THE "AVO"

VALVE CHARACTERISTIC METER

Mk. III.

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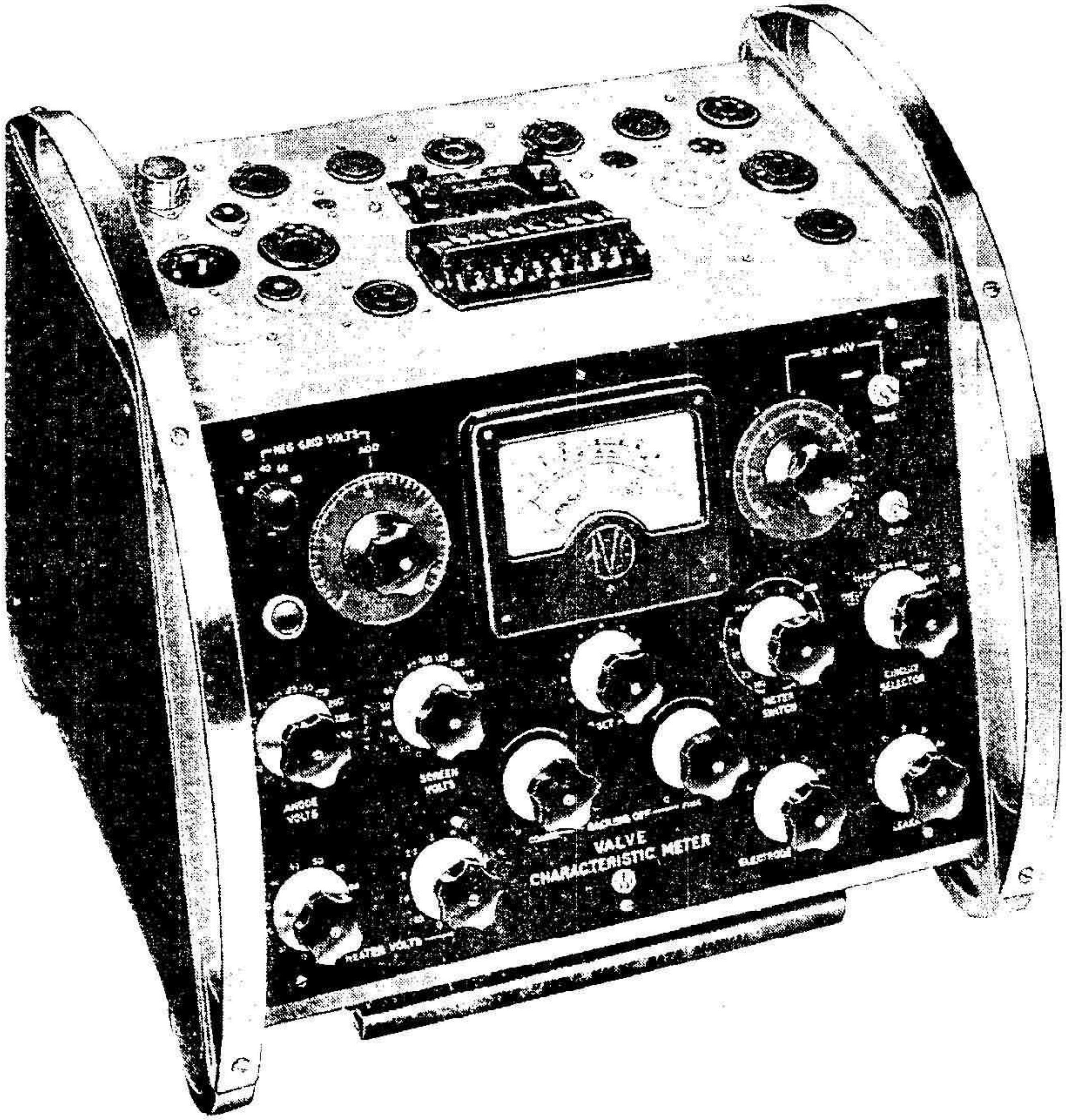

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Introduction

to

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The problem of designing a Valve Testing Instrument capable of giving a true and comprehensive picture of the state of any valve, has always been one of considerable magnitude, increasing in complexity as new valve types are brought into general use.

For a quick general purpose test necessitating a minimum of time and technical effort a mutual conductance figure will give an adequate idea of a valve's usefulness, and the original "AVO" Valve Tester was designed to test the efficiency of valves on this basis.

Whilst a Valve Tester must, of necessity, be accompanied by a data book correlating the results of the Tester with the condition of the valve in question, a purely empirical figure, if used as a standard, will always give rise to doubts in the mind of the operator. The instrument should therefore, produce a figure which can be compared with some standard quoted by the valve manufacturer, if the operator is to use his instrument with confidence. For this reason the "AVO" Valve Tester used the static zero bias mutual conductance figure as a basis of comparison, this figure being at that time almost universally quoted by the valve manufacturer.

