Inherent Feedback in Triodes

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SUMMARY—The triode is imagined to be replaced by an infinite-impedance pentode (with its simplified anode-current expression $g_m dV_c$) with a fictitious emf in the grid circuit to represent the "back action" of the anode on the field at the cathode It is shown how this transformation makes it possible to obtain practical triode circuit formulæ from conventional feedback theory.

IN COMPARISON WITH A PENTODE, a triode has both strong and weak points. If, in mathematical analyses, the triode be considered as an infinite-impedance pentode with negative feedback, certain of its advantages appear as direct and expected results of negative-feedback theory and in some cases a simplified analysis can result. The method is of particular interest for control circuits and output stages utilizing low-μ triodes, since the back action from the anode on the emission-controlling field at the cathode is then appreciable. Fundamentally, *this electric field action is a form of negative feedback.*‡

Fig. 1a shows a conventional pentode representative of any screen-grid, multi-electrode valve. Fig. 1b shows a conventional triode. The dynamic mutual conductance g_{md} is, for the pentode circuit:

$$g_{md} = g_m = \frac{dI_b}{dV_c} \qquad (1)$$

and for the triode circuit:

$$g_{md} = \frac{r_a}{r_a + Z_b} g_m = \frac{dI_b}{dV_c} \qquad (2)$$

or

$$g_m = \frac{dI_b}{dV_{ce}} \qquad (3)$$

where the equivalent; control voltage, $dVce$, is:

$$dV_{ce} = dV_c + \frac{dV_b}{\mu} \qquad (4)$$

It is seen that Eqn. 1 becomes identical with Eqn. 3 when the term dV_b/μ in Eqn. 4 tends to zero. The presence of this term may then be considered as the result of the removal of one or more shielding or screening grids in the circuit Fig. 1a. Thus, it is logical to consider dV_b/μ as a feedback voltage injected in series with dV_c and thus added to dV_c because of lack of electric shielding between the anode and the cathode. (If dV_c is positive, dV_b produces a negative term hence $dV_{ce} < dV_c$).

Eqn. 2 represents a form of the Equivalent Anode Circuit theorem. This theorem also applies to the circuit in Fig. 1c where a fictitious screen grid has been inserted between the anode and cathode to justify the transfer of the voltage dV_b from the anode circuit to the grid circuit where it appears as the fictitious voltage $dV_f = dV_b/\mu$, as required by Eqn. 4. Equivalence is now established between the circuit

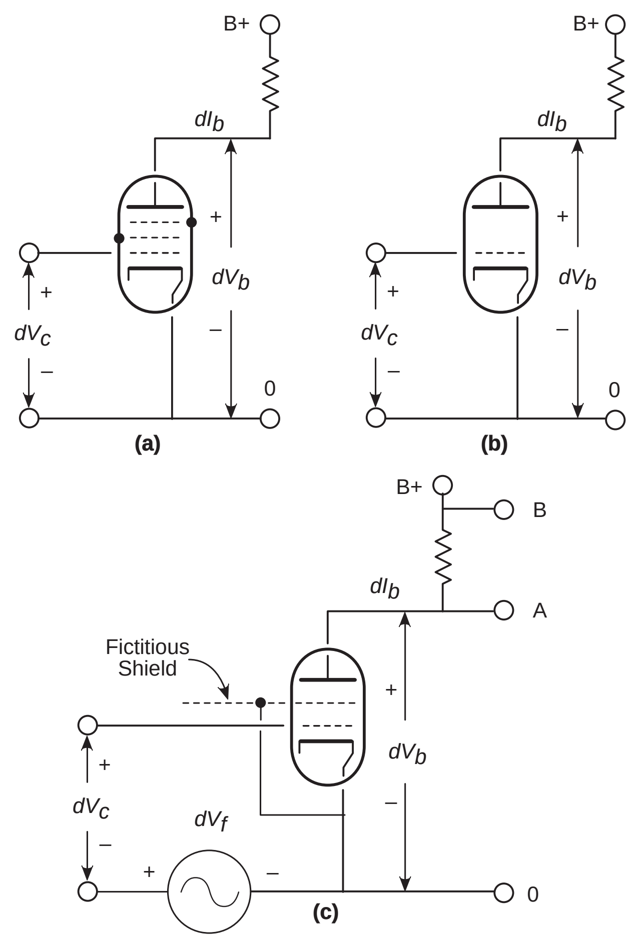

Fig. 1. Pentode and triode circuits (a) and (b) along with an equivalent (c) in which a voltage, dV_f, in the grid circuit produces the effect of a screen grid.

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