<u>Note On Paper on "CALCULATION OF TRIODE CONSTANTS"</u>

(Phil. Mag., June 1939, p. 709)

To the Editors of the Philosophical Magazine.

GENTLEMEN, -

The paper entitled "Calculation of Triode Constants" by Dr. J. H. Fremlin (Phil. Mag. June 1939, p. 709) is a most valuable contribution to the subject. There is, however, an unstated assumption in that the position of the equivalent diode plane, given by equation (XIII.) is assumed to be constant at any grid bias, whereas it has necessarily this value only at the grid voltage.

$$\left(\frac{I_g}{I_a}\right)^{4/3} V_A.$$

Sometime ago the writer made a similar calculation on the following lines:- Suppose that a very high ω grid at a potential V_L is located between grid and anode. Then the current flow and potential distributions both in the cathode grid space and in the grid to anode space can be calculated, assuming that the electrons are projected into the grid to anode space on each side of the grid will determing Q_g, the charge per cm.^{2} induced on the grid. Now suppose the high ω grid to be replaced by a low ω grid, then the actual potential of the grid wires, V_g, will be depressed below the potential V_L by an amoung

$$-\frac{4\pi Q_g}{K},$$

where

$$K = \frac{2\pi N}{\log_e \frac{1}{\pi N \delta}},$$

N = No. of turns per cm.

δ = Diam. of grid wires in cm.,

K is a constant independent of the grid location.

The above relation can be shown to be true for the electrostatic case, and is assumed to be true on using the value of Q_g in the case of current flow. We then have I_A/cm.^{2} a known function of V_L, and V_L of V_g.

Suppose now that Q_g is a linear function of V_g, and that Q_g equals zero when V_g equals some voltage V_f. The following relationship follows:-

$$I_A/cm.^2 = \frac{2.34 \times 10^{-6}\left(\frac{V_A}{\mu} + V_g\right)^{3/2}}{X_1^2\left[1 + \frac{1}{\mu}\frac{V_A}{V_f}\right]} \text{ amperes/cm.}^2 \qquad (1)$$

As an example, if the effect of space charge in the grid to anode space is neglected

$$V_f = \frac{\frac{3}{4}X_1}{\frac{3}{4}X_1 + X_2}$$

where X_1 = grid to cathode gap, X_2 = grid to anode gap (in cm.) so that

$$I_A/cm.^2 = \frac{2.34 \times 10^{-6} \left(\frac{V_A}{\mu} + V_g\right)^{3/2}}{X_1^2\left[1 + \frac{1}{\mu}\,\frac{X_1 + \frac{4}{3}X_2}{X_1}\right]^{3/2}} \qquad (2)$$

In actual fact, however, the relation between Q_g and V_g is not quite linear.

Let Q_2 = charge induced on the anode side of the grid, then it can be shown that if V_L is small compared with V_A

$$Q_2 = a + bV_L + cV_L^{3/32},$$

where the third term arises as an effect of space charge between grid and anode and is proportional to anode current. Clearly when V_L = zero, as near cut-off, the conditions giving equation (2) are satisfied, but when $V_g = \left(\frac{X_1}{X_1 + X_2}\right)^{4/3} V_A$, we must satisfy Dr. Fremlin's equation.

As a final equation, I obtain

$$I_A/cm.^2 = \frac{2.34 \times 10^{-6}\quad A + V_g^{\;3/32}}{X_1^2\left\{\left[\frac{X_1 + \frac{4}{3}X_2}{\mu X_1}\right] + \frac{1 - \left(\frac{X_1 + \frac{4}{3}X_2}{X_1}\right)\left(\frac{X_1}{X_1 + X_2}\right)^{4/3}}{\left[\frac{X_1}{X_1 + X_2}\right]^3\left[1 + \frac{1}{\mu}\left(\frac{X_1 + X_2}{X_1}\right)^{4/3}\right]^{1/2}}\left(\frac{1}{\mu} + \frac{V_g}{V_A}\right)^{1/2}\right\}^{3/2}}$$

showing that the equivalent diode plane varies with V_g.

It should be noted that the deviations from Dr. Fremlin's equation or from equation (2) are more apparent at large values of the same ratio $\frac{X_2}{X_1}$

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