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A NEW TYPE OF TUNING INDICATOR FOR BATTERY OR MAINS RECEIVERS

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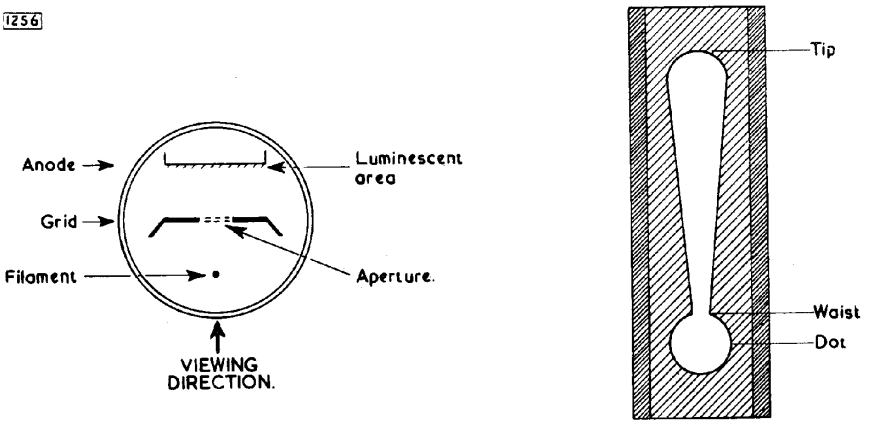
The problem of tuning a receiver so that the carrier frequency of the desired signal coincides with the midpoint of the resonance curve of the receiver is simplified by the use of a visual tuning indicator. Early attempts to solve this problem included the application of milliammeters, shadow indicators and specially designed neon tubes. These were superseded by the luminescent-screen type of indicator such as the Mullard EM34 in which the variation of an area of fluorescence produced a sharply defined indication of the tuning. A new valve, the Mullard DM70, retains this method of indication but with an entirely new form of construction.

Although the DM70 is essentially a cathode ray tuning indicator, it differs from the conventional type of "magic eye" in the arrangement and simplicity of its electrode structure, in its compact subminiature bulb and in its directly-heated filament suitable for operation from a 1·4-volt battery.

CONSTRUCTION

The electrode structure can best be described as that of a triode in which the "anode" fulfils the duties of electron accelerator and luminescent target. The "grid" is both the electrode controlling the flow of electrons from the filament to the anode and the visual standard by which the amount of luminescence is compared. These two electrodes together with the filament are mounted in a standard 10-mm. subminiature bulb with a B8D base of wire-in leads.

The anode consists of a flat plate coated on one side with a luminescent material. The grid is also a metal plate at the centre of which is an aperture of varying width, shaped rather like an "exclamation mark". In front of the grid and parallel to the axis of the aperture is located the filament. The luminescent area of the anode is visible through the aperture in the grid when viewed from the filament side of the assembly. The filament, being an extremely thin oxide-coated wire, is hardly perceptible when the



(a) CROSS-SECTION

(b) GRID APERTURE.

FIG. 1.

indicator is viewed. Fig. 1a shows a cross-section of the valve indicating the relative positions of the electrodes. The appearance of the aperture in the grid is shown in Fig. 1b.

The luminescent area on the anode appears as a linear " column " when viewed through the aperture in the grid. This type of indication and its small bulb dimensions permit the DM70 to be mounted in several novel ways. For instance, it can form part of the moving cursor in the tuning dial of the receiver and

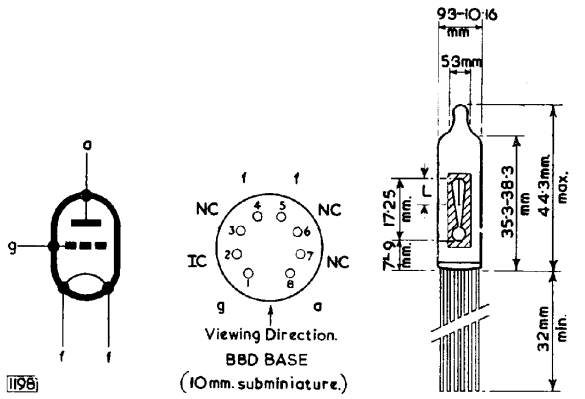


FIG. 2.—PIN CONNECTIONS AND DIMENSIONS OF DM70.