In order to reproduce this standard correctly, it was also necessary to reproduce the stated values of DC anode and screen voltage, a matter of some considerable difficulty when it is realised that for any stated condition of anode and/or screen volts the corresponding electrode currents can vary over very wide limits, and in the case of valves of low initial anode current and high slope, the actuation of the control which produces the milliamp-per-volt reading might easily double the anode current flowing. With DC methods of testing the inherent internal resistance of the rectifying circuits used could be such as to give regulation errors which could cause results to be meaningless unless complicated thermionic stabilising circuits and a vast array of monitoring meters were used in all voltage supply circuits. Such complications would not only render the Tester of prohibitive price and size, but would considerably increase the complication of operation for the non-technical user.

The problem was overcome by the introduction of the AC method of operation (Patent No. 480752) by which means the necessary DC test conditions were correctly simulated and a true mutual conductance figure produced by the application of AC voltages of suitable amplitude to all electrodes. This enormously simplified the power supply problem, rendered regulation errors negligible, and obviated the necessity for voltage circuit monitoring. The "AVO" Valve Tester thus fulfilled normal testing needs for a long period.

During recent years, however, electronic techniques have become much more precise and the nature and multiplicity of valve types have continuously increased. The zero bias mutual conductance figure is seldom quoted by the valve manufacturers, who, usually now publish the optimum working point mutual conductance and voltage figures, and in a large number of cases give full families of curves, from which, precise operation, under a variety of working conditions, can be judged. To cater for present day requirements therefore, a valve testing device should not only be capable of producing a working point mutual conductance figure at any reasonable value of anode, screen or grid voltage recommended by the manufacturers, but should also be capable, if necessary, or reproducing any one of the mutual characteristics associated with the valve in question. The instrument thus has

