APPENDIX XVIII

MEASUREMENT OF VALVE CATHODE INTERFACE RESISTANCE

GENERAL

This Appendix describes a convenient low frequency method of measuring thermionic valve cathode interface resistance.

Section 1. THEORETICAL ANALYSIS

1.1. The measuring method outlined below gives a simple means of measuring the total effective resistance occurring in the cathode coating and cathode interface layer of triodes and pentodes.

1.2. Referring to Fig. 1, fundamentally the assumption is made that at constant grid current V_{g-k} is constant, so that a variation in cathode current δI_k produces a variation in cathode surface potential $\delta I_a \times r_{kt}$. Since at constant grid current V_{g-k} is constant, then

$$\delta I_k \times r_{kt} = \delta V_{g-e}$$

$$\therefore \quad r_{kt} = \frac{\delta V_{g-e}}{\delta I_k}$$

i.e, r_{kt} (the total coating and interface resistance) is equal to the slope of the V_g: I_k characteristic at constant grid current.

A more strict mathematical analysis of the system leads to the equation

$$\frac{\delta V_{g-e}}{\delta I_k} = r_{kt} + \frac{1}{1 + \mu'/\mu} \cdot \frac{1}{g_m}$$

where $\mu = \frac{\delta V_{a-k}}{\delta V_{g-k}}$, I_a being constant

and $\mu' = \frac{\delta V_{a-k}}{\delta V_{g-k}}$, I_g being constant

and $g_m = \frac{\delta I_k}{\delta V_{g-k}}$

As the valve is connected as a tricde, and as the grid current is maintained at a constant value, then $\delta I_k = \delta I_a$ and the expression becomes:

$$\frac{\delta V_{g-e}}{\delta I_a} = r_{kt} + \frac{1}{1 + \mu'/\mu} \cdot \frac{1}{g_m}$$

The error caused by the second term in the above expression is usually not greater than about 10 ohms, and if new valves can be assumed to have very low values of r_{kt}, the correction can be determined by measurement.

For the purpose of investigating changes in interface occurring during life, the correction can be ignored if this second term stays constant.

Section 2. PRACTICAL METHODS OF MEASURING INTERFACE RESISTANCE

2.1. A practical circuit for performing the measurements described in Section 1 above is given in Fig. 2.

2.2. The grid is returned through a 0.5 MΩ resistor to a variable positive voltage and the grid current is conveniently set to about 0.4mA. Since 0.5 MΩ is large compared with the grid-cathode diode-impedance, the grid current is held closely constant and the grid follows the cathode surface potential. The $I_a = I_k$ is adjusted by the V_a control to nominal and the anode voltage is modulated by the low impedance 0-10-50 v transformer in the anode lead. The modulation is increased to give a reading of 100 mV across the 100Ω resistor. If the valve voltmeter is switched into the grid circuit, δV_g will be indicated for a pre-set value of δI_a. The grid reading is therefore $\frac{K \delta V_g}{\delta I_a}$ where K is a constant calibration.

The instrument may be made direct reading in ohms.

By inserting a decade box in the cathode, the performance of the apparatus may be checked. With a new valve inserted and zero resistance inserted, a value of resistance is read. This has been found to be closely constant for all new valves of the same type measured at the same values of I_g and I_a.

This is termed the zero error and is subtracted from all subsequent measurements, the I_a and I_g always being the same.

2.3. The limitation of the method is that no indication is obtained of the capacitive component of interface, and no distinction can be drawn between true interface and the actual resistance of the cathode coating.

THEORETICAL CIRCUIT

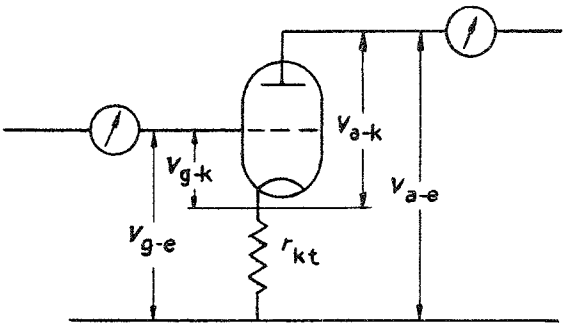
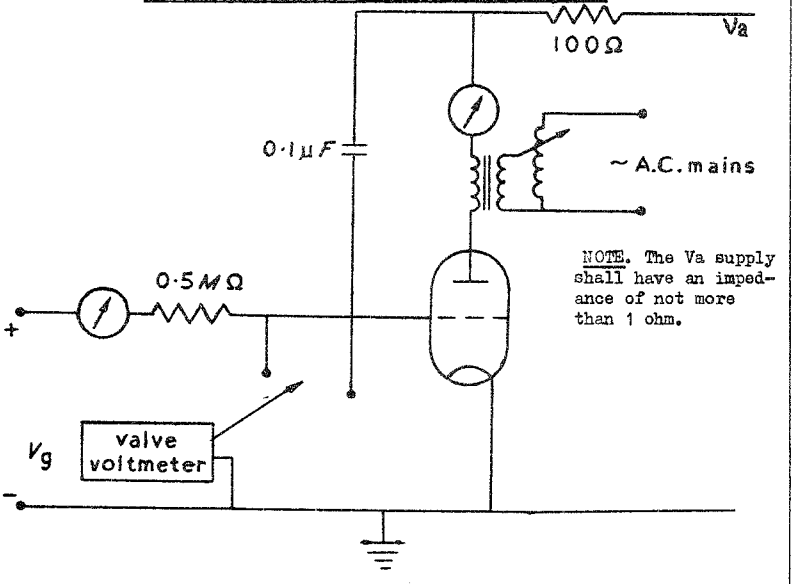


FIG. 1

PRACTICAL CIRCUIT
FOR MEASURING CATHODE INTERFACE RESISTANCE



NOTE. The Va supply shall have an impedance of not more than 1 ohm.

FIG. 2

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