TWO-WAY SPEAKERS

From Commercial Components

Assembly directions for adding tweeters to cone speakers to give better reproduction.

WHILE the two-way speaker system may well be considered the ideal for sound reproduction, it is a costly device if purchased as a factory-built item, or it requires considerable work if entirely home built. The principal problem centers around the construction of the high-frequency horn. Once this is solved, the assembly of a good quality speaker system can be accomplished easily. Fortunately, several manufacturers have taken steps to solve this very problem, and a two-way speaker can now be a working reality without any sheet metal work, and with a minimum of measurement and adjustment.

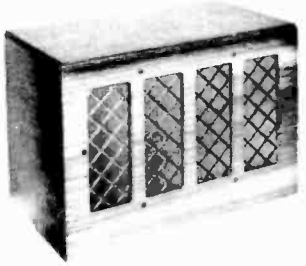

Fig. 1. Atlas HF-1 high-frequency speaker assembly, which includes its own dividing network in the cabinet which is designed to be placed on top of radio or speaker cabinet.

Atlas High-Frequency Speaker

One of the simplest methods of assembling a two-way speaker system is to employ an Atlas HF-1 speaker with an existing cone speaker in its normal baffle. This model of "tweeter" is made in the form of an attractive cabinet, shown in *Fig.* 1, which is intended to rest on top of a radio or a speaker enclosure. The dividing network is included in the HF-1 cabinet, and all that is necessary is to remove the present leads from the loudspeaker, connect them to the dividing network chassis, and run another pair of leads from the chassis to the loudspeaker. That is all there is to it. Phasing adjustments may be made by moving the entire cabinet backward or forward, and the balance between lows and highs is made by a control mounted on the dividing network chassis.

This unit is designed for an impedance of 8 ohms, which is a common value in better grade cone speakers, and works at a cross-over frequency of 1,400 cps. The h-f horn is made of cast aluminum to avoid resonances, and a moulded phenolic diaphragm is used; the magnet is Alnico V. The constant-resistance dividing network is of the parallel configuration.

This is an ideal unit when used with any good low-frequency cone as a "woofer." Users should be cautioned about the correct balance between the two speakers, since the action of the control is not similar to that of a tone control. *Figure* 2 shows the output resulting from adjustment of the control. The entire band above the cross-over frequency is raised or lowered, putting a step in the response curve. The dotted line shows the action of a normal tone control. With the tone control of the amplifier or receiver in the "flat" position, the balance adjustment should be set for normal reproduction.

One advantage of the Atlas unit is that it is supplied with the dividing network already built in. While these networks are not difficult to construct if suitable measuring equipment is available, it is at least more convenient to have it already made. Some means for preventing the low frequen-

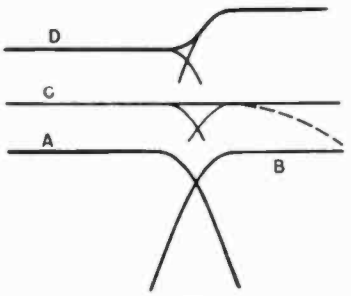

Fig. 2. Curves resulting from various components of speaker system. (A) is output of woofer; (B) is output of tweeter; (C) combined output of system when properly adjusted; (D) output when tweeter gets too much signal. Dotted line indicates action of normal tone control.

Fig. 3. University Model 4407 tweeter assembly, with adapter ring.

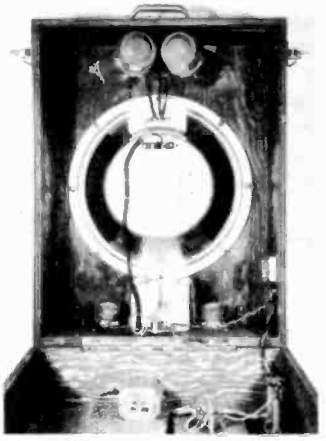

Fig. 4. Experimental assembly of 12" cone and University Model 4402, with dividing network and impedance-matching input transformer.

cies from reaching the diaphragm of the h-f unit is necessary, and while this may be done by the use of a series capacitor, the network also removes the high frequencies from the woofer, preventing cone breakup and avoiding the possibility of phase cancellation at the higher frequencies.

