The Cathode Follower Output Stage

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Summarizing the advantages and disadvantages of a much discussed circuit arrangement which has many zealous adherents.

ALTHOUGH THE ADVANTAGES and method of operation of the cathode follower have been known for years and covered thoroughly in the literature, there has been relatively little material devoted to the use of the circuit as an audio power output stage.[1] As a result, there are widespread misconceptions regarding this use of the cathode follower, even among otherwise well-informed engineers. These misconceptions involve: (1) the relation between the static and the dynamic characteristics, i.e., between d.c. and a.c. conditions; (2) impedance matching; and (3) damping effects. These three concepts are those usually misunderstood in treating negative voltage feedback amplifiers in general, and, consequently, the conclusions obtained here for the cathode follower will be directly applicable to other voltage feedback circuits.

The simple general negative voltage feedback circuit, its equivalent, and the simple cathode-follower circuit are shown in *Fig.* 1 at (A), (B), and (C) respectively. The fraction of the output voltage that is fed back out of phase with the input voltage is denoted by β. For the cathode follower, β is 1, and consequently there is 100 per cent inverse feedback. From (B) it may be seen that since the equivalent generator magnitude is $\mu/(\mu\beta + 1)$ times the input, the cathode follower can never give a voltage gain, but must always result in a loss, the value of which depends directly on the amplification factor of the tube. There can be, however, a considerable power gain, and it is this fact that makes the circuit useful as a power output stage.

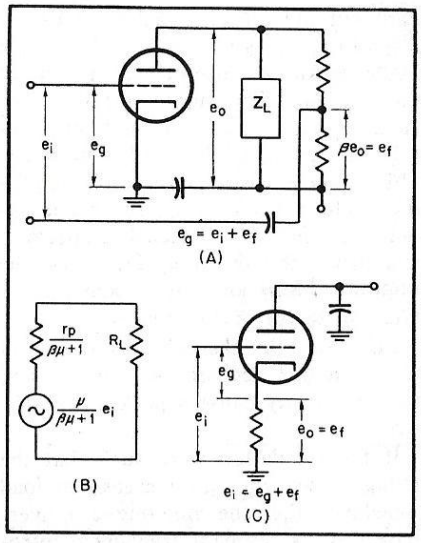

Fig. 1. (A) General schematic of voltage-feedback circuit, and (B) its equivalent. (C) Simple cathode-follower circuit.

D-C versus A-C Conditions

The equation of the output voltage e_o of a negative-voltage-feedback amplifier is

$$e_o = e_i \left(\frac{\mu}{\mu\beta + 1}\right) \times \left(\frac{Z_l}{Z_l + r_p/(\mu\beta + 1)}\right) \quad (1)$$

Comparison of this formula with that for an ordinary voltage amplification stage

$$e_o' = e_i(-\mu)\left(\frac{Z_l}{r_p + Z_l}\right) \quad (2)$$

shows that the magnitudes of both the amplification factor and the plate resistance have been effectively reduced by the factor $1/(\mu\beta + 1)$. Since the amplification factor and the plate resistance are shown to have been changed when feedback is present, it is possible to construct an equivalent characteristic for the tube under feedback conditions.

Figure 2 shows the plate characteristic for a rather high r_p power triode—the 807 triode connected. For cathode-follower operation the value of β is unity. Then for any cathode voltage e_o the feedback voltage e_f equals βe_o, which is e_o. A voltage of 300 on the cathode represents a feedback voltage of 300. Reference to (C) of *Fig.* 1 will show that the voltage

[1] C. J. Mitchell, "The cathode-follower output stage," *Wireless World*, April 1944, pp. 108–110.