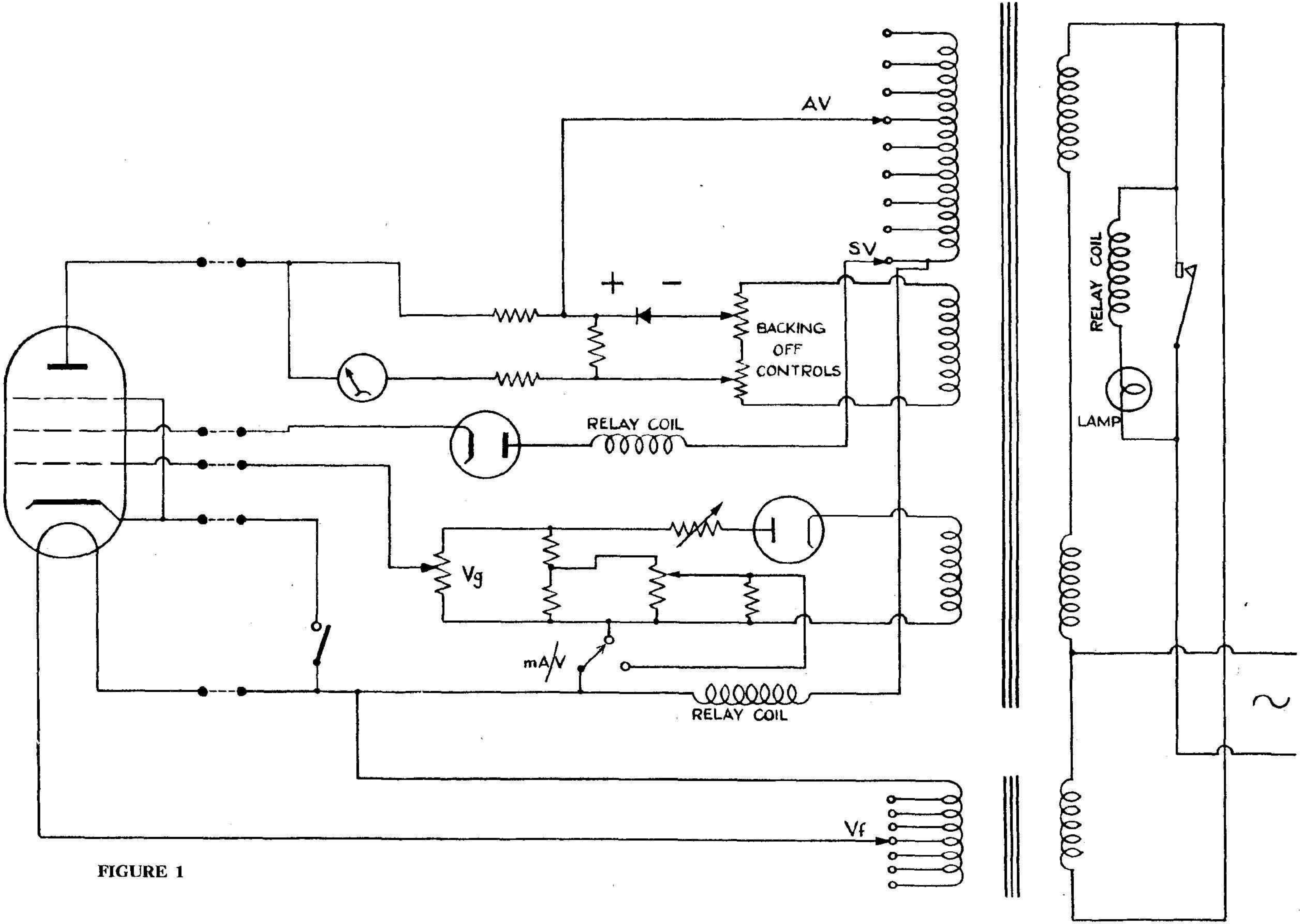

AV
SV
+
-
BACKING OFF CONTROLS
RELAY COIL
Vg
mA/V
RELAY COIL
Vf
RELAY COIL
LAMP

FIGURE 1

to simulate the performance of a comprehensive valve measuring set-up of laboratory type and yet, at the same time, be sufficiently cheap and simple to cater for the needs of the comparatively inexperienced radio test assistant. It is obvious that the very much wider application of an instrument of this class, would render the regulation difficulties, already referred to, much more critical.

Investigations were, therefore, put in hand to see whether the AC test method would reproduce DC conditions not only in respect of the mutual conductance figure taken at a single discrete point, but at all points on all characteristics from zero bias to cut off. In other words, it was necessary to determine whether the general function for a DC static valve characteristic

$$Ia = f\frac{(Va + \mu_1 Vg_1 + \mu_2 Vg_2)}{Ra.}$$

would hold when Ia was measured in terms of DC current, but when Va, Vg_2 and, if necessary, Vg_1, were replaced by 50 cycle AC voltages of suitable magnitude and phase. It was eventually found that a complete co-relation between these two sets of conditions was held when the grid voltage took the form of a sinusoidal wave form with the positive half cycle suppressed (in other words, rectified but completely unsmoothed AC), and the following relationships were maintained:—

$$Va\ RMS = 1.1\ Va \text{ indicated DC}$$
$$Vg_2\ RMS = 1.1\ Vg_2 \text{ indicated DC}$$
$$Vg_1 \text{ (mean unsmoothed)} = 0.52\ Vg_1 \text{ indicated DC}$$
$$Ia \text{ (mean DC)} = 0.5 \text{ indicated } Ia$$

From the above conditions, therefore, the required relationships were obtained which formed the basis of operation of the Valve Characteristic Meter (Patent No. 606707).

Such an instrument, whilst retaining the advantages of simplicity, size and reasonable price, resultant upon the elimination of complicated regulated DC supply systems and universal monitoring, would have the inherent regulation easily obtained from a well-designed AC transformer. It would enable a valve to be checked at any point on any one of its many mutual characteristics and if necessary would allow a full family of characteristics to be drawn.

The basic method of characteristic checking

The fundamental circuit of operation of the instrument is shown in Figure 1. As in the original Valve Tester, the process of obtaining a direct reading mutual conductance figure is simplified by the introduction of a backing off circuit, which balances out the deflection due to the standing anode current at the desired test conditions prior to the measurement of mutual conductance. It will be noticed that the current flowing in this backing off circuit is similar in wave form, but precisely opposite in phase to the anode current, this eliminating any indesirable ripple that could otherwise become apparent when the meter, after backing off, was set to a sensitive range. To facilitate the measurement of mutual conductance of high slope/short grid base valves and valves requiring a long heater stabilising period, two distinct methods of measurement have been incorporated.

The basic method of checking diodes and rectifiers

Any simple emission test at low applied voltage must necessarily give rise to a purely empirical figure for the valve in question, which cannot necessarily be correlated with any one of the maker's characteristics and which, owing to the fact that it relates to the lower bend portion of the rectifier characteristic may vary very widely for any given type of valve.

The important function of a rectifying valve is that it will, under suitable reservoir load conditions, produce sufficient current to operate the apparatus which it is intended to supply. This fundamental requirement, therefore, is the basis of rectifier testing in the Valve Characteristic Meter. A sufficiently high AC voltage is applied to operate the valve above the bend in its characteristic, and to ensure that its internal voltage drop is negligible. With a suitable reservoir condenser in circuit, the DC load is adjusted to correspond to a number of DC current conditions, i.e. 1mA, 5mA, 15mA, 30mA, 60mA, 120mA and 180mA. The actual current flowing in the load circuit is then indicated on a meter shunted to correspond with the DC load required. The meter reading will then indicate the comparative efficiency of the valve on the basis of the required DC load. Each half of a full wave rectifying valve is tested separately thus enabling the two halves to be checked for matching and any tendency to produce hum by partial half waving to be indicated.

The pre-determined load figures are chosen so that they not only give a sufficiently wide range of currents to cater for the normal requirements of electronic apparatus, but also correspond to the DC maximum emission figures usually quoted by manufacturers in their rectifying valve data.

Signal diode valves are similarly tested, but usually these loads at the 1mA or 5mA load positions, being normally more than sufficient to cover the rectified signal current that would be obtained. The basic operating circuit of the diode and rectifier system is shown in Figure 2.

