. In addition to the normal mains supply tapplings, the primary of T1 has eleven $3V \pm 10\%$ subsidiary tapplings. They are the fine controls for inputs to both transformers. The auto-transformer arrangement for the input to T2 enables the secondary outputs to be adjusted to maintain the d.c. calibration of the electrode supply controls.

48. T2 has five secondary windings. Four of these supply:-

- | | |
|---------------------|--|
| (a) $6.3V \pm 0.1V$ | Diode heaters |
| (b) $25V \pm 1V$ | SET ZERO anode current backing-off circuit |
| (c) $2V \pm 0.25V$ | mA/V positive grid swing voltage |
| (d) $145V \pm 3V$ | grid working voltage circuit |

The fifth winding has eighteen tapplings to provide anode and screen voltages within the range 0-400V as selected by the ANODE VOLTS and SCREEN VOLTS switches SE and SF, respectively.

49. Secondary tapplings of T1 provide the heater volts at the standard ratings within the range 1.1V to 110V, as selected by two FILAMENT VOLTS switches SC and SD. Switch SC is used to select heater voltages in the range 0-16V and switch SD selects heater voltages from 0-110V in 10V steps. By suitable positioning of the switches, voltages in either range may be used or the two voltages can be made additive (see Fig 5 for examples). It should be noted that the 10, 20, 30, 40 and 50V tapplings do not exist as such but are in fact the differences between the 60V tapping and the 70, 80, 90, 100 and 110V tapplings.

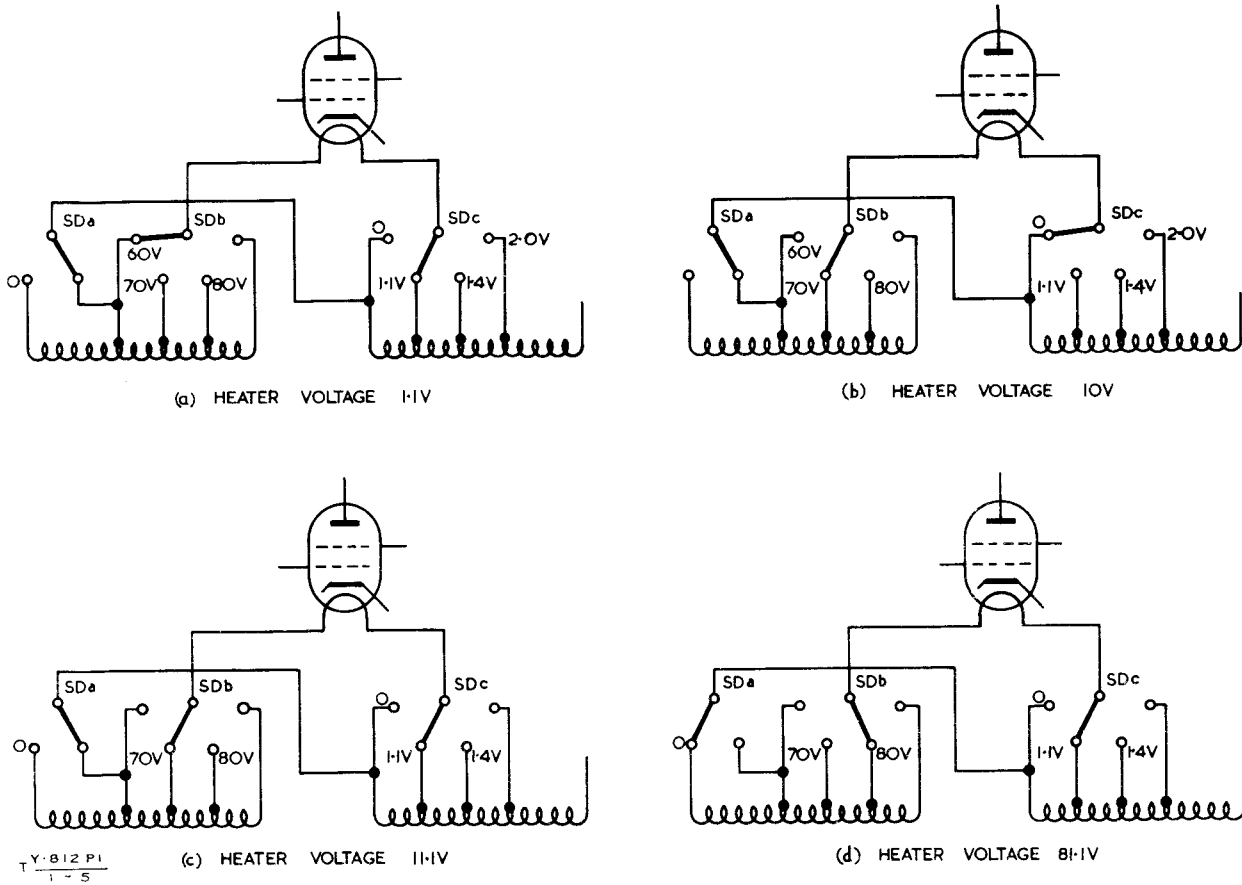


Fig 5 - Heater voltage supply - examples. Tester No 3

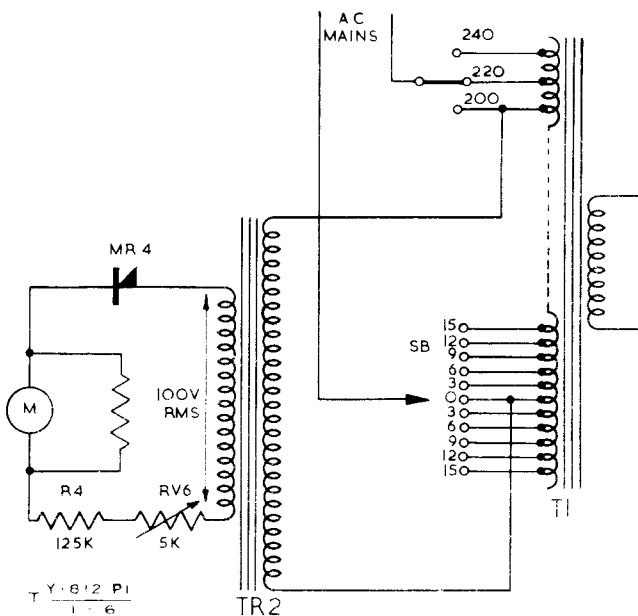


Fig 6 - Set ~ circuit. Tester No 3

Set ~ circuit (Fig 6)