thus act as an illuminated pointer. The valve may be soldered directly into the circuit, care being taken that the soldered connections are at least 5 mm. from the base and that the leads are not bent within 1·5 mm. of the base. The dimensions of the valve, together with the pin connections, are given in Fig. 2. The dimension L, which will be referred to later, is the length of the upper portion of the indicating column measured from the tip of the aperture. The inside of the bulb is coated with a transparent conductive film connected to the filament. This reduces the possibility of external electrostatic fields affecting the electron beam.

METHOD OF OPERATION

The electrical characteristics of the valve permit its use in a receiver in such a manner that the fluorescent column is observed over the entire length of the aperture when not tuned to a signal. On " tuning-in ", the length of the column, L, decreases from the " waist " upwards so that when the receiver is correctly tuned to a carrier the column is of minimum length. In receivers fitted with A.G.C. the column is reduced to a small patch of luminescence at the tip for all but the weakest signals. The fluorescent dot at the lower end of the aperture remains illuminated over the whole range in order to facilitate tuning when the valve forms part of the tuning scale (see Fig. 3). It can also serve as a pilot lamp in battery receivers.

The length of the column is controlled by the grid voltage. This may be obtained from the A.G.C.

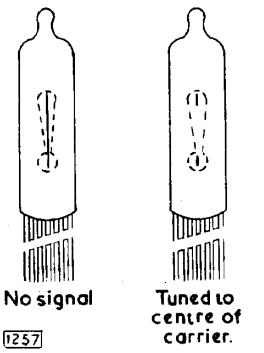


FIG. 3.—EFFECT OF " TUNING-IN " ON APPEARANCE OF FLUORESCENT COLUMN.

line in those receivers employing undelayed A.G.C. or otherwise from the demodulator circuit.

A number of requirements had to be met in the design of this valve. Satisfactory operation in either battery or mains receivers means that the electrode structure must operate at anode voltages as low as 60 V and with a wide range of control voltages depending upon the A.G.C. voltage of the receiver. The condition of maximum illumination has to be consistent with the steady zero-signal voltage present in the A.G.C. or demodulator circuit. The design was also influenced by the requirement, previously mentioned, that the dot should remain illuminated until the column has almost receded to the tip of the aperture. These conditions have been satisfied by careful choice of the dimensions of the aperture in the grid and of the inter-electrode spacings. In the small space

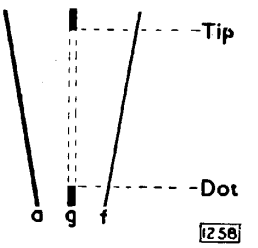


FIG. 4.—DIAGRAM SHOWING VARIATION OF INTER-ELECTRODE SPACINGS FROM TIP TO DOT.

available, it was necessary, not only to make the anode-to-grid distance greater at the tip than at the dot, but also to increase the corresponding grid-to-filament distance. (See Fig. 4).

CHOICE OF OPERATING CONDITIONS

In order to make the best use of the variation in length of the fluorescent column with different input signals, it is essential to select the operating conditions for the valve to suit the type of receiver to which it is to be fitted. A typical curve showing the variation of the length, L, of the observed column with control grid voltage is shown in Fig. 5.

This curve, for a specific anode voltage, is dependent upon the type and polarity of the filament voltage supply. The value of the control voltage at which maximum column length (L=14 mm) occurs is referred to as V_c. If V_g becomes more positive than V_c there will be no change in the indication of the DM70.