Insulation Testing

To cover all eventualities, three distinct forms of insulation measurement are catered for in the Valve Characteristic Meter. Measurements are taken with DC applied voltages, and direct indication of the insulation value in megohms is shown on the meter scale. As an initial test, prior to the application of operating voltages to the valve, the rotation of a switch enables the insulation figure to be shown, which occurs between each of the valve

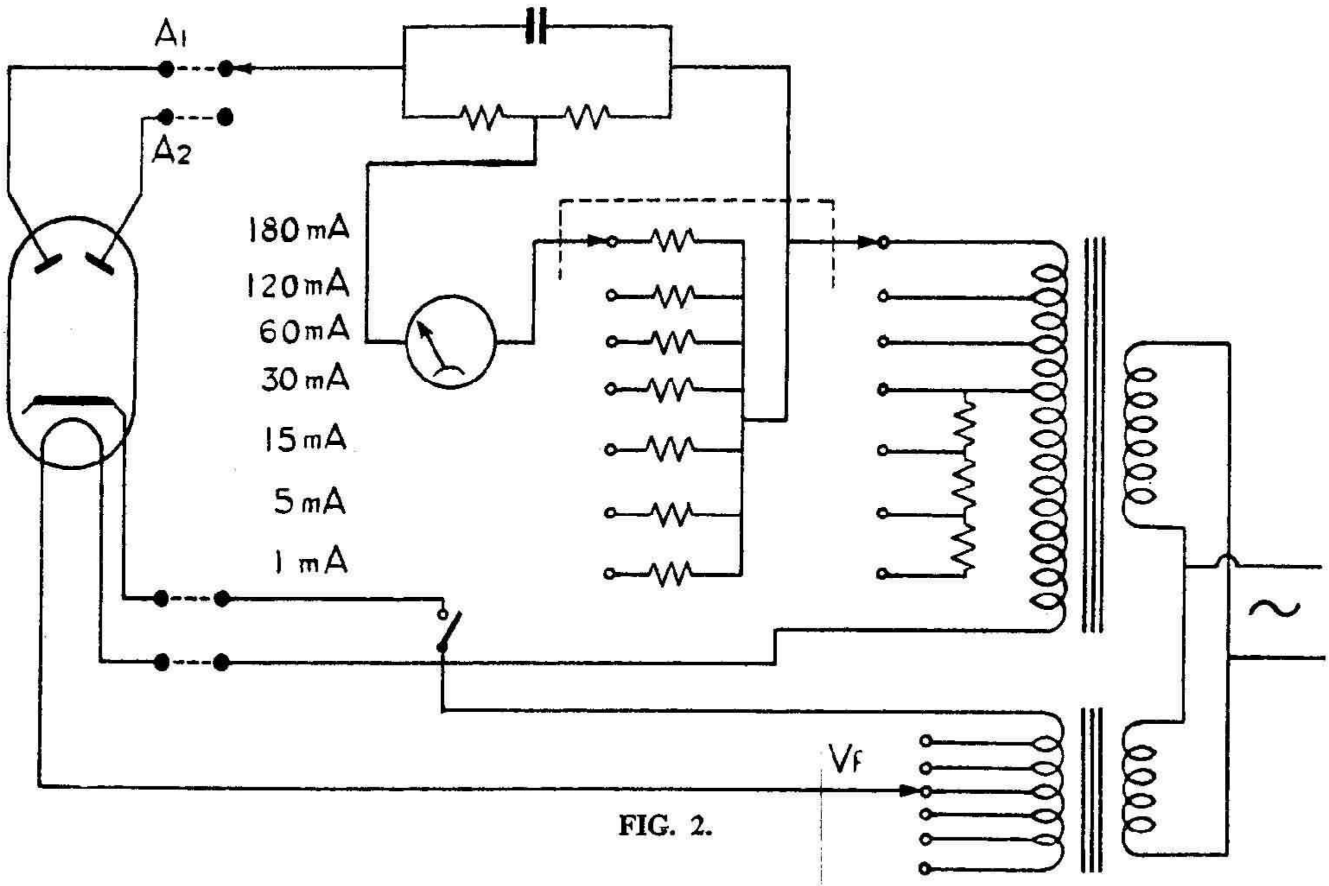


FIG. 2.

electrodes taken in order and all the others strapped together. The denomination of the electrodes between which any breakdown exists will thus be automatically indicated and further, the continuity of the heater circuit is shown as a zero resistance at the heater (H) position of the switch.

With the application of heater voltage to directly heated valves, electrode expansion may be sufficient to cause a breakdown between the heater and an adjacent electrode. In the same manner cathode distortion may occur in indirectly heated valves causing similar breakdowns. To show up this condition a test circuit is provided indicating the insulation resistance between the heater and cathode of a valve and all other electrodes strapped when heater voltage has been applied.

Finally the very important factor of heater to cathode insulation when the heater is hot can be tested, the insulation again being shown directly in megohms, the usual cathode to heater connection being opened for this purpose and the applied voltage being in such a direction as to make the cathode negative with respect to the heater, thus avoiding false indications of insulation resistance due to electrode emission.

