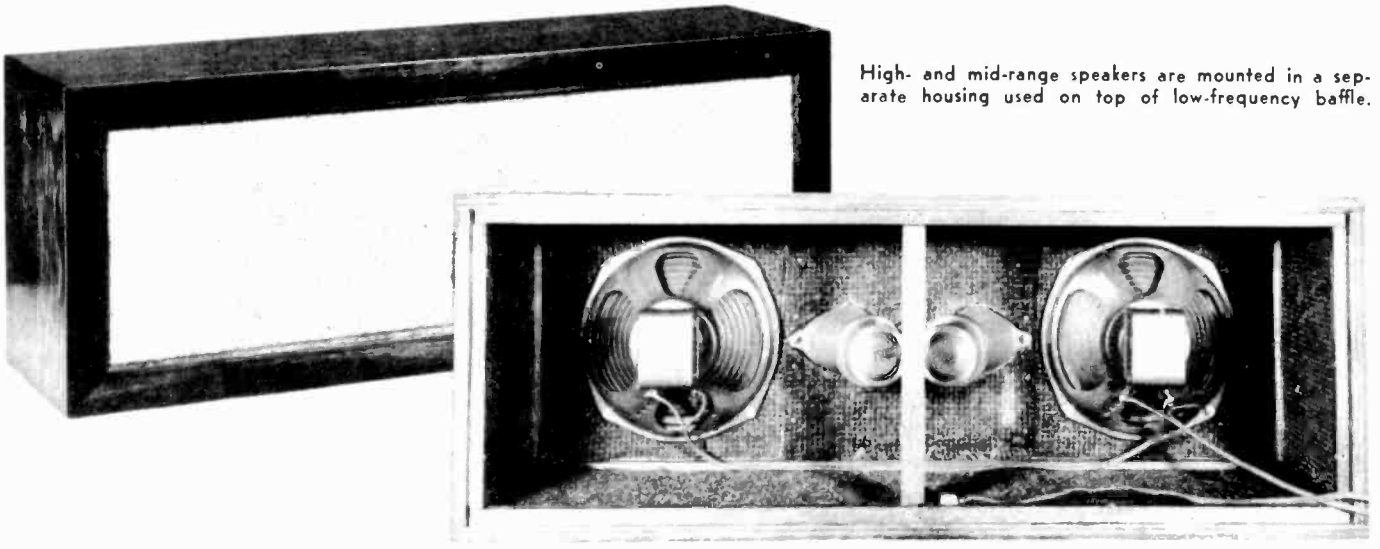

High- and mid-range speakers are mounted in a separate housing used on top of low-frequency baffle.

Three-Way Speaker System

GEORGE A. DOUGLAS

THE wide acceptance of some form of multiple speaker arrangement as a requisite of high-quality reproduction is responsible for a renewal of interest in three-way systems. The extraordinary strides made by dual speaker systems in the last few years has tended to a state of complacency and has resulted in obscuring somewhat the need for further experiment along these lines. The writer has been unable to find any published data on the three-way system, and has worked at the problem according to his own ideas—which may or may not be consistent with good engineering practice. However, the results attained with the system to be described should warrant serious consideration of the three-way system as a factor in tracking down the elusive will o' the wisp of realism in sound reproduction.

Theoretical discussion is not within the scope of this article other than to point up the desirability of limiting the coverage of single speakers to bandwidths within their capabilities, and utilizing as many as are deemed necessary to overcome as much as possible the shortcomings of each unit as regards mass, cone breakup, and other inherent deficiencies of design contributing to distortion. In a three-way system, these deficiencies are minimized in that each unit is called upon to deliver only within a range of about three octaves, a band well within the ability of any speaker of reasonably good quality. Besides permitting the use of a small unit in the upper band and thereby reducing the effects of mass, a separate middle frequency speaker allows the choice of a very low cross-over without the excessive cost of a comparative dual system, and restricts the low frequency speaker to operation within optimum limits.

Components

A three-way system was constructed along the same lines as the conventional two-way system, design data being merely extended to include an additional speaker. The existing reproducer, a 15″ cone in a large cabinet, became the low frequency unit without modification. Eight inch cones serve in the mid section, two being used to provide sufficient power-handling capacity. In this connection, a horn type speaker was considered, and might have been used if a suitable one had been available. However, the cones were convenient and have proven satisfactory. The upper range is adequately taken care of by the dual horn unit shown in the photograph. It has excellent horizontal and vertical distribution with a manufacturer's rating of 12 watts and response to 15,000 cycles.

Figure 1 shows the manner in which the filters are arranged to provide the cross-overs. Two series type dividing networks are cascaded to form the low-pass, band-pass, and high-pass transmission characteristic of *Fig. 2*. Economy and the limitations of the speakers were factors in the choice of cross-over points at 500 and 3000 cycles.

The cabinet shown in the photograph was constructed to house the upper and middle frequency speakers. No difficulty due to relative positioning was experienced. At 3000 cycles the distance involved is so small that the units could all be mounted flush and phasing accomplished by observing polarity. The small cabinet, on top of the large baffle, may be placed to advantage with reference to the low frequency speaker.