In conventional A.M. receivers there is a steady voltage, $V_{d(o)}$, developed across the demodulator or the undelayed A.G.C. diode when no signal is being received. This potential is applied to the grid of the DM70. If the full extent of the luminescent column is to be utilised it is apparent that V_c should be more positive than $V_{d(o)}$. Generally, $V_{d(o)}$ is between −0·2 V and −0·6 V, as indicated in Fig. 5. The mean length of column at this value of V_g is designated L_o.

For any particular set of operating conditions the value of V_c is subject to the normal production spread between valves. It is necessary to consider this when deciding if V_c will always be more positive than $V_{d(o)}$. This is indicated in Fig. 5, in which it is seen that this condition is met and L_o remains a reasonable length (10·2 mm).

The value of grid voltage at which the column is completely extinguished (L=0) should approximate to the maximum potential likely to be produced across the demodulator or A.G.C. diode. This ensures that very strong signals are adequately indicated.

Typical families of curves for the DM70 are shown in Figs. 6, 7, 8.

FILAMENT CONNECTIONS

The value of V_c for any particular anode voltage is determined chiefly by the potential difference between the grid and filament in the region where the aperture is narrowest—the " waist ". As this point is not equidistant from each end of the filament, the potential difference will change if the polarity of the filament voltage is reversed. In the same manner the use of alternating instead of direct filament voltage will affect the potential difference.

The filament connections for each particular application are chosen to give optimum use of the indicating column consistent with the voltage limitations for each receiver. For instance, in battery receivers for use with a 90 V supply, it is preferable to earth pin 4 of the DM70, whilst with a 67·5 V supply pin 5 should be earthed. For operation in A.C. mains receivers the only satisfactory arrangement is with pin 5 earthed. In each case the " earthed " pin should be at the same potential as the earthed side of the demodulator or A.G.C. circuit. This is normally connected to the chassis of the receiver.

APPLICATION OF THE DM70 TO VARIOUS TYPES OF RECEIVER

Battery receivers

These can be divided into two main classes, depending upon the type of H.T. battery. Those having a battery voltage of 90 V operate with an H.T. of about 85 V

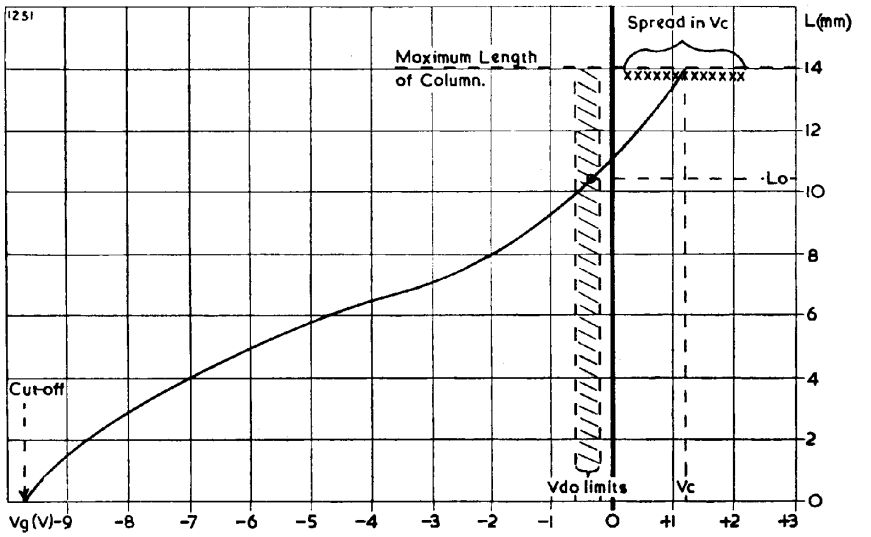


FIG. 5.
CURVE ILLUSTRATING THE CHOICE OF OPERATING CONDITIONS.