If the user desires, the h-f horn may be removed from the cabinet and mounted inside a speaker baffle, since the horn is flat along the front surface, and is equipped with flanges by which it may be mounted on a flat surface. This begins to require some constructional work, however, which is completely avoided if the unit is used in its own cabinet.

University Models

Another equally simple method is to add a Model 4404 University Dual Tweeter to an existing low-frequency speaker and baffle. This unit, somewhat smaller than the Atlas, also comes with its own cabinet, and with a high-pass filter and balancing potentiometer built in. Two small horns are used, each with its own driver, and they reinforce the woofer above about 2,000 cps. Since the filter consists solely of a series capacitor, low frequencies are kept off the h-f unit, and it is adequately protected.

Another University unit, Model 4407, is shown in *Fig.* 3. It consists of a 12" adapter ring which is used as a spacer between a 12" cone speaker and the baffle, setting the cone back far enough to accommodate a single small horn unit which mounts on a metal strap across the back surface of the adapter ring. To install this unit, it is only necessary to remove the cone from its baffle, assemble the h-f unit and horn to the strap, and attach the cone to the adapter ring. The entire assembly is then remounted on the baffle, and a two-way system results. The same type of high-pass filter may be used with this arrangement, or a separate dividing network may be built.

The single unit and horn, Model 4401, may be installed directly on a speaker baffle; or the dual unit, Model 4402, consisting of two similar horns made as a single casting and set at an angle of approximately 30° may be used, the latter giving somewhat better spatial distribution of the high frequencies. This type of mounting entails more work, but the final results are generally more satisfactory. The impedance of each driver unit is 12 ohms, and they may be connected either in parallel or in series, depending upon the impedance of the woofer with which they are to be used. *Figure* 4 shows an experimental two-way system using a 12" Stromberg-Carlson cone and the dual tweeter, together with a dividing network operating at a 2,000-cps crossover. This box, although too small for good bass response, also incorporates a tranformer and switch, and provides input impedances ranging from 8 to 10,000 ohms, making it a general purpose test speaker. The schematic is shown in *Fig.* 5.

The Racon Two-Cell Horn

Still another model is available commercially to provide a simple assembly of a good system. This is the Racon two-cell horn and the unit designed to work with it. This combination operates at a cross-over frequency of 1,200 cps, and requires a dividing network for best results, although a series capacitor will protect the driver unit sufficiently. If this model is employed, it is necessary to provide a suitable means for mounting, such as cutting an opening in the baffle or woofer cabinet.

Any one of these three methods will give added brilliance and definition to reproduction from a high quality amplifier or radio receiver. It must be remembered that additional h-f output will tend to show up any distortion in the amplifier, so it is important to reduce distortion to a minimum when adding a separate high-frequency speaker.

In this connection, it is well to mention one fault common to many two-way speaker system users. Having a means for reproducing highs well, it is not unusual for systems to be operated with an unbalance between the two units, on the apparent theory that "now we have a tweeter so you're going to hear highs!" Good reproduction should be based on the proper balance between treble and bass, with the principal benefit being gained in a truer response in the upper middle range—1,500 to 4,000 cps.