50. Correct calibration of the electrode voltage controls is ensured in the setting up procedure by the SET ~ circuit. The CIRCUIT SELECTOR switch SI and the ELECTRODE LEAKAGE switch SJ establish the circuit conditions shown schematically in Fig 6. The selection of a fine tapping on T1 by means of SB ensures that the input to the primary of T2 will be such that the output voltage across the winding GB1 and GB2 is 100V r.m.s. A setting-up mark is provided on the meter scale and initial calibration in manufacture or major overhaul is made by adjustment of the preset control VG (RV6).

Circuit control arrangements

51. The instrument switching arrangements are complex because of the multiplicity of tests that have to be carried out on the varied valve types. It should be noted that the detached contact system for switches has been used in the circuit diagram (Fig 2005).

Circuit selector switch SI

52. The CIRCUIT SELECTOR switch has six positions with six double-sided, twelve-contact wafers, the function of the wafers being as follows:-

SIaa Controls anode circuit supply volts.

SIbb Routes the anode supply either to the meter or to the load in the case of rectifiers.

SIcb) Control connections to meter.
SI da)

The remaining wafers, - ab, ba, ca, db, ea, eb, fa and fb-select electrodes for the insulation tests in conjunction with the ELECTRODE LEAKAGE switch SJ.

53. In position 1, CHECK (C), all the electrode circuits are connected to the ELECTRODE LEAKAGE switch SJ. The instrument can then be set up for mains voltage adjustment (para 50 refers) or for electrode leakage tests with the valve cold. The electrodes of the valve under test are connected to SJ by SI(cb) and to the 100V negative supply by SI(da). Rotation of the switch SJ then tests the insulation which occurs between each of the valve electrodes taken in order and all others strapped. Continuity of the heater is indicated in position H of SJ. In this position of SI, SI(fa) removes the valve heater supply.

54. Position 2, CHECK (H). Heater supply to the valve is restored by SI(fa). The heater and cathode are connected together via SI(eb). All the other electrodes are strapped together via their respective contacts on SI and insulation resistance between them and the heater/cathode strapped, is checked.

55. Position 3, C/H Ins, checks the cathode/heater insulation. Here the 100V negative supply is applied via SI(da) meter M1, SI(cb) and SI(eb) to the cathode, the meter giving direct reading of the cathode to heater insulation.

56. Position 4, TEST, enables all mutual characteristic tests to be carried out in conjunction with switches SE, SF, SN, NEG GRID VOLTS control RV3, and with the meter, anode/screen selector switches correctly set. The anode supply is now connected by SI(aa) and SI(bb) to the anode 1 and anode 2 circuits. The meter is connected to the shunt circuits by SI(cb) and (da). The other contacts of SI connect the ROLLER SELECTOR switch to the appropriate power supplies.

57. Position 5, DIODE, is used for the testing of signal diodes. The anode supply is connected to a 30V tap on T2, tapping b, by SI(aa), and SI(bb) connects the diode anode circuits to the test load. SI(cb) and (da) connect the meter to the diode load circuit.

58. Position 6, REC, is in all respects similar to position 5 except that SI(aa) now selects the 150V tap on T2, tapping j.

Meter selector switch SG

59. This switch has a bank of two double-sided wafers. It has no effect on the meter circuit in positions 1, 2 and 3 of the CIRCUIT SELECTOR switch. With SI at position 4, positions 1, 2, 3 and 4 of SG provide meter current ranges of 100mA, 25mA, 10mA and 2.5mA by the switching of the meter shunt elements R10, R10 + R12, R10 + R12 + R28, R10 + R12 + R28 + R27.

60. For position 5, mA/V, of SG a special meter circuit condition is established whereby a meter shunt element of R5 in series with RV4 is connected across the meter. RV4, SET mA/V, is calibrated in terms of mA/V. Its value at a particular setting is such as to produce half scale deflection of the meter when a current equal in value to the selected setting is passed by the valve, consequent upon the positive grid swing voltage being applied by pressing the mA/V button. This arrangement is used for the comparative or batch testing of valves in terms of the mutual conductance.

61. In position 4 of SI, shunt selection is done by SG(ab) and (bb), SG(aa) and (ba) being inoperative.

62. With the CIRCUIT SELECTOR switch at positions 5 and 6, SG(aa) and (ba) become operative. SG(ba) determines the load resistance values for d.c. loadings of 1mA, 5mA, 15mA, 30mA, 60mA and 120mA by the switching of resistors R21 to R25. SG(aa) applies the appropriate meter shunt element of R15 to R20.

Grid voltage controls

63. A multiplier network of R6, R7, R8, R9 and RV3 across the 100V negative supply enables either 10V or 100V to be applied across RV3 by means of the switch SN (Vg, X1, X10). The arrangement of the network is such that the same load appears across the 100V negative supply in both positions of SN. Fine control of the grid voltage is given by RV3, the scale being calibrated 0-10. A 2V winding on transformer T2 and the half-wave rectifier MR3 supply the small positive change of grid bias obtained when the mA/V button is pressed. RV5 is a preset potentiometer used to set up this voltage.

64. The GAS press button switch is connected across R11, a 100,000Ω resistor in the grid circuit. Presence of gas in the valve will cause excessive grid current to flow. Operation of the GAS button, therefore, will cause a d.c. bias voltage to be developed across R11. The presence of this bias will be indicated by a change in anode current, an excessive change denoting a soft valve.