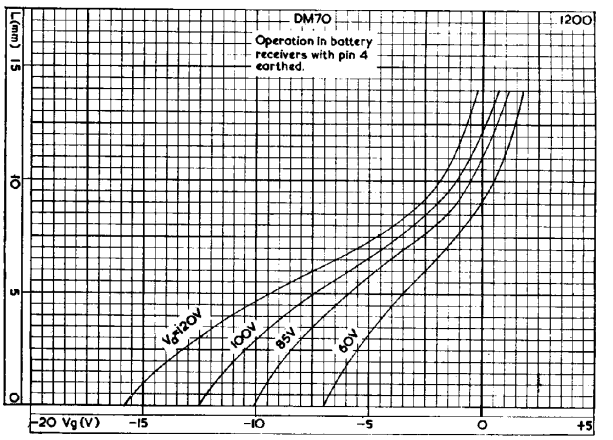


FIG. 6.—VARIATION OF LENGTH OF FLUORESCENT COLUMN WITH GRID VOLTAGE WHEN CONNECTED WITH PIN 4 EARTHED IN BATTERY RECEIVERS.

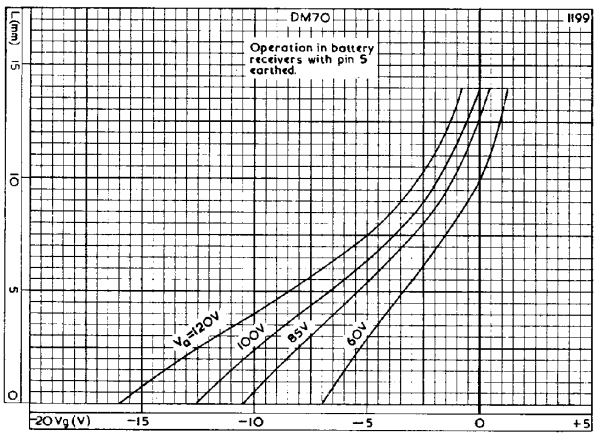


FIG. 7.—VARIATION OF LENGTH OF FLUORESCENT COLUMN WITH GRID VOLTAGE WHEN CONNECTED WITH PIN 5 EARTHED IN BATTERY RECEIVERS.

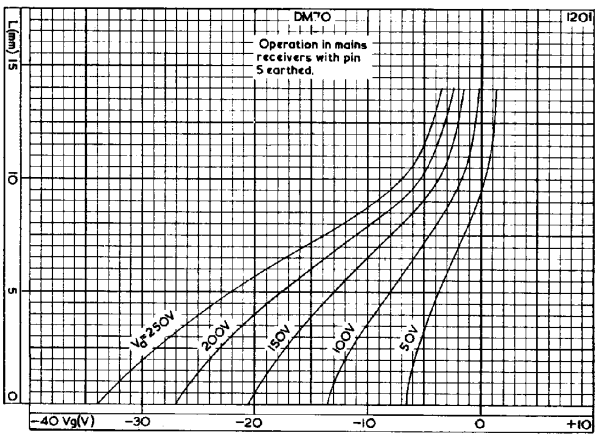


FIG. 8.—VARIATION OF LENGTH OF FLUORESCENT COLUMN WITH GRID VOLTAGE WHEN CONNECTED WITH PIN 5 EARTHED IN MAINS RECEIVERS.

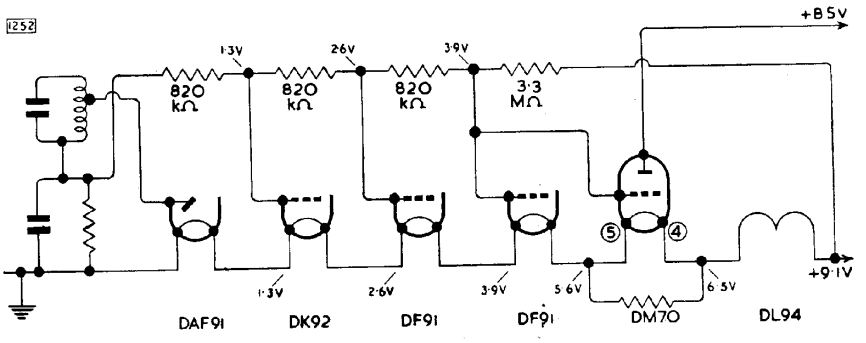


FIG. 9.
TYPICAL FILAMENT CHAIN FOR AN ABC RECEIVER SHOWING CONNECTIONS TO DM70.

