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The AEROVOX Research Worker

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The Essential Factors in the Design of Receiver and Amplifier Systems

Part IV*

By the Engineering Department, Aerovox Wireless Corporation

A TRANSFORMER coupled amplifier is used when only low plate voltages are available and where it is desired to use but few tubes. From a single high-mu tube used in a resistance or impedance coupled stage and its associated input and output circuits a gain of about 20 can be obtained. From a single tube and associated input and output transformers a gain of from 60 to 100 can be obtained. As in the case of the resistance coupled amplifier, an analysis of the frequency response must be considered, from the standpoint first of low frequencies and second of high frequencies. Fig. 9 is the fundamental diagram of a single stage of transformer coupled audio amplification. Fig. 10 is the approximate equivalent circuit at low frequencies. In the latter circuit Mu Eg is the signal voltage in the plate circuit, Rp is the a. c. plate resistance of the tube, La is the leakage reactance of the transformer, L is

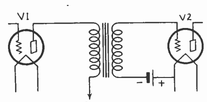

Fig. 9

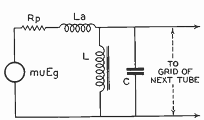

Fig. 10

NOTE: The first, second and third instalments of this article appeared in Vol. 3, Nos. 5, 6 and 7 of the Research Worker.

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the inductance of the primary of the transformer and C is the input capacity of V2 together with the distributed capacity of the transformer windings.

TABLE 2.

$\frac{Xl}{Rp}$	Percentage of total Voltage Across L
4.0	97
2.0	89
1.0	71
0.5	44.6

At low frequencies the reactance of C is very large in comparison with the reactance of L and therefore at low frequencies the available signal voltage divides between Rp and L. The percentage of the total voltage that appears across L depends upon the ratio of the reactance of L (Xl) to Rp and varies as indicated in column 2 of Table 2. Let us apply the same criteria to the performance of this transformer coupled circuit as were used in discussing the resistance coupled amplifier, and state that the voltage amplification at 50 cycles should not fall to less than 90 percent. From Table 2, we find that the reactance of L (Xl) should therefore be approximately twice as great as Rp at 50 cycles to maintain a voltage amplification of 90 percent. If the tube is a type 327 Rp will be approximately 10,000 ohms and therefore the reactance of L must be 20,000 ohms. The reactance of a coil is determined as follows:

$$Xl = 6.28fL$$

where
Xl is the reactance in ohms
f is the frequency in cycles per second
L is the inductance in henries.

In this case Xl must be 20,000 ohms when f is 50 cycles. Therefore L must be

$$L = \frac{20,000}{6.28 \times 50} = 66.6 \text{ henries}$$

Therefore a transformer which is to give 90 percent response at 50 cycles must have a primary inductance of about 67 henries. If the inductance of the primary is smaller the response falls off at low frequencies.

At high frequencies the reactance of L is very large in comparison with that of C and therefore the voltage divides between Rp, La and C, and L can be neglected. Essentially we then have a circuit consisting of Rp, La and C in series. At a certain frequency La and C will produce a resonant circuit, the overall impedance of the circuit will thereby be decreased, and more current will flow, tending to increase the voltage across C, which is the voltage applied to the following tube. However the voltage across C is inversely proportional to the frequency and this helps to prevent an undue rise. In some transformers, especially those made a few years back, there was a pronounced peak in the curve around the frequency at which La and C were resonant. The point at which resonance occurs should be made high in frequency, which means that the magnetic coupling between the windings must be practically complete.

To obtain good frequency response characteristics in a transformer coupled amplifier therefore it is necessary to use transformers having a high primary inductance, low leakage and low distributed capacity.

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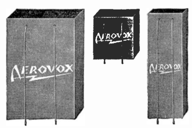

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