Anode selector switch SH

65. This is a double-sided twelve-contact wafer with group contacts and has three positions marked A1, A2 and S. It is used when testing valves with more than one anode or when it is desired to measure the screen grid current. In position 1 of SH (CIRCUIT SELECTOR switch to TEST) the anode 1 of the valve under test is connected to the metering circuit, anode 2 going via a limiting resistor R2 to the anode supply and screen grid to the screen supply. Diode anode 1 is also brought into circuit

but it is not connected to the load or metering circuits until the CIRCUIT SELECTOR switch is set to DIODE or REC. Position 2 of the ANODE SELECTOR switch reverses the anode connections, anode 2 going to the metering circuit and anode 1 via R2 to the anode supply. If the CIRCUIT SELECTOR switch is at DIODE or REC, then the diode anode connections are reversed by SH. In this case the diode anode, not being metered, is left floating. Position 3 of SH connects anodes 1 and 2 direct to the anode voltage supply and places the meter in the screen grid circuit of the valve under test.

Set zero

66. To obtain a direct meter reading of mutual conductance, a backing-off circuit is used to balance out any deflection due to the standing anode current at the desired test conditions. In order to prevent ripple which may affect the meter, used on a sensitive range after backing-off, a current similar in waveform but opposite in polarity to the anode current is used. A 25V winding on T2 supplies half-wave rectifier MR1 via the SET ZERO control RV1 and RV2, two ganged potentiometers. The negative-going half-wave rectified current flow from MR1 develops a p.d. across the meter shunt circuits, opposite in polarity to that developed by the anode current. RV1 and RV2 are adjusted to make these p.d.s equal, indicated by the meter returning to zero.

Safety cut-out (Fig 7)

67. The cut-out is a two-circuit polarized relay with its windings supplied by the anode and screen currents of the valve under test. With the valve electrodes taking normal currents, half-wave rectified d.c. pulses will energize the windings, the direction and magnitude being such that, with anode current only or considerably larger anode current than screen current, the relay will hold in. If a short-circuit occurs on the anode or screen electrodes or on the valve holder sockets associated with these electrodes, the current flowing will be a.c., since rectification will not occur in the valve. The first negative-going half-cycle of the a.c. current will cause the relay to operate, contacts X, Y and Z will open with the following effects:-

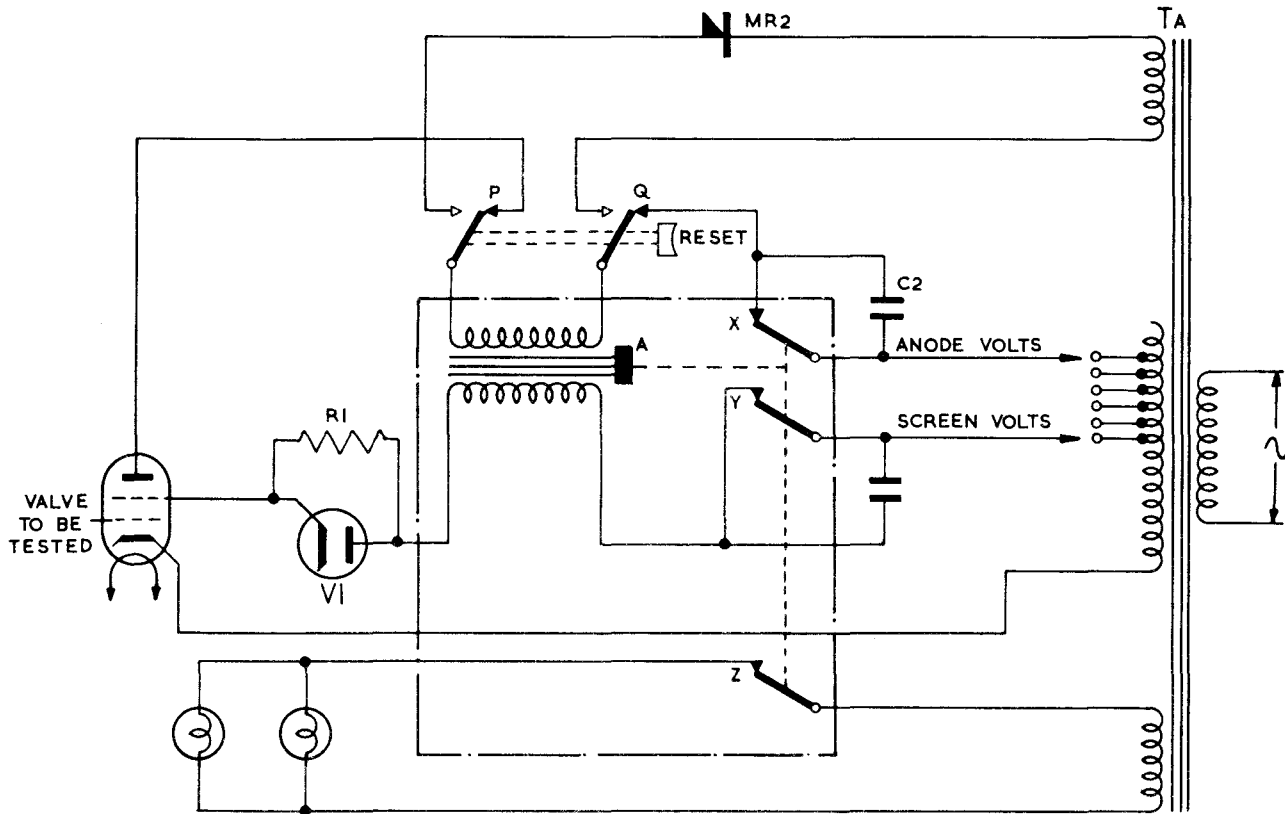
- (a) Anode voltage supply disconnected
- (b) Screen voltage supply disconnected
- (c) Lamps ILP1 and ILP2 illuminating the meter will go out.

68. If the screen current exceeds the anode current, the relay is so set that it will open, preventing damage to the valve.

69. The cut-out will NOT operate when heavy currents of a d.c. nature occur in the valve anode circuit and thus it will not protect the meter if it is wrongly set to a range lower than the value of current drawn by the valve.