after deducting the negative grid bias required for the output valve. In such a receiver the DM70 with pin 4 earthed has a grid cut-off voltage of −10 V (see Fig. 6). This is adequate to ensure that the luminescent column will indicate even the strongest signal likely to be encountered. If the battery is rated at 67·5 V the H.T. is of the order of 60 V. Reference to Fig. 7 shows that pin 5 should be earthed to give satisfactory operation at this voltage. The cut-off voltage for the DM70 is then −7 V.

ABC receivers

It is usually necessary to connect the filament of the DM70 in series with the filaments of the other valves in an ABC receiver. If the series chain is for valves with 50 mA filaments it is necessary to shunt the 25 mA filament of the DM70 by a 56Ω resistor. The sequence of the valves in the filament chain is determined by such requirements as the provision of grid bias for the output valve, the reduction of hum, and the derivation of the optimum A.G.C. voltage for each of the valves to be controlled. It is, therefore, not always possible to include the DM70 in the most suitable position in the chain.

A typical arrangement for a five-valve receiver having two stages of I.F. amplification with A.G.C. applied to both these valves and to the frequency changer is shown in Fig. 9. A potential divider network between the demodulator diode and the positive end of the filament chain is used to provide the A.G.C. voltage for the three valves.

This potential divider is designed so that under zero signal conditions the bias of each of the valves is zero. As the taps on the divider approach the positive end of the network the proportion of the total control voltage which can be applied to each valve becomes less. If the grid of the DM70 were connected to a tap with the same potential as the negative terminal of its filament the amount of control voltage available would be insufficient to cut off the valve on large signals. Sufficient control is obtained by applying the same voltage to the grid of the DM70 as to the second I.F. valve. This means that, with an anode potential of 85 V and with pin 4 at a lower potential than pin 5, the *effective* value of V_c is +2·5 V instead of + 1·2 V, as given in Fig. 6. However, by connecting the valve with pin 5 at a lower potential than pin 4 (as in Fig. 7) the *effective* value of V_c is altered to +0·4+1·3=+1·7 V. This method of connection is shown in Fig. 9.

A.C. mains receivers

When operated in an A.C. mains receiver it is usually necessary to feed the filament of the DM70 from the

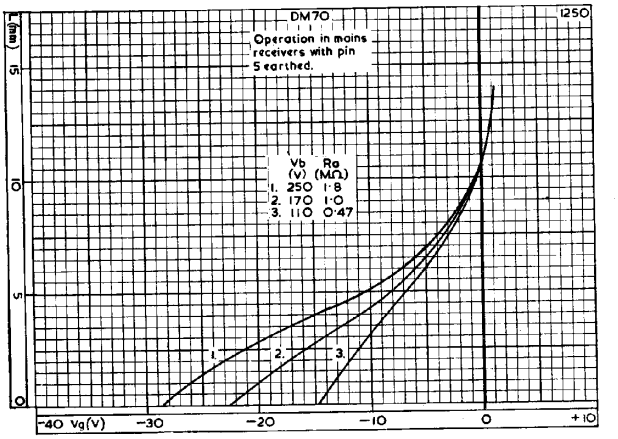


FIG. 10.—VARIATION OF LENGTH OF FLUORESCENT COLUMN WITH GRID VOLTAGE WHEN CONNECTED WITH AN ANODE SERIES RESISTOR, AND WITH PIN 5 EARTHED, IN MAINS RECEIVERS.

