THE "AVO"
VALVE CHARACTERISTIC METER

WORKING INSTRUCTIONS

THIRD EDITION

PUBLISHED BY

THE AUTOMATIC COIL WINDER & ELECTRICAL EQUIPMENT CO. LTD.

WINDER HOUSE, DOUGLAS STREET, LONDON, S.W.1

Telephone: VICtoria 3404-9

THE AVO VALVE CHARACTERISTIC METER Mk II

FOREWORD

FOR more than a quarter of a century we have been engaged in the design and manufacture of "AVO" Electrical Measuring Instruments. Throughout that time we have consistently pioneered the design of modern multi-range instruments and have kept abreast of and catered for the requirements of the epoch-making developments in the fields of radio and electronics.

The success of our steadfast policy of maintaining high standards of performance in instruments of unexcelled accuracy, and making such instruments available at reasonable cost, is reflected in the great respect and genuine goodwill which "AVO" products enjoy in every part of the World.

It has been gratifying to note the very large number of instances where the satisfaction obtained from the performance of one of our instruments has led to the automatic choice of other instruments from the "AVO" range. This process, having continued over a long period of years, has resulted in virtual standardisation on our products by numerous Public Bodies, The Services, Railway Systems, and Post Office and Telegraph Undertakings throughout the world.

Our designers have thereby been encouraged to ensure that new instruments or accessories for inclusion in the "AVO" range fit in with existing "AVO" apparatus and serve to extend the usefulness of instruments already in use. Thus, the user who standardises on "AVO" products will seldom find himself short of essential measuring equipment, for, by means of suitable accessories, his existing equipment can often be adapted to meet unusual demands.

It is with pleasure that we acknowledge that the unique position attained by "AVO" is due in no small measure to the co-operation of so many users who stimulate our Research and Development staffs from time to time with suggestions, criticisms, and even requests for the production of entirely new instruments or accessories. It is our desire to encourage and preserve this relationship between those who use "AVO" Instruments and those who are responsible for their design and manufacture, and correspondence is therefore welcomed, whilst suggestions will receive prompt and sympathetic consideration.

INDEX

The "AVO" Valve Data Manual

This instrument will produce maximum information when used in conjunction with the Valve Manufacturer's Graphs and Technical Data, but to enable rapid checks to be made relative to a valve's general efficiency, the "AVO" Valve Data Manual has been produced.

This instruction book refers throughout to the "AVO" Valve Data Manual, a copy of which should always be kept with the instrument. New editions of this data manual will be published from time to time. Watch our advertisements in the technical press for further announcements.

Introduction

to

THE "AVO" VALVE CHARACTERISTIC METER

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 D.C. 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, 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, of reproducing any one of the mutual characteristics associated with the valve in question. The instrument thus has to simulate the performance of a comprehensive valve measuring set-up of laboratory