70. When the RESET button is pressed, armature A is forced against the relay core. Contacts X, Y and Z are mechanically coupled to the armature and thus they close. Contacts P and Q also change over, connecting a rectified supply (due to MR2) across the top winding of the relay, its object being to 'replace' magnetism lost by the core. When the switch is released the armature is held in contact with the core,

due to the permanent magnetism of the core. Fig 2 represents a simplified diagram of a valve under test. The cut-out itself is enclosed by the heavy black line.



TY 812 P1
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CONTACTS P AND Q ARE RESET SWITCH CONTACTS
CONTACTS X, Y AND Z ARE RELAY CONTACTS

Fig 7 - Safety cut-out. Tester No 3

Anti-parasitic oscillation precautions

71. Comparatively long grid and anode leads are used in this equipment and along with stray capacities these can constitute tuned lines having a resonant frequency in the v.h.f. spectrum. A valve having a large value of mutual conductance may be able to overcome the inherent losses associated with such a line and burst into parasitic oscillations. Stoppers have been inserted in the valve panel wiring but these can only be used in a few positions as a large number of pin combinations have to be used for one valve holder. Stopper resistors could not be tolerated in what may be the anode or grid circuit of one particular type of valve and heater or cathode of another. Oscillation is only likely to occur when the valve is being tested at or near its maximum mutual conductance.

Anti-parasitic oscillation stopper circuits

72. For the Mk 1 instrument the circuits are as follows:-

- (a) International octal base. Stoppers in the form of an r.f. choke fitted to pins 4 and 5.
- (b) British 7 pin. 75Ω resistors fitted to pins 3 and 7.
- (c) B8A. Pin 7 to earth via two $0.005\mu\text{F}$ condensers in series.
- (d) Loctal base. 75Ω resistor fitted to pin 6.
- (e) Resistors in three leads to ROLLER SELECTOR switch busbars, one of $5,000\Omega$ and two of 75Ω .

73. For the Mk 2 instrument the circuits are as follows:-

- (a) B9G: This valve holder has a 130Ω resistor in each lead to ROLLER SELECTOR switch. This resistor is in parallel with the loop, for any denomination of the roller switch, which connects all valve bases to the ROLLER SELECTOR switch. This resistor acts as a damping resistor across what may be looked on as a resonant line. Thus these lines will not oscillate.
- (b) Resistors in four leads to ROLLER SELECTOR switch busbars. One resistor of $5,000\Omega$ and three of 75Ω .

74. When a beam tetrode is being tested with a.c. voltages applied to its electrodes, a condition may arise when, due to the electrode voltages approaching zero during the a.c. cycle, the beam focusing is to some extent upset. This may give rise to reverse screen current, anode current will then rise and screen current decrease rapidly and become negative. This would give erroneous readings and, if allowed to continue, damage the valve. To overcome this a diode is placed in series with the screen supply to the valve. Under normal conditions, this will have little effect on the screen working conditions, but if there is a reversal of screen current, it will present a very high impedance and prevent the above conditions from occurring.

Valve panel and roller selector switch

75. The top panel of the instrument mounts nineteen valve holders (eighteen on the Mk 1) of different types, a five-way socket terminal board TB2, and the nine-way ROLLER SELECTOR switch SO. The valve holders are of the following types:-

- (a) British 4/5 pin, 7 pin, 9 pin and 8 pin side contact.
- (b) B3G, B7G, B8A, B9A (not in Mk 1), B8G.
- (c) B8B or B9G (American loctal).
- (d) British octal, International octal.
- (e) Hivac 4 and 5 pin.

(f) American 4 pin, 5 pin, 6 pin, small 7 pin UX, medium 7 pin UK.

These valve holders have the corresponding pin numbers wired in parallel. The five-way socket terminal board is connected directly to the tag board TB2 and provides supplies for valves with top cap or side connections. The five connected circuits are GRID 1, SCREEN, ANODE 1, ANODE 2 and DIODE 1.

76. The ROLLER SELECTOR switch carries nine spring contacts each of which can be rotated to make connection to any one of ten busbars arranged co-axially in the barrel of the switch. Thus any valve pin number can be connected to any one of the instrument circuits, as shown in Fig 2004. The rollers are held in their selected positions by leaf springs acting on the moulding escapement. The particular connection made for any one of the pin rotating contacts is indicated in the escutcheon windows by suitably engraved position markers as under:-

1	2	3	4	5	6	7	8	9
C	H-	H+	G	S	A	A ₂	D ₁	D ₂

TESTER, VALVE, AVO, CT 160

INTRODUCTION

77. The Tester, valve, Avo, CT160 is a self-contained mains-operated instrument for the simple testing of general purpose Service and commercial type valves. Heater continuity, inter-electrode insulation, anode current and mutual conductance can be quickly measured. The instrument enables static and dynamic characteristic curves to be obtained if required. The instrument may also be used as a simple 'go' or 'no go' device.

BRIEF TECHNICAL DESCRIPTION

Electrical

78. The instrument uses an a.c. testing method which eliminates the need for elaborate d.c. power packs. Full-wave and half-wave unsmoothed a.c. voltages are applied to the valve electrodes in a manner such that, when anode current and changes of anode current are measured in terms of d.c. currents, the general function of a static d.c. valve characteristic is maintained.

79. Valve electrode voltages to establish the test conditions are derived from multi-tapped transformers via calibrated selector switches. One transformer provides heater voltages, the other h.t., g.b. and backing-off voltages. Unsmoothed 50c/s a.c. is applied direct to the anode and screen of the valve under test. Unsmoothed half-wave rectified a.c. is used to fix the grid working point, to provide a grid swing and the anode current backing-off voltage to facilitate the measurement of mutual conductance.

80. A single 2.1/2 inch scale, moving-coil meter, used in conjunction with various switches in combination, provides direct readings of inter-electrode insulation or electrode currents or mutual conductances.

81. A cut-out in the form of a treble-circuit electro-magnetic relay with two of its windings energized by anode and screen currents provides protection against inadvertant or deliberate shorting of supply voltages.