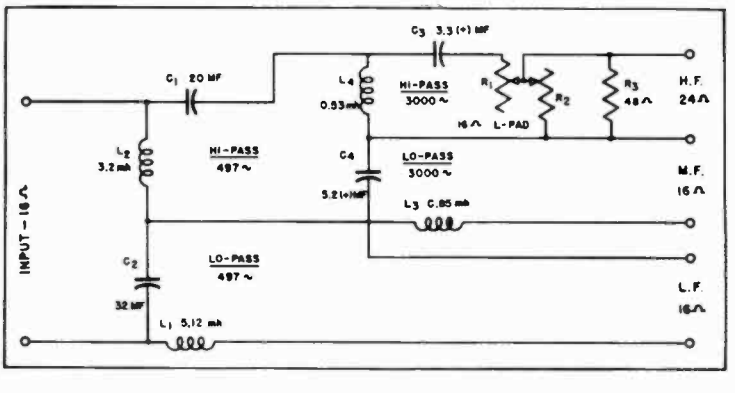

Fig. 1. Schematic showing circuit of the cross-over networks.

Constructional Data

In the design of the dividing networks, the configuration and accompanying data described fully in the article commencing on page 101, were followed. Flanges for the coil forms were made by cutting discs of one-eighth inch masonite with a circle cutter, the edge of the tool being reversed so that the bevel does not appear on the disc. One and one-quarter inch dowel stock in lengths of three quarters and one and one quarter inches served as cores. The flanges are glued to the core, being held in place with a small wood screw until the glue is dry, after which the screw is taken out.

Using No. 17 DCE wire, coil specifications are approximately as follows:

Inductance MH	Winding Space	Turns
5.12	1.25	375
3.2	1.25	315
.85	.75	140
.53	.75	115

Capacitors were assumed to be reasonably accurate and were used to check the coils with the aid of an audio oscillator. It will be noted in the circuit diagram that each pair of inverse reactances are resonant at the cross-over frequency. Connected in series across the output of the oscillator, it was only necessary to alter the inductance until the point of greatest attenuation coincided with the cross-over frequency. Thus the pairs *L1* and *C1*, and *L2* and *C2*, are resonant at 500 cycles; *L3* and *C3*, and *L4* and *C4* resonate at 3000 cycles. Components were calculated for an *Ro* of 16 ohms, and in the case of the lower network, the cross-over point was fixed at 497 cycles to arrive at standard capacitor values.

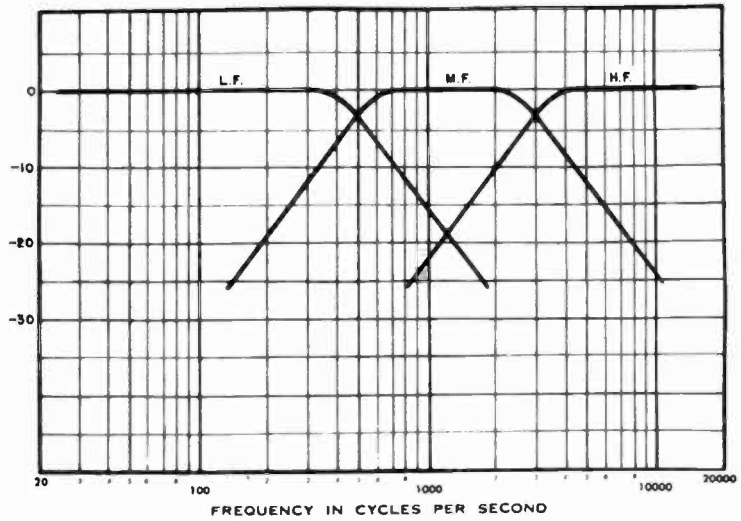

Fig. 2. Transmission characteristic of the dividing networks shown in Fig. 1.

This slight shift can be ignored and is only mentioned as a point of information. An eight-ohm L pad is connected as shown in the h-f output, the resistor, *R1* changing the pad impedance to 16 ohms and at the same time reducing the maximum attenuation possible to 6 db.

The small cabinet is of plywood and was constructed with no particular attention to acoustical considerations other than to build it solidly and of ample proportions, and to partially line it with felt. Open mesh grill cloth covers the entire front panel, enhancing the appearance by concealing the speaker openings. On the rear panel is the h-f level control and two jacks for convenient access to speaker leads.

Phasing

The pairs of speakers in the upper and mid sections were each connected in series and phased separately before connection to the outputs of the dividing network. Then, with all speakers in the circuit and the entire system connected to the amplifier, 3000 cycle response was measured with a microphone and VU meter. Maintaining a constant level, the h-f leads were reversed and the two meter readings compared. Maximum indication occurred when the high- and mid-frequency speakers were correctly phased. As mentioned before, the relative position of the upper and middle speakers was found to be approximately correct when both are mounted on the front panel in the usual manner.

Using a 500-cycle signal, the same procedure was followed with the low and mid frequency speakers. In addition it was necessary to locate the small cabinet by sliding it backward and forward for maximum response.