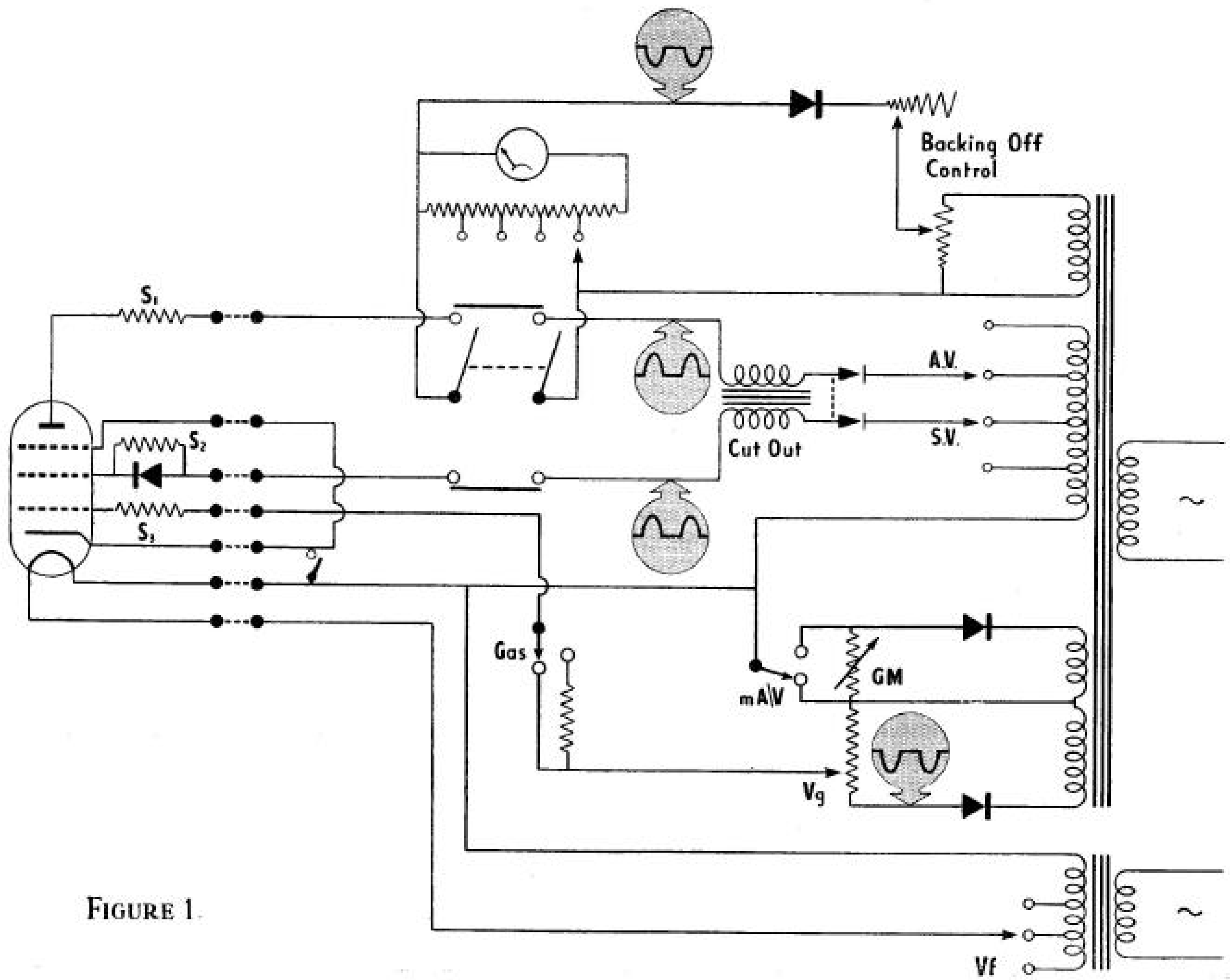

FIGURE 1.

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. 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 :—

$$\text{Va RMS} = 1{\cdot}1 \text{ Va indicated DC}$$
$$Vg_2 \text{ RMS} = 1{\cdot}1\ Vg_2 \text{ indicated DC}$$
$$Vg_1 \text{ (mean unsmoothed)} = 0{\cdot}52\ Vg_1 \text{ indicated DC}$$
$$\text{Ia (mean DC)} = 0{\cdot}5 \text{ indicated Ia}$$

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, the nature of the wave forms present in the various parts of the circuit being indicated thereon. As in the original Valve Tester, the process of obtaining a direct reading mutual conductance figure is simplified by the production of a backing off circuit, which balances out the deflection due to the standing anode current at the desired test conditions prior to the operation of the mutual conductance button. Only the desired figure appears on the meter scale, thus enabling the meter to be set at a sufficiently sensitive range for precise determination 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 direction to the anode current, thus eliminating any undesirable ripple that could otherwise become apparent when the meter, after backing off, was set to a sensitive range.

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 co-related 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. 5mA, 15mA, 30mA, 60mA and 120mA. 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 as a percentage, the comparative efficiency of the valve on the basis of this required DC load. Each half of a full wave rectifying valve is tested separately thus enabling matching of two halves to be checked 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 a lower AC voltage is applied and comparison is made with a single DC load figure of 1mA, this figure 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 electrodes taken in order and all the others strapped together. The denomination of the