82. Valve holders are provided in the valve holder panel. These holders cater for valves in current use and a nine-way rotary switch enables any one of the valve base standard pin numbers to be connected to any one of the electrode test circuits in the instrument.

Power requirements

83. The power supply required is 105-120V or 175-250V at 50-500c/s. The consumption is approximately 50VA.

Mechanical

84. The instrument consists of two major assemblies each of which is housed in one half of the suitcase-type case. The lid houses the valve holder panel which is a light aluminium plate on which the holders, rotary switch and external sockets are mounted. The remainder of the instrument, its transformers, controls, meter, etc, is in the bottom half of the case. The controls and the meter are mounted on the top panel, which is aluminium. The remainder of the components are mounted on a framework consisting of two 1/2 in. x 1/8 in. U shaped aluminium members screwed and bolted to two 1/2 in. x 1/2 in. x 1/8 in. angled sections. A pressed aluminium cabinet forms the suitcase and completes the instrument.

DETAILED TECHNICAL DESCRIPTION

Method of comparative testing (Fig 8)

85. The general function for a d.c. static valve characteristic is:-

$$I_a = f \left(\frac{V_a + \mu_1 V_{g1} + \mu_2 V_{g2}}{R_a} \right) \quad (1)$$

Where I_a = anode current

V_a = anode volts

R_a = mean slope resistance

V_{g1} = control grid voltage

V_{g2} = screen grid voltage

μ_1 = amplification factor grid/anode

μ_2 = amplification factor grid/screen

The relationship only holds under the conditions that μ_1 , μ_2 and R_a are constant over the operating region.

86. In the instrument a patented a.c. method of operation is used whereby raw 50-500c/s a.c. voltages are applied to the anode and screen electrodes. The grid conditions are established with unsmoothed half-wave rectified a.c. but the I_a is measured in terms of d.c. current. Co-relation between the a.c. and d.c. test conditions is arranged in the instrument design by maintaining the following relationships:-

$$\begin{aligned} V_a \text{ r.m.s.} &= 1.1 \text{ indicated d.c. } V_a \\ V_{g2} \text{ r.m.s.} &= 1.1 \text{ indicated d.c. } V_{g2} \\ V_{g1} \text{ (mean unsmoothed)} &= 0.52 \text{ indicated d.c. } V_{g1} \\ I_a \text{ (mean d.c.)} &= 0.5 \text{ indicated } I_a \end{aligned}$$

The manner of operation is shown in Fig 8. Included are voltage waveforms at various points as is the current waveform in the anode circuit.

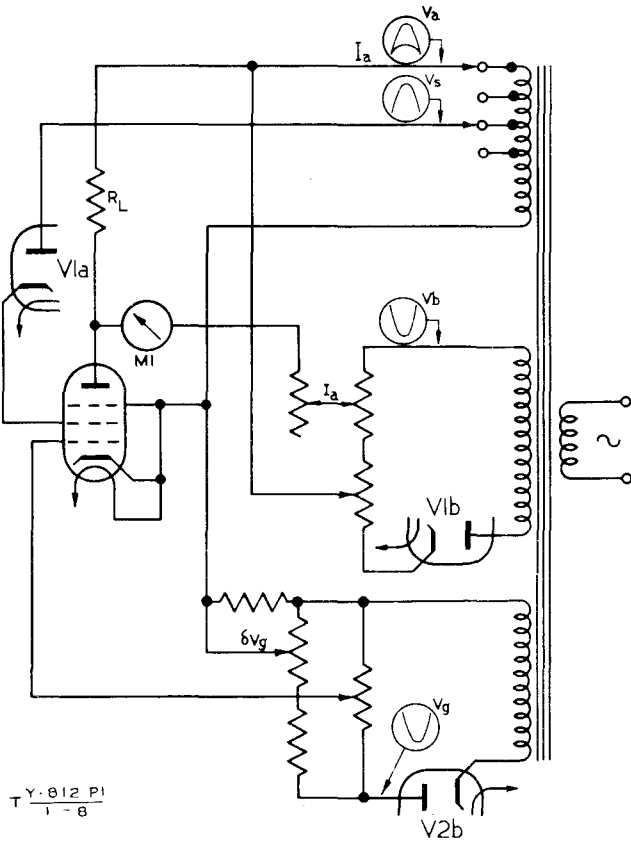


Fig 8 - Method of comparative testing.
Tester CT 160

87. The electrode voltage controls are directly calibrated in terms of d.c. voltages and provide the indicated test voltages; for example, with the ANODE VOLTS switch set at 200V we have 220V r.m.s. applied to the anode and with the NEG GRID VOLTS set at -3V the mean d.c. voltage at the control grid is -1.56V. A factor of 2 has been introduced into the meter circuit and the actual d.c. I_a flowing in the anode circuit will be half that indicated on the ANODE CURRENT controls.

88. The principles of operation of the main function of the tester, ie, the comparative testing of mutual conductance, lie in the application of anode, screen, grid and heater voltages corresponding to the working point of the valve and backing off to zero the standing anode current thus obtained. A small incremental bias is applied to the valve and the change in anode current thus obtained is a measure of the mutual conductance of the valve. This change is then compared with the correct mutual conductance to give comparative 'goodness' on a coloured scale.

89. The basic circuit used is shown in Fig 8. With the correct electrode voltages applied to the valve, the half-wave current causes a voltage drop across the resistor RL, which is sufficiently low in value (200Ω) as not to influence the characteristics. This voltage is backed-off by a voltage (V_b) of similar form from the ANODE CURRENT controls. The voltage difference across the two arms of the bridge thus formed is shown on the meter. When the difference is zero, the voltage V_b is a measure of the anode current in RL and the control V_b is thus calibrated in mA anode current. A small change in bias is then applied from control dV_g (SET mA/V) which causes an increased drop in RL, thus unbalancing the bridge. This unbalance is shown on the meter and is a measure of the mutual conductance. For a deflection on the meter of $RL \times I_a$ millivolts the mutual conductance of the valve in mA/V is $\frac{1}{dV_g}$ (volts)

90. The r.s.d. of the meter is $1.3 \times RL \times I_a$ millivolts and the scale is zoned in three colours, green indicating a good, white a failing and red a reject valve.