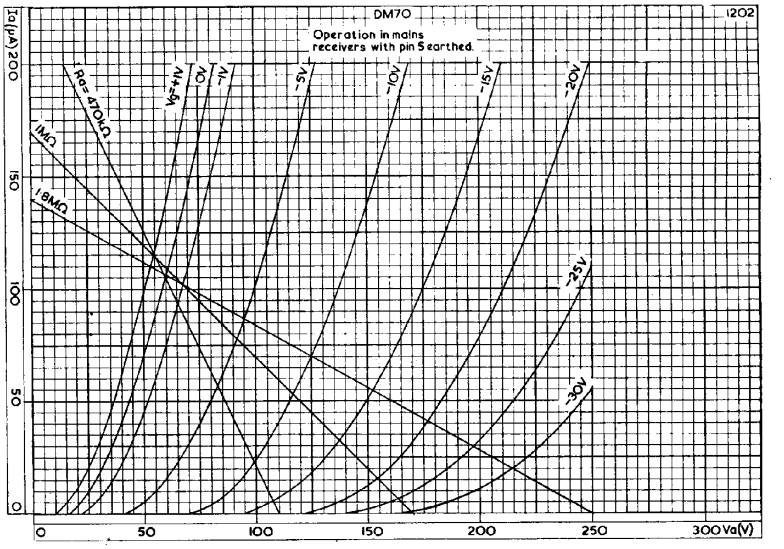


FIG. 11.
CURVES OF ANODE CURRENT PLOTTED AGAINST ANODE VOLTAGE WITH GRID VOLTAGE AS PARAMETER.

6·3-volt winding of the transformer used to supply the heaters of the other valves. This may be done by connecting a resistor in series with the filament. Under these conditions the nominal voltage for a 1·4-volt filament should be 1·3 V to allow for possible variation in mains voltages, component tolerances, etc.

The nearest preferred value of resistor to give this voltage is 220Ω±5% for operation from a 6·3-volt supply. The resistor should have a dissipation of 1 W in order to limit the possibility of reduction of resistance due to increased temperature. It is possible to connect the filament to a 3·15-volt centre-tap on the heater supply by using an 82Ω±10% resistor of 0·5 W dissipation.

Feeding of the filament with a direct current from the cathode resistor of the output valve or from a resistor common to several valves is not recommended. In either of these cases it is possible for the current through the filament to vary to such an extent that it exceeds the permitted limits and may cause the life of the DM70 to be reduced. The variations in current can be caused by tolerances in the values of resistors, spread in the cathode current of the output valve, mains voltage fluctuations and spread in the filament resistance of the DM70.

It has already been stated that the filament should be connected with pin 5 earthed when operated in A.C. mains receivers. From Fig. 8 it is seen that the optimum value of H.T. for the DM70 in order that there is maximum column length with no input signal is about 60 V. This is obtained by connecting the anode to the H.T. line of the receiver by means of a series resistor. The inclusion of this resistor results in a sliding anode voltage dependent upon the current through the valve. The effect of typical resistors upon cut-off voltage is shown in Fig. 10.

In each case the cut-off voltage is adequate to deal with strong signals in a very sensitive receiver. Fig. 11 shows the anode current plotted against anode voltage with load lines drawn for the recommended values of anode resistor.

The anode of the DM70 should not be connected to the screen-grid of any of the other valves in the receiver. This method of connection would probably result in more than 60 V being supplied to the DM70 and might cause a hum voltage from the directly-heated filament of the indicator to be fed to the screen-grid of the valve concerned.

To prevent a hum voltage being introduced into the A.G.C. circuit from the grid of the DM70 it is necessary to incorporate the circuit shown in Fig. 12. R1 represents the load of the demodulator or A.G.C. diode of the receiver. With a normal undelayed A.G.C. supply the decoupling network R2, C1 is already present and the only additional component required is the 6·8 MΩ resistor R3. In receivers

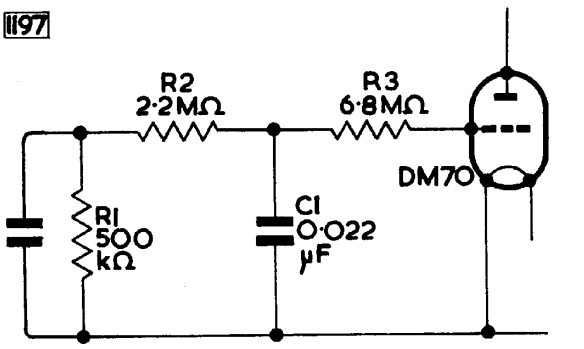


FIG. 12.—PREVENTION OF HUM TRANSFER FROM DM70 TO RECEIVER.

having delayed A.G.C. the DM70 is fed from the demodulator resistor and the network R2, R3, C1 should then be included in the circuit.