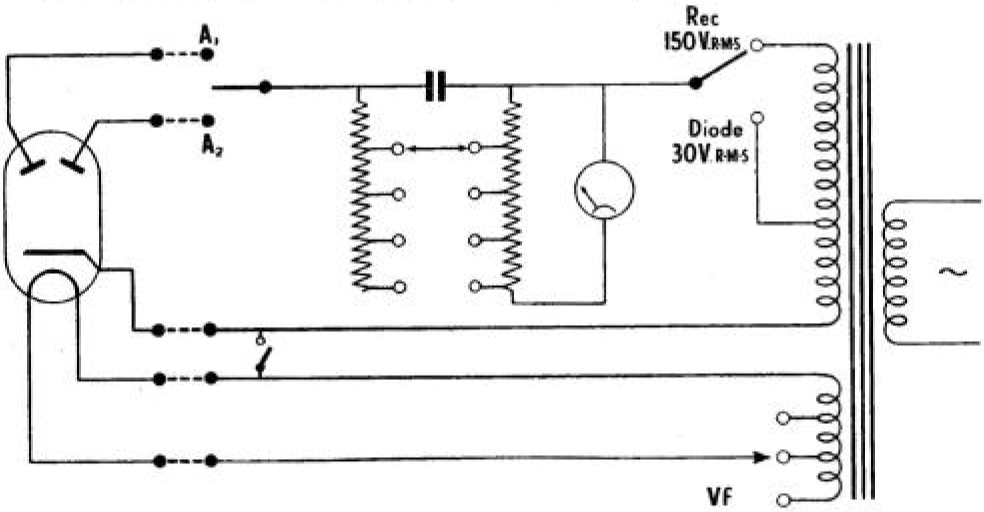

FIGURE 2

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 directly heated valves it is not uncommon for electrode sagging to occur on the application of heater voltage, with the result that a breakdown occurs between heater and an adjacent electrode. 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.

Safety Cut-Out

To prevent damage to internal components of the Valve Characteristic Meter, due to inadvertent or deliberate shorting of the supply voltages, a safety cut-out is incorporated, operative when damaging overloads of AC current are taken from either the anode or screen voltage sources. The cut-out takes the form of a two circuit polarised electro-magnetic relay which has two windings incorporated in its electro-magnetic system, one associated with the screen voltage supply and one with the anode voltage supply. It will be appreciated that with the valve electrodes taking normal current, half wave DC pulses only will flow through these windings and the direction and magnitude of the windings are such that with anode current only flowing, or alternatively, with a considerably larger anode current than screen current flowing, the cut-out will be held in contact and the instrument will work normally. It is obvious, however, that if an internal valve short occurs on any one of its high voltage electrodes, or alternatively, if such a short is applied externally via the valve holder sockets, or other part of the circuit, or further if any internal short occurs associated with the anode or screen supply circuits, then the current flowing in these circuits will not take the form of uni-directional pulses, but will be ordinary AC current.

In such circumstances, the effect of the first half cycle of AC current in the reverse direction from normal will be such as throw out the cut-out and thus break both anode and screen supply circuits. The overload is, therefore, removed from the supply system and burn out of transformers and associate parts is obviated. Note that this protection does not apply in the case of a short applied to the heater voltage windings as these normally pass sinusoidal AC current. Further, if for any reason when testing a pentode the anode circuit should become disconnected (this can occur when the roller switch is wrongly set up) then the normal result would be for a damagingly heavy rectified current to flow in the screen circuit ; the relative direction and magnitude of the two windings on the cut-out is then such that when the current in the screen circuit seriously exceeds the current in the anode circuit the cut-out is thrown and damage both to valve and circuit is obviated. *It must be stressed that this cut-out will not operate upon the passage of normal heavy currents of a DC nature occurring in the valve anode circuit, and it will not protect the movement if the latter is wrongly set on a range not corresponding to the current passing. This problem is dealt with by ensuring that the movement is always set to its maximum current range when the probable magnitude of the current is unknown.*

THE VALVE PANEL AND SELECTOR SWITCH

The Valve Panel comprises 18 valve holders of the following types :—English—4/5 pin, 7 and 9 pin, 8 pin side contact, B7G, B8A, B8B (American Loctal), B9G, English Octal, B3G, 4 and 5 pin Hivac : American—4, 5, 6 and small 7 pin UX, medium 7 pin UX, Octal, and B9A. Provision is made by means of plug-in adaptors to cater for newly introduced valve bases. These 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 proper, 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 five sockets marked G1, S, A1, A2, D1 the markings corresponding to the valve electrode connection which is 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	E

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.
(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)	E	,, ,,	any earthed screen or screening electrode not operating under applied voltage conditions nor normally connected to cathode.

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, 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