Method of rectifier and diode testing (Fig 9)

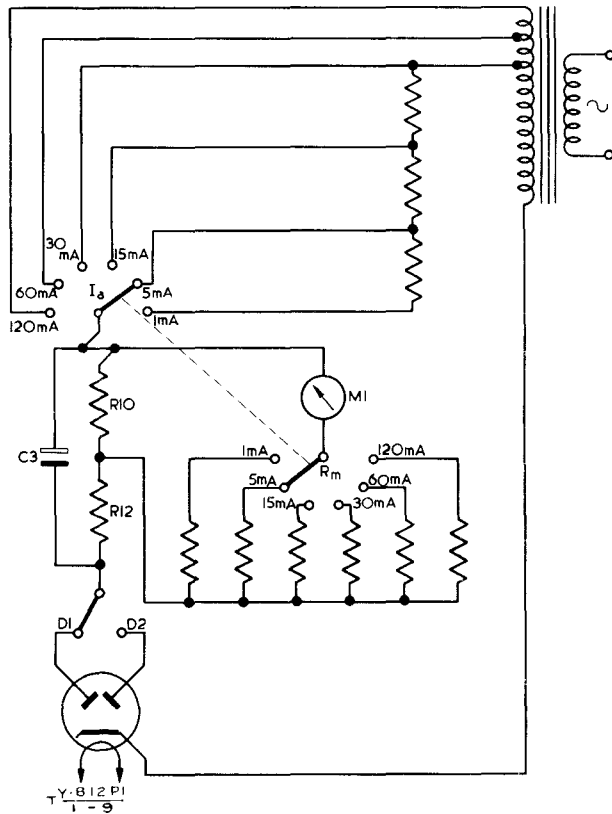


Fig 9 - Method of rectifier and diode testing. Tester CT 160

91. Rectifiers can be tested to ensure that each section will produce sufficient current under suitable load conditions. Tappings b, d and g on transformer T2 provide r.m.s. voltages of 44, 88.5 and 137.5V respectively and these are fed to the anode of the rectifier under test, which supplies the reservoir condenser, C3. The resistors R27, 28 and 29, in conjunction with resistors R10 and R12, provide six d.c. load conditions of 1mA, 5mA, 15mA, 30mA, 60mA and 120mA. The 44-volt tapping supplies the voltage for the 1mA test through R27, 28, 29, 10 and 12, for the 5mA test through R27, 28, 10 and 12, for the 15mA test through R27, 10 and 12 and for the 30mA test through R10 and 11. The 88.5V tapping supplies the voltage for the 60mA test through R10 and 12. The 137.5V tapping supplies voltage for the 120mA test through R10 and 12. Current in the load circuit is indicated by the voltage drop across R10 as read by the meter. The voltage multipliers R30 to R35 are so chosen that the meter will give a deflection in the centre of the 'green band' for a valve

passing the required load current as chosen by the inner ring of figures on the ANODE CURRENT coarse control.

92. The load figures are chosen to correspond with the maximum emission specified by the valve manufacturers, which is to be found in Table 6 of Radar and FCE Y 811 Issue 1.

93. Signal diodes are tested only on the 1mA and 5mA ranges of the load test.

Continuity and insulation test circuits

94. The unsmoothed grid voltage is used for the continuity tests. The eight test circuits are established by settings of the CIRCUIT SELECTOR SG and ELECTRODE SELECTOR SF (paras 100-106 and 108-109 refer). The positions are shown in Fig 10. There is an example for heater continuity (a), two examples of insulation test with valve cold, (b) and (c), one for heater and cathode strapped to the rest, with valve hot (d), and the heater to cathode insulation test, with valve hot (e).

Transformer assembly (Fig 2009)

95. All supplies for the instrument are derived from the transformer assembly, consisting of the heater transformer T1 and the h.t. and grid voltage transformer T2. The mains tappings into T2 provide an auto-transformer control for the input to T1.

96. T2 has three secondary windings which supply:-

- (a) 50V a.c. ANODE CURRENT backing-off voltage
- (b) 55V a.c. grid working voltage circuit
- (c) 12 tappings to provide anode and screen volts within the range 0-400 as selected by ANODE VOLTS and SCREEN VOLTS switches SD and SE, respectively.

97. Secondary tappings of T1 provide the heater volts in two ranges 0.625-117V and 1.4 to 80V. This changeover is effected by SC, a small toggle switch, and the selection of voltages by the HEATER VOLTS switch SB. The voltages in the range 0.625-117V are obtained with the auto-transformer input to T1 set at 200V on T2 and the voltages in the range 1.4 to 80V are obtained with this input set to 230V. Selected tappings only are used for this second range, These are 1.25, 2.5, 4.0, 5.0, 6.3, 11.0, 13.0, 16.0, 25.0, 30.0, 40.0, 48.0, 70.0, which have all been multiplied by the factor of 1.15 to give the voltages in the second range.

Set ~ circuit

98. Correct calibration of the electrode voltage controls is ensured in the setting-up procedure by the SET ~ circuit. With the CIRCUIT SELECTOR switch in the SET ~ position the meter is connected across the grid voltage circuit to earth and the mains selector adjusted for full scale deflection, ie, at the red mark in the centre of the SHORT mark on the insulation scale.

Circuit control arrangements

99. The instrument switching arrangements are complex because of the multiplicity of tests that have to be carried out on the varied valve types. It should be noted that the detached contact system for switches has been used in the circuit diagram (Fig 2007).