Dividing Networks

The most satisfactory operation of any two-way speaker system will be obtained if a dividing network is employed because of the fact that the sound then comes from either the woofer *or* the tweeter (except right in the crossover range) rather than from the woofer only in the lower ranges and from both together in the upper range. It is definitely recommended that the

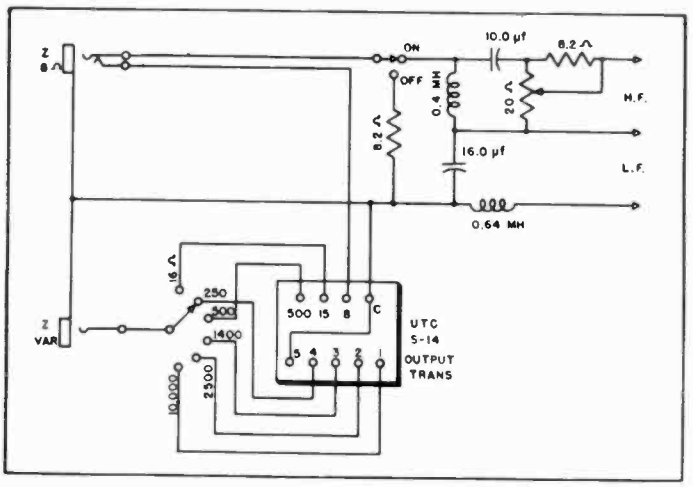

Fig. 5 (left). Schematic of speaker shown in Fig. 4.

TABLE I

DIVIDING NETWORK COMPONENTS

INPUT Z	TWEETERS TYPE	TWEETERS Z	f_c cps	L1 mh	L2 mh	C1 uf	C2 uf	R1 ohms
8	1-UNIV	12	2,000	.636	398	9.95	15.9	10
	2-UNIV	6*	2,000	.636	398	9.95	15.9	15
	RACON	15	1,200	1.06	.662	16.6	26.6	10
10	1-UNIV	12	2,000	.795	.497	7.95	12.7	15
	2-UNIV	24	2,000	.795	.497	7.95	12.7	10
	RACON	15	1,200	1.32	.825	13.2	21.1	15
12	1-UNIV	12	2,000	.955	.596	6.64	10.6	20
	2-UNIV	24	2,000	.955	.596	6.64	10.6	15
	RACON	15	1,200	1.59	.995	11.0	17.6	15
15-16	1-UNIV	12	2,000	1.25	.782	5.07	8.11	30
	2-UNIV	24	2,000	1.25	.782	5.07	8.11	20
	RACON	15	1,200	2.08	1.30	8.45	13.5	25

* UNITS IN PARALLEL

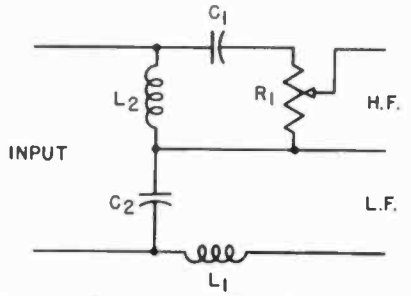

Fig. 6. Crossover network configuration for which values are given in Table I.

extra effort be expended to construct the network because of the improved performance.

Table I shows the components to be used with single or dual University tweeters, or with the Racon two-cell horn and unit, with 8-, 10-, 12-, and 15- or 16-ohm woofers. Since the cross-over network is an integral part of the Atlas unit, it is not necessary to build one if this model is used.

The configuration for the network is shown in *Fig.* 6. There are a number of usable configurations, but the one shown is best suited for this purpose since the phasing for the two speakers is most nearly correct at crossover when the horns are mounted on the same baffle as the woofer. The component values were calculated from the formulas:

$$L_1 = \frac{R_e}{2\pi f_c} \text{ henries}$$

$$L_2 = \frac{L_1}{1.6} \text{ henries}$$

$$C_1 = \frac{1}{2\pi f_c R_e} \text{ farads}$$

$$C_2 = 1.6C_1 \text{ farads}$$

where R_e is the impedance of the network, and f_c is the cross-over frequency.

The values for the balancing potentiometer, R_1, were determined for the condition where the h-f speaker is 6 db more efficient than the cone, which is about normal for average cone speakers and the nearest standard value is listed in the table. A 10-watt resistor with an adjustable tap is ideal for this application, since it should be set when the system is assembled and then left at the optimum position. Impedance changes resulting from this method of adjustment will not affect the performance noticeably.