Protective relay

To prevent damage to the internal components of the valve characteristic meter due to inadvertent or deliberate shorting of the electrode voltages, a protective relay is incorporated which operates when damaging overloads of alternating current are taken from either the anode or screen voltage sources. The relay carries three windings, one in each of the two high tension supplies, the remaining winding being a " hold-off " coil. Operation of the relay connects a high resistance lamp in series with the transformer primary winding whilst simultaneously a red warning indicator is illuminated behind the transparent meter scale and aural warning given. This operation places the instrument in a safety condition and normal working cannot be restored until the instrument has been switched off, the fault removed and the instrument switched on again. The relay is entirely self-setting and in consequence no reset mechanism has been incorporated.

NOTE: *The relay does not protect the valve when incorrect heater voltages are applied. It must also be stressed that the relay will not operate on the passage of normal heavy current of a DC nature occurring in a valve anode circuit, and it will not protect the movement if the latter is wrongly set on a range too low to accommodate the current passing. This problem can only be dealt with by ensuring that the movement is always set to its maximum current range when the magnitude of the expected current is unknown,*

THE VALVE PANEL AND SELECTOR SWITCH

The Valve Panel comprises 19 valve holders of the following types :—English 4/5 pin, 7 and 9 pin, 8 pin side contact, B7G, B8A, B8B, (or B8G) (American Loctal), B9A, B9G, Mazda Octal, B3G, 4 and 5 pin Hivac: American-4, 5, 6 and small 7 pin UX, medium 7 pin UX, and Octal. Provision is made by means of plug-in adaptors to cater for newly introduced valve bases. The valve holders are all wired with their corresponding pins, according to the standard pin numbering, in parallel, i.e., all pins number one are wired together, all pins number, two, and so on. This wiring combination is associated with the well-known " AVO " Multi-Way Selector Switch which enables any one of the nine standard pin numbers to be connected to any one of the electrode test circuits in the Valve Characteristic Meter, thus enabling any electrode combination to be set up for any normal valve holder.

It will be seen that the Selector Switch comprises nine thumb control rollers, numbered from left to right 1—9. This numbering appears on the moulded escutcheon immediately behind the rollers and corresponds to the valve pins in the order of their standard pin numbering. Thus valves with any number of base connections up to nine can be accommodated. Further, to accommodate top cap and other external valve connections a socket panel is provided with nine sockets marked G1, S, A1, A2, D1, D2, C, H—, H+, the markings corresponding to the valve electrode connections which are made externally to the valve.

Rotation of the rollers by the finger rim provided will reveal that each roller can be set in any one of ten positions, the setting in question being indicated in the window opening at the front of the escutcheon. The ten positions on the roller are marked as under:—

1	2	3	4	5	6	7	8	9	0
C	H—	H+	G	S	A	A2	D1	D2	—

The numbers are provided for ease of memorising and noting base combinations, but the corresponding electrode denominations are shown by the letter appearing in the escutcheon window immediately underneath the number, thus:—

(1) C corresponds to Cathode, or to an electrode normally connected to cathode e.g., G3.

(2) H— ,, ,, Heater normally Earthy or connected to negative L.T. in the case of a battery valve.

(3) H+ ,, ,, the other Heater connection or centre tap.

(4) G ,, ,, Control Grid

(5) S ,, ,, Screen Grid or g_2.

(6) A ,, ,, normal anode of single or multiple valve. In the case of an Oscillator mixer valve, A represents the Oscillator anode.

(7) A2 ,, ,, second anode of double valves, and in the case of Oscillator mixer valves, the mixer anode.

(8) D1 ,, ,, the first diode anode of half and full wave signal diode and rectifier valves, diode and rectifier/amplifier combinations.

(9) D2 ,, ,, the second diode anode of signal diode and rectifier valves, diode and rectifier/amplifier combinations.

(0) — ,, ,, a disconnected valve pin or to a pin upon which an internal electrode is anchored. Such pins are marked "I.C." in manufacturers' literature, or by an asterisk (*) in the "AVO" valve data manual. This switch position leaves the particular valve pin completely disconnected.

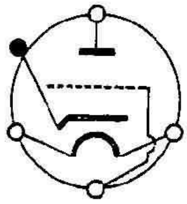
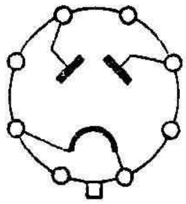
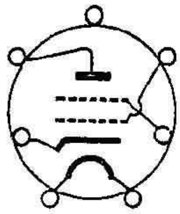
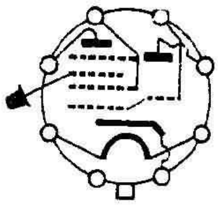
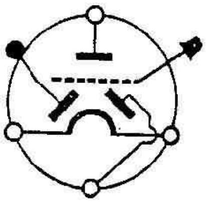
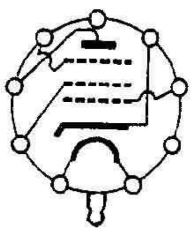
NOTE: *Some instruments are fitted with this roller position marked* $\frac{0}{E}$