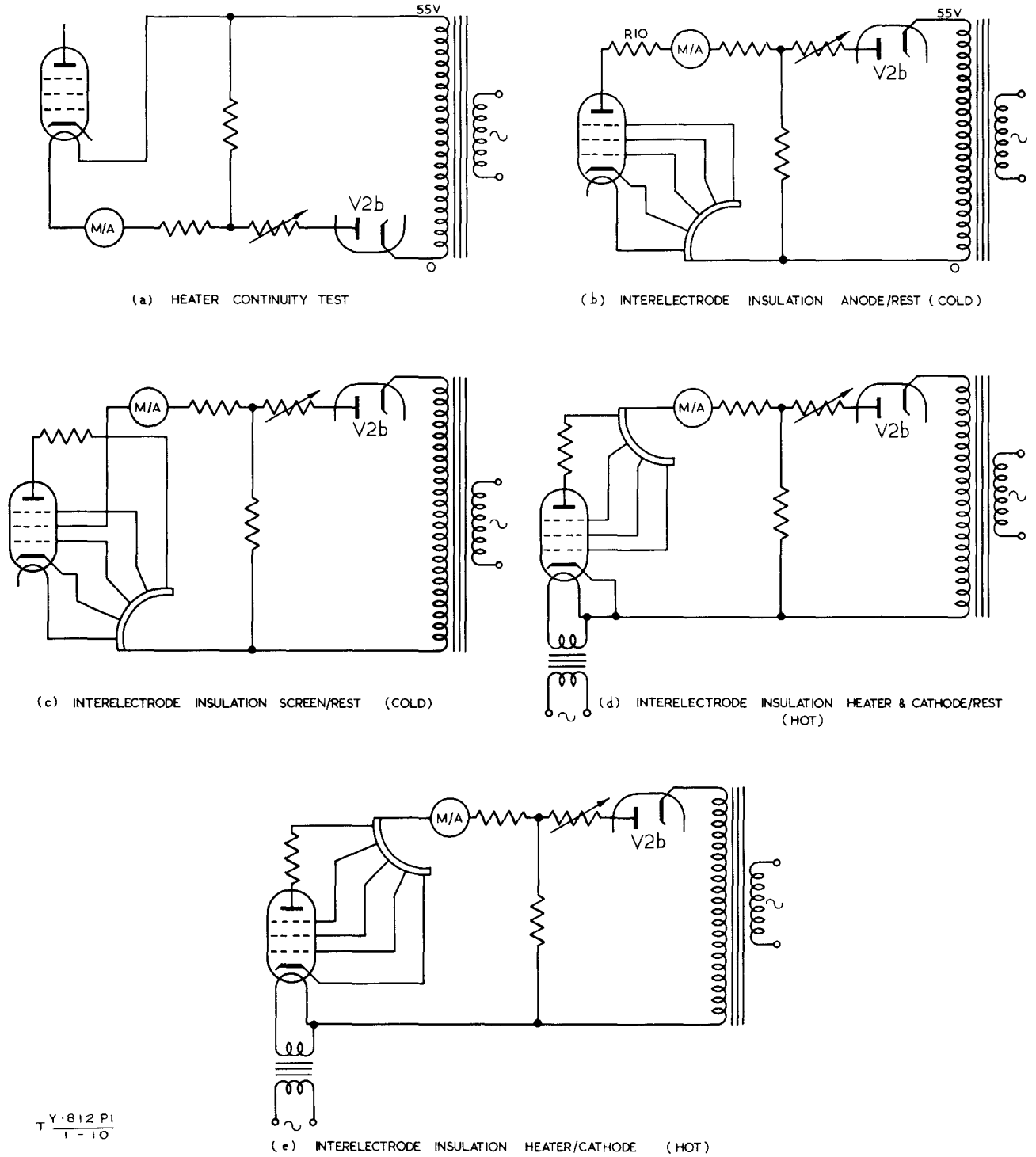


Fig 10 - Continuity and insulation test circuits. Tester CT 160

Circuit selector switch SG

100. The CIRCUIT SELECTOR switch has eight positions with three wafers each carrying eighteen contacts, only sixteen of which are used in conjunction with two wiper arms on each wafer. The functions of the wafers are:-

- SG aa controls connections to the grid
- ab controls connections to the screen
- ba controls connections to the anode circuits
- bb) controls connections to the meter
- ca)
- cb controls heater voltages connections

101. In position 1, SET ~, the meter is connected across the grid working voltage supply to check this for a correct setting. If this supply is correct then all other supplies in the instrument are correct. All other connections to this switch are in a blank position.

102. Position 2, H CONT, connects the meter in series with the heater and limiting resistors across the grid voltage supply, to check the continuity of the heater.

103. Positions 3, 4 and 5, A/R, S/C and C H/R, respectively, are all positions for insulation tests. In each case the meter is connected in series with the first named electrode, the remainder strapped together and the grid working voltage. Condensers C1 and C2 prevent spurious readings on the insulation ranges when the instrument is used at high mains frequencies.

104. Position 6, C/H. In this position of the switch the insulation between cathode and heater is checked with the heater hot. To perform this test the ELECTRODE SELECTOR switch SF must be in position 1, C/H.

105. Position 7, TEST, enables the mutual characteristic tests to be carried out in conjunction with switches SD, SE, SH, NEG GRID VOLTS CONTROL, RV3, SET mA/V, RV2, and the ANODE CURRENT fine control, RV1. The anode supply is now connected via SG(ba), R10 and SF(bb) to the anode 1 or anode 2 circuits. The meter is connected by SG (bb) and (ca) to the backing-off circuits. SG (aa) connects the grid to the NEG GRID VOLTS control and SG (cb) the heater volts supply.

106. Position 8, GAS, SG (aa) connects two resistors R7 and 8 in series with the grid of the valve and SG (bb) and (ca) connect the meter across R8. The meter is directly calibrated in $\mu\text{A.Ig}$ and this reads grid current.

Anode current switch SH and fine control RV1

107. The switch has six wafers but only three sliders. Reading from the front panel the sliders are on wafers a, c and d. The resistors R15 - 23 which form the potential divider across the backing off voltage are between wafers a and b. The remaining resistors between wafers e and f, ie, R24 - 26, R27 - 29, R30 - 35, are meter multipliers when on mutual conductance tests, load resistors for the rectifier under test, and meter multipliers when testing rectifiers, respectively.

Dependent upon the position of SH the backing-off voltage is applied to the meter to produce a zero. RV1 is in series with the potential divider R15 - 23 and provides a fine control of backing-off voltage, which is supplied by the 50V winding on the h.t. transformer T2.