A.C./D.C. receivers

The filament of the DM70, shunted by a suitable resistor may be connected in series with the heaters of the other valves in an A.C./D.C. receiver. The heating time of the tuning indicator being much shorter than that of the indirectly heated receiving valves, it is necessary to include a surge current limiting device in series with the filament.

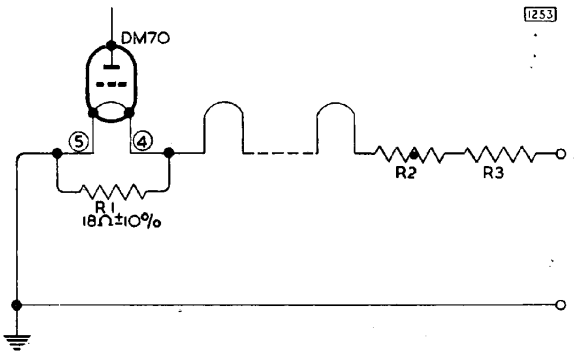


FIG. 13.—CONNECTION OF FILAMENT OF DM70 IN A.C./D.C. HEATER CHAIN.

In order to earth pin 5, the DM70 must be inserted at the earthy end of the heater chain, and the earthed side of the demodulator or A.G.C. circuit connected to the same pin. A typical circuit for a series chain for 100 mA heater valves is shown in Fig. 13.

The shunt resistor R1 is $18\Omega \pm 10\%$ for mains voltages above 160 V. R2 represents the current limiting device and R3 is the usual voltage dropping resistor. If the mains voltage is so low that the chain of normal valves cannot be extended to include both the DM70 and the current limiter, it may be possible to include the tuning indicator in a second chain which feeds the dial lamp and some of the valves. For mains voltages between 110 V and 127 V the shunt resistor R1 should be $15\Omega \pm 10\%$ when connected in series with 100 mA heaters.

BRIEF TECHNICAL DATA

Filament

V_f	1·4	V
I_f	25	mA

Mounting Position

The valve may be mounted in any position, the direction of viewing being indicated on the diagram of pin connections (Fig. 2).

Direct soldered connections to the leads of this valve must be at least 5 mm from the seal and any bending of the valve leads must be at least 1·5 mm from the seal.

Limiting Values

$V_{b(o)}$ max.	450	V
V_b max.	300	V
*V_a max.	90	V
V_a min.	45	V
**p_a max. ($V_a \leq 90$ V)	25	mW
**p_a max. ($V_a = 200$ V)	10	mW
I_k max.	300	μA
R_{g-f} max.	10	MΩ

*In circuits without anode series resistor.

**Values of p_a max. for intermediate values of V_a may be determined by linear interpolation.

Operating Conditions

Battery-operated receivers

	Pin 4 earthed	Pin 5 earthed	
V_b	90	67·5	V
V_a	85	60	V
V_g	0	0	V
I_a	170	105	μA
*L	11	10	mm
V_g (for complete extinction)	−10	−7	V

Mains-operated receivers (Pin 5 earthed)

V_b	110	170	250	V
R_a	0·47	1·0	1·8	MΩ
V_g	0	0	0	V
I_a	105	110	105	μA
*L	10	10	10	mm
V_g (for complete extinction)	−15	−23	−34	V

*Length of fluorescent column observed, measured from the top of the aperture. The maximum value is approximately 14 mm.

Base

B8D (10 mm subminiature).