Multiple Speaker Matching

IN PUBLIC ADDRESS systems using a number of loudspeakers, it is considered good practice to regulate the amount of power delivered to each speaker in the system in accordance with its requirements. There are a number of ways in which this can be accomplished, but the simplest is by proper choice of impedance for the transformers matching the speaker to the line. With this method, no power is lost in resistance attenuators, and at high power levels every watt of power must be utilized most efficiently.

For most systems, the usual connection of the output lines puts the various loads in parallel across the output transformer. This simplifies the wiring, since all distribution lines branch out from the amplifier, and one pair of wires feeds each speaker or each line of speakers. When the speakers are arranged in a long loop, however, it may sometimes be more economical to feed them from a series circuit, so that a single lead can be used for the wiring. These two methods are shown in *Fig. 1* and *Fig. 2*, together with the formulas for calculating the required primary impedances. In these formulas, P_t represents the total available power, with $P_1, P_2, P_3 \ldots P_n$ representing the power delivered to each speaker; and Z_s represents the source impedance — which is the output impedance into which the amplifier is to feed — with $Z_1, Z_2, Z_3 \ldots Z_n$ representing the reflected primary impedance of the individual speaker transformers.

Slide Rule Method

Although the calculations for either type of connection are quite simple once they are reduced to these formulas, a recent attempt to simplify the problem even more by means of a chart indicated a slide-rule method for determining the correct impedances.

For the case where the parallel connection is to be used, let us consider the following example: The system in a small auditorium is capable of putting out a maximum of 15 watts at an impedance of 600 ohms; the stage speaker line requires 12 watts, a speaker in the lounge requires 2 watts, and a speaker in the manager's office requires 1 watt. What is the required primary impedance of each of the speaker matching transformers?

For the solution, each circuit is handled separately, using a slide rule for each computation. Opposite 15 on the *"D"* scale, representing the total available power, set 12 on the *"C"* scale, representing the power required for the stage speaker. Under 500 on the *"C"* scale, representing the output impedance of the amplifier, appears 625 on the *"D"* scale, which is the impedance of the primary of the speaker matching transformer, the secondary value being matched to the speaker itself. Similarly, for the lounge speaker, an impedance of 3,750 ohms is indicated; and for the manager's office, an impedance of 7,500 ohms is indicated. All three of these primary impedances are connected in parallel across the output circuit of the amplifier, and the resulting impedance is given by

$$Z = \frac{1}{\frac{1}{625} + \frac{1}{3{,}750} + \frac{1}{7{,}500}}$$

$$= 500 \text{ ohms.}$$

The calculations for the series speaker circuit are performed in a similar manner, except for the position of the two impedances on the slide rule. For the same problem as before, the settings for the power available (*"D"* scale) and for the individual load power required (*"C"* scale) are used, but the impedances are read from the opposite scales. Thus, the output impedance of the amplifier is on the *"D"* scale, and the required impedance for the matching transformer is directly above this value on the *"C"* scale. For the example, then, the three impedances are 400, 66.7, and 33.3 ohms, which, when connected in series, match the 500-ohm output of the amplifier.

The decimal point must be watched carefully in these calculations, as in all other slide rule uses. As an aid in this regard, it is simple to remember that all impedances are higher than the source for the parallel connection, and all are lower than the source for the series connection. Furthermore, it will be noted that if any speaker load is to receive more than one-half of the total power, the transformer impedance will be between one and two times the source impedance for the parallel connection. For the series connection, the transformer impedance for any line receiving more than one half of the total power will be greater than one half the source impedance.

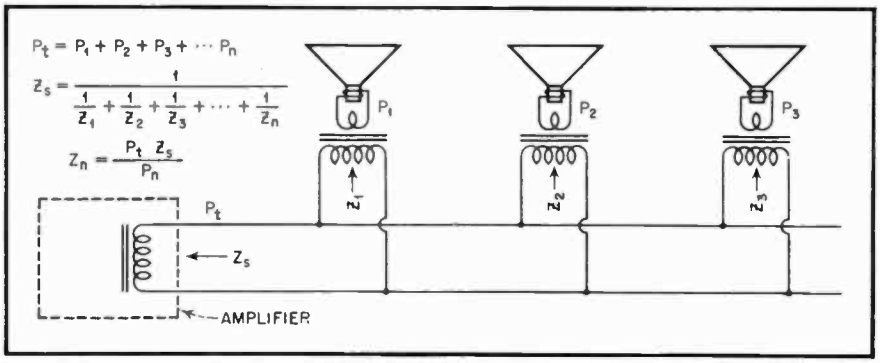

Fig. 1. Typical distribution system for number of speakers fed in parallel from the output of an amplifier. By adjusting the primary impedance of the transformers, the percentage of the total power fed to any individual speaker can be regulated.

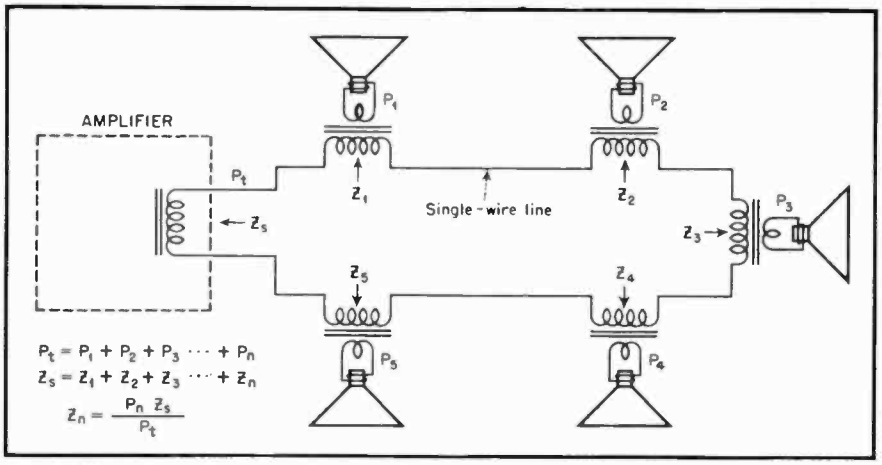

Fig. 2. Alternate method of feeding speakers by means of a series circuit. The use of a single line proves economical where the speakers are distributed in a loop, such as around a race track.