This marking is synonymous with $\frac{0}{\_\_}$

Procedure for setting up valve base connections

The standard procedure for setting up a valve ready for test is as follows. From some suitable source i.e. "AVO" Valve Data Manual or Handbook, Valve Manufacturer's Data Leaflet or published manual of Valve Data, determine, the pin basing connections for the valve, in order of their standard pin numbering. Rotate the rollers of the Selector Switch until the set up number or electrode letter combination appears in the window reading from left to right in order of the standard pin numbering. In the case of valves having less than nine pins, the free rollers on the right of the set up combinations corresponding to non-existent valve electrodes should be set at $\underline{0}$. When the valve is inserted in the appropriate valve holder, use the universal top cap lead to connect any top cap or side connection on the valve to its appropriately marked socket, on the Socket Panel immediately behind the Selector Switch. Note that the loctal valve holder having only eight normal pins has its centre lug connected to the ninth roller (corresponding to pin No. 9) to accommodate valves which have a cathode connection made to this lug.

The accompanying examples show how to correlate the pin basing data and the equivalent set-up combination for a number of valves in common use.

Valve Type	*Set up Number*	*Base Diagram*
1. Osram MH4 indirectly heated triode. British 5-pin base.	6 4 2 3 1 0 0 0 0 A G H— H+ C — — — —	
2. Osram U50 full wave rectifier directly heated. Octal base.	0 2 0 8 0 9 0 3 0 — H— — D1 — D2 — H+ —	
3. Mullard PenA4 indirectly heated output pentode. British 7 pin base.	0 4 5 2 3 1 6 0 0 — G S H— H+ C A — —	
4. American 6K8 indirectly heated frequency changer. Octal base.	0 2 7 5 4 6 3 1 0 — H— A2 S G A H+ C — Top Cap G1.	
5. Mullard TDD2A battery double diode triode. British 5-pin base.	6 8 2 3 9 0 0 0 0 A D1 H— H+ D2 — — — — Top Cap G1.	
6. Mullard EF50 indirectly heated HF pentode. B9G base.	2 5 6 1 0 1 4 0 3 H— S A G 3 — C G — H+	

Provision for New Valve Bases

To cover the possibility of the introduction of new valve bases not provided for on the standard panel and also the introduction of valves which may necessitate special conditions associated with standard valve holders, a plug-in adaptor is available which enables many non-standard valve holders to be combined in this adaptor and plugged into the octal or other suitable base on the Valve Characteristic Panel. These adaptors are available for bases not included on the Valve Panel, and also with a blank valve holder mounting panel in which can be mounted the user's own valve holder if he requires any special arrangement for which we have not catered.