Electrode selector switch SF

108. This is a double-sided twelve-contact wafer switch with six contacts on either side of each of the three wafers. It has five positions, marked C/H, A1, A2, D1 and D2. It is used when testing valves with more than one anode. In position 1, C/H, SF(ca) connects the cathode to the remaining electrodes with the exception of the heater. The grid working voltage is then applied to the circuit to test the cathode/heater insulation with the valve hot.

109. In the remainder of the positions meter multipliers are selected by SF(aa), (ab) in conjunction with SH as is the amount of backing-off voltage. The anode not under test in positions A1 and A2, is connected via SF(ab) and a limiting resistor R11 to the screen voltage supply. When rectifiers are being tested, however, the anode not under test is left floating and R12 is put in series with R10 via SF(ba) in the anode circuit under test.

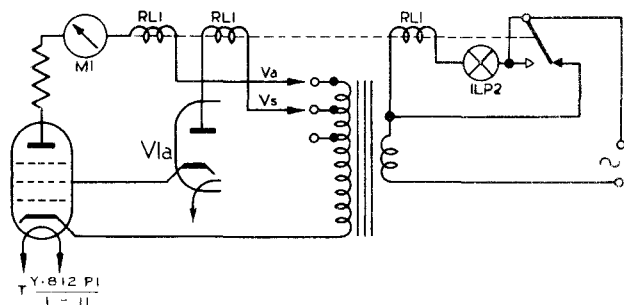
Grid voltage supply and control

110. The grid voltage is supplied by the 55V winding on T2 and is rectified by V2(b). The positive side of the output is earthed and hence a negative potential is applied to the grid of the valve under test controlled by the NEG GRID VOLTS, RV3. The SET mA/V control, RV2, provides a small incremental change of grid voltage to enable the test to be made on mutual conductance.

111. The cathode of the other diode V2(a) is taken to the 60V tapping on transformer T1, from which 66V r.m.s. is obtained. The purpose of this diode is to apply a negative voltage to the grid during the half cycle when the anode and screen are negative and hence ensure the valve does not, under any circumstances, draw grid current.

Safety cut-out (Fig 11)

112. From Fig 11 it can be seen that the overload relay RL1 consists of three coils:-



- (a) One in the anode voltage supply.
- (b) One in the screen voltage supply.
- (c) One connected in series with the primary of T2 if an overload occurs. This is the 'audible warning' coil.

Fig 11 - Safety cut-out. Tester CT 160

Under normal test conditions sufficient current will not flow in the anode or screen circuits to

operate the relay and the contacts will remain closed.

113. Should a short-circuit develop in either the valve or its associated sockets, with normal test voltages applied, the relay will operate with the following results:-

- (a) Anode and screen voltages drop to zero
- (b) The 'audible warning' coil chatters and a red warning lamp illuminates the meter scale from behind.

114. The cut-out will NOT operate when heavy currents of a d.c. nature occur in the valve anode circuit and thus it will not protect the meter if the ANODE CURRENT controls are set to a lower range than the value of current drawn by the valve. Normal working cannot be restored until the instrument has been switched off, the fault removed, and the instrument switched on again.

Anti-parasitic oscillation precautions

115. The problem of self oscillation can occur with high slope valves, which have a large enough value of mutual conductance to overcome the inherent losses of a tuned line. These tuned lines are formed by the connecting leads on the valve holder panel and the stray capacities and the oscillations would be in the v.h.f. spectrum. This problem has been overcome by having the connecting leads in loops of approximately the same length and configuration. These loops are closed on themselves via a connector loaded with ferrox-cube beads to give a high loss, so lowering the 'Q' of the line and making oscillation virtually impossible.

116. When a beam tetrode is being tested with a.c. voltages applied to its electrodes a condition may arise in which, due to the electrode voltages approaching zero during the a.c. cycle, the beam focusing is, to some extent, upset. This may give rise to reverse screen current, anode current will then rise and the screen current decrease rapidly and become negative. This would give erroneous readings and, if allowed to continue, damage the valve. To overcome this a diode is placed in series with the screen supply to the valve. Under normal conditions this will have little effect on the screen working conditions, but if there is a reversal of screen current it will present a very high impedance to this reversed current and prevent the above conditions from occurring.

Valve holder panel and roller selector switch

117. The valve holder panel, housed in the lid of the instrument, mounts twenty-two valve bases, a nine-way socket terminal board, anode links LK1 and LK2 and the nine-way ROLLER SELECTOR switch SJ. The valve holders are of the following types:-

- (a) British 4/5 pin, 7 pin, 9 pin, and 8 pin side contact.
- (b) B3G, B7G, B8A, B9A, B9G.
- (c) B8B or B8G (American octal).
- (d) British and International octal.

R E S T R I C T E D

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- (e) Hivac 4 and 5 pin.
- (f) American 4 pin, 5 pin, 6 pin, small 7 pin Sm7, medium 7 pin UX7.
- (g) Disc seal and flying lead.

118. These valve holders have the corresponding pin numbers wired in parallel. The nine way socket terminal board is connected to the sliding contacts on the ROLLER SELECTOR switch and provides supplies for valves with top cap or side connections. All the nine test circuits are connected to this tag board.

119. The ROLLER SELECTOR switch carries nine spring contacts, each of which can be rotated to make connections to any one of nine busbars arranged co-axially along the barrel of the switch. Thus any valve pin number can be connected to any one of the instrument circuits as shown in Fig 2007. The rollers are held in their selected positions by leaf springs acting on the moulding escapement. The

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particular connection made for any one of the pin rotating contacts is indicated in the escutcheon windows by suitably engraved markers as under:-

1	2	3	4	5	6	7	8	9
C	H-	H+	G	S	A	A ₂	D ₁	D ₂

120. The separate cable-forms lying side by side across the instrument ensure that the grid circuit and its associated wiring is kept well apart from the h.t. wiring to prevent the transference of energy from one circuit to the other at high mains frequencies.

57/Maint/5921

END OF PART 1