The Prevention of Self Oscillation of valves under test

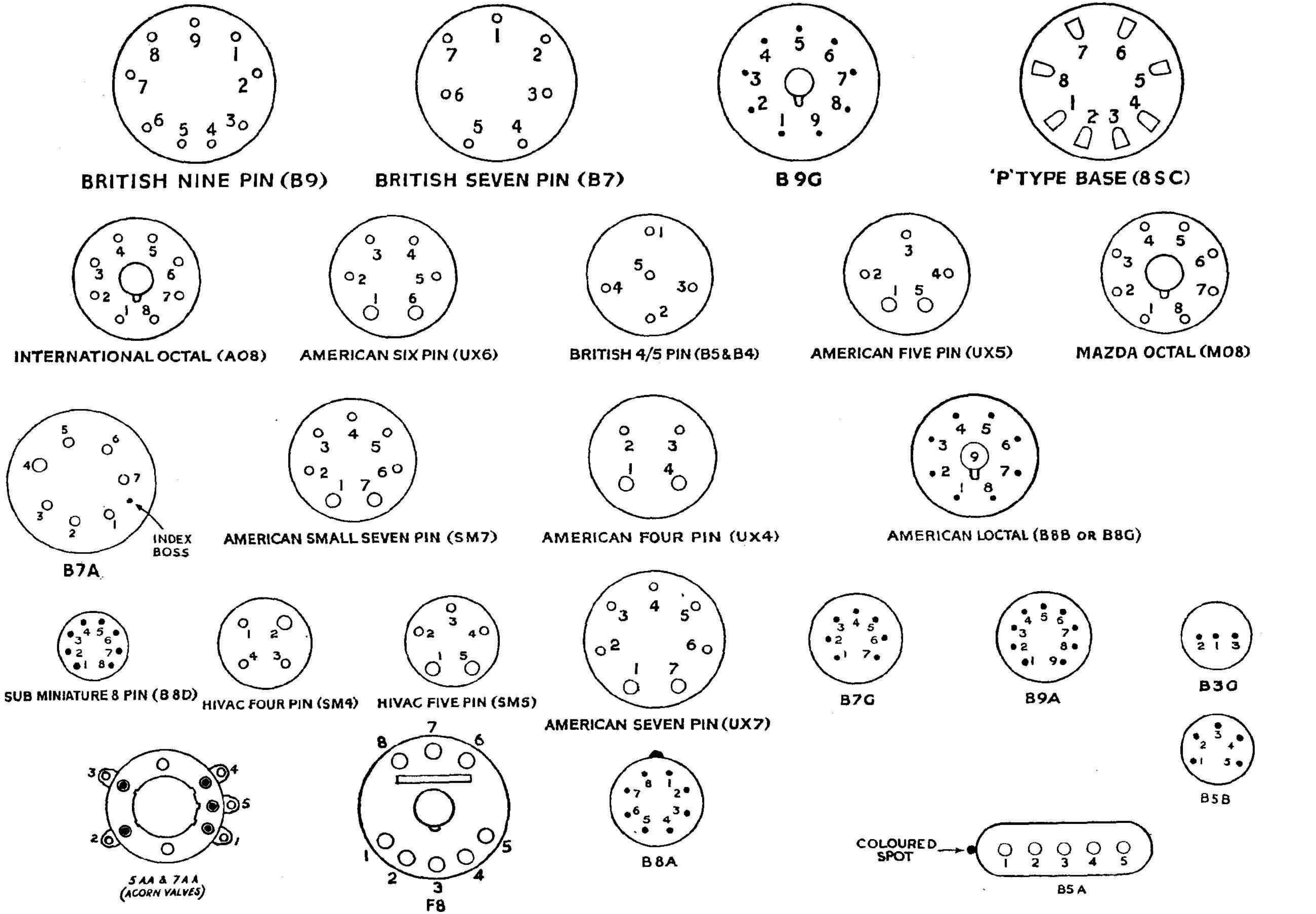
It will be realised that the length of wiring and its associated capacity, connected to the grid and anode pins of any one of the valve holders, can constitute a tuned line corresponding to a high resonant frequency often of the order of 100 megacycles per second or higher. A number of modern valves have sufficiently high slope to overcome the inherent losses associated with such a tuned line, and are, therefore, capable of bursting into oscillation at a frequency determined by the constants of their associated valve holder wiring when being tested at or near their maximum working slope. It is quite obvious that in order to test a valve some wiring must exist between the valve holder and test circuit. Further, since a multiple test panel is desirable to obviate the necessity of a vast number of separate plug-in units, the total amount of wiring associated with any one valve holder must be a considerable number of inches in length. It is almost impossible to increase the effective resonant frequency of the lines thus produced to such a high value that no normal valve will oscillate therewith. The only alternative is to render the line of comparatively high loss and in extreme cases to stopper the valve in question right on top of its anode and/or grid connection. Unfortunately, however, since a very large number of pin combinations have to be accommodated in any one valve holder the presence of such a resistance in say a heater or cathode circuit could give completely erroneous results, and this stoppering system could therefore only be very sparsely used.

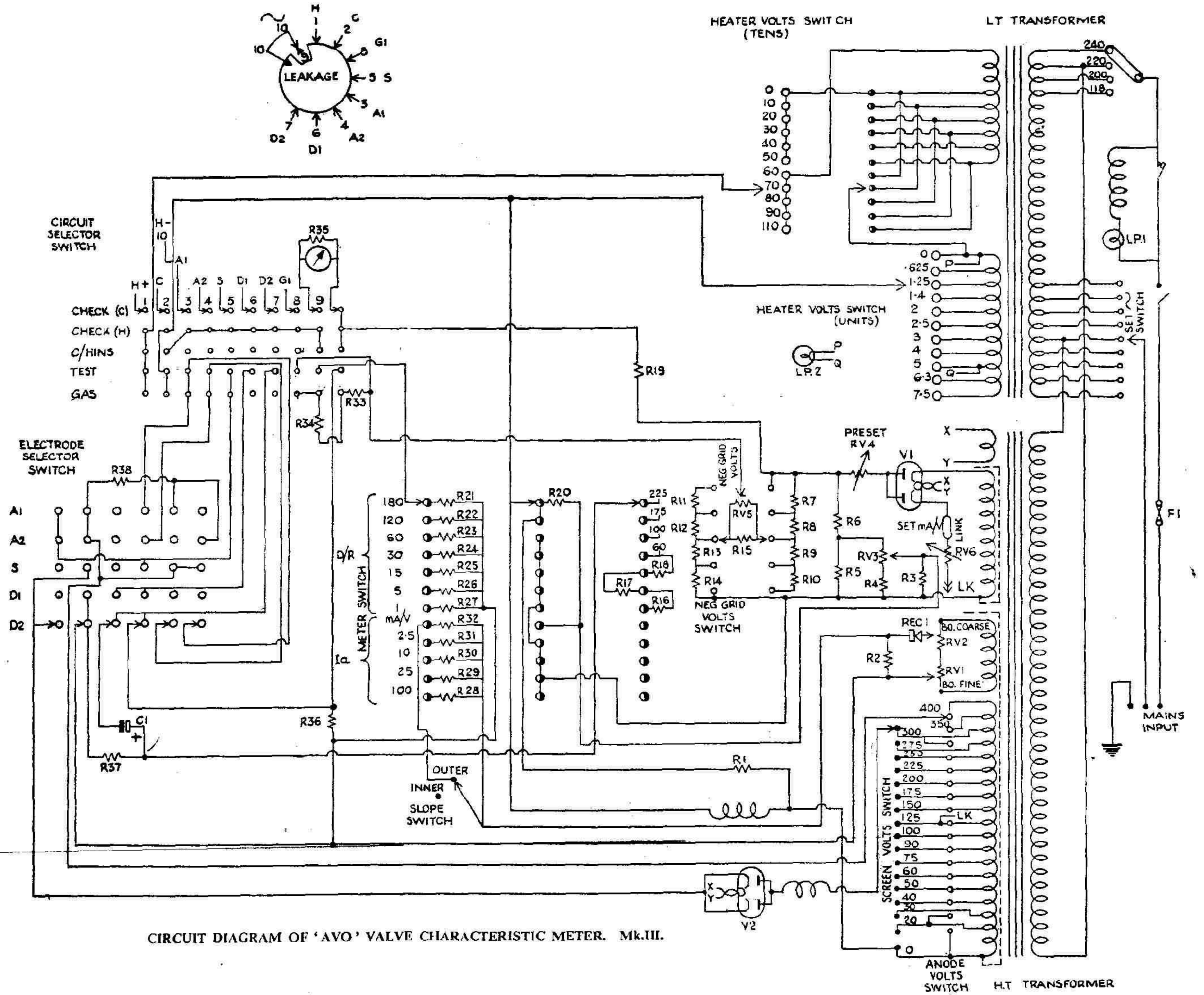
The problem of self oscillation has been almost completely eliminated in the " AVO " Valve Characteristic Meter Mark III, by wiring the Valve Holder Panel in connection loops of predetermined lengths, so that any valve inserted would tend to oscillate at a definite frequency dependent on the loop lengths. These separate inter-connection loops are then loaded with ferrox cube beads so that oscillation cannot occur when testing valves with conventional characteristics, irrespective of the Valve Holder and pin combination used.

In certain circumstances where a newly introduced valve of high efficiency is likely to be tested in any quantity and shows signs of oscillation, the separate valve holder adaptor can be employed with considerable advantage. By this means a valve holder can be stoppered to the maximum extent necessary for the valve in question without references to any other valves that may be incorporated therein, for when other types of valve are likely to be used, the adaptor can be set aside and the valve panel used normally. It must be stressed that this oscillation is unlikely to occur where the valve is tested at anode currents lower than normal, or at a point on its curve which renders its mutual conductance low. Were a purely empirical method of testing employed in the Valve Characteristic Meter, therefore, the problem would in all probability not arise, but since every effort has been made to actually test the valve under its correct operating conditions of current and voltage, then it is on this account working at its normal efficiency and can, unless special precautions are taken, give rise to the oscillation troubles to which we have referred.

DIAGRAM OF STANDARD PIN CONNECTIONS

(viewed from underside of base)





CIRCUIT DIAGRAM OF 'AVO' VALVE CHARACTERISTIC METER. Mk.III.

REF.	TOL.	VALUE
R1	± 20%	3·9 Ω
R2	± 2 %	760 Ω
R3	± 1 %	2 K Ω
R4	± 1 %	1860 Ω
R5	± 1 %	300 Ω
R6	± 1 %	25·6 K Ω
R7	± 1 %	2·5 K Ω
R8	± 1 %	"
R9	± 1 %	"
R10	± 1 %	"
R11	± 1 %	"
R12	± 1 %	"
R13	± 1 %	"
R14	± 1 %	"
R15	± 1 %	3·54 K Ω
R16	± 2 %	15 K Ω
R17	± 2 %	3 K Ω
R18	± 2 %	600 Ω
R19	± 1 %	2·96 M Ω MATCHED PAIR
R20	± 2 %	10 K Ω
R21	± 2 %	1·22 M Ω
R22	± 2 %	814 K Ω
R23	± 2 %	406 K Ω
R24	± 2 %	202 K Ω
R25	± 2 %	100 K Ω
R26	± 2 %	31·5 K Ω
R27	± 2 %	4·35 K Ω
R28	± 1 %	249 K Ω
R29	± 1 %	59·6 K Ω
R30	± 1 %	21·8 K Ω
R31	± 1 %	2·9 K Ω
R32	± 1 %	6·8 K Ω
R33	± 2 %	330 K Ω
R34	± 2 %	10 K Ω
R35	± 1 %	10 K Ω
R36	+ 5 % − 0 %	190 Ω {OVERWOUND TO 200 Ω ± ·5%
R37	± 2½ %	500 Ω
R38	± 5 %	5 K Ω
L.P.1.		200 V 15 W SMALL EDISON SCREW
L.P.2.		6·3 V 0·3A M.E.S.
RV1		25 Ω
RV2		250 Ω
RV3		10 K Ω
RV4		5 K Ω
RV5		10 K Ω
RV6		5 K Ω
F1		2-3 AMP
C1		8 ufd ELECTROLYTIC
V1		D77
V2		D77
REC. 1		1/6A