As to making the inductances, close approximations can be obtained if a certain size of wooden spool is used and specific winding directions are followed for a given wire size. For these values of inductance, a suitable spool size has a core 1-¼" in diameter and offers a ¾" winding space. With No. 16 enameled wire, laid thirteen turns per layer, the total number of turns required for the listed inductances are shown in the curve of *Fig.* 7. No iron should be used in constructing the spools, and they should be mounted with brass screws through the center. One pound of wire will make both of the coils for any combination shown except the last one in the table, which will require almost 1½ pounds.

Paper capacitors must be used for these networks, and low-voltage types are quite acceptable, since there will never be more than 25 volts across them, even at 30-watt levels. Many of the surplus houses list suitable values at low prices. If it is not possible to obtain a single capacitor of the desired value, the total may be built up by connecting smaller values in parallel.

Performance Tests

In order to make comparisons of the performance of these systems, two types were assembled. *Figure* 8 shows a single baffle using the Racon unit with a 15-inch Jensen cone while the dual University tweeter and a 12-inch cone were shown in *Fig.* 4. For testing, the Racon-Jensen combination was mounted on a 6 cu. ft. enclosure and the response measured using a warble-tone frequency record through a flat amplifier as the source, the sound output measurement being made with an Electro-Voice Model 630 dynamic microphone working directly into a high impedance a-f voltmeter. This microphone has an excellent response up to around 11,000 cps and is quite adequate for measurements of fair accuracy.

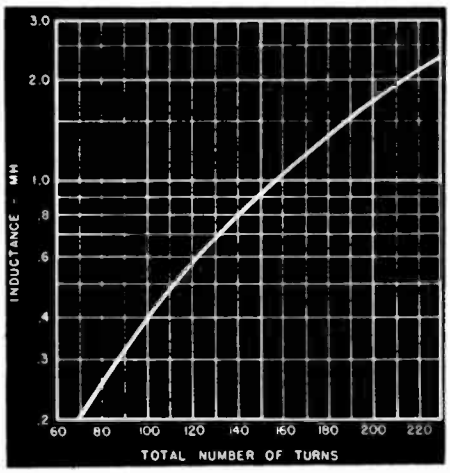

Fig. 7. Chart for determining number of turns to give inductance values necessary for various networks. This chart applies to coils wound on 1¼" core of wooden spool to a width of ¾", using #16 enameled wire with 13 turns per layer.

Fig. 8. Baffle with two-cell Racon horn and 15" Jensen cone and dividing network for 1,200-cps crossover frequency.

The smaller unit was measured in its cabinet and the Atlas unit was connected with the Jensen speaker, using the Atlas dividing network and with the Racon unit disconnected. After adjusting levels, the runs were made, and the results were consistently flat with all models. All three units gave appreciable output up to 13,000 cps, so the h-f performance was quite acceptable throughout. Naturally, the small box was deficient in the lower register, due to its inadequate size. The measuring set-up is certainly open to question, since all measurements were made in a normal living room, but the principal reason for making them was to check performance through the cross-over region. Further checks were made with an oscillator, but standing waves made these measurements less reliable.

Subjectively, the two systems with the lower cross-over had more presence on speech than the University model, but on music there was little noticeable difference—except for the poorer bass from the small box, which is only 14"x18"x7" inside. However, any of the three systems was noticeably more realistic than a good single speaker, and the time spent in assembling any of the types will be well repaid in listening pleasure.

Additional Notes

Since this article was originally published, several changes have taken place in the components field, and there is now a greater variety of speakers available with which to assemble a system of this type. The University line has added a new horn designed for a crossover at 600 cps, along with an already-assembled network. A similar network is also available for a 2000-cps crossover, and both consist of a capacitor and an inductance, which is superior to a single capacitor in that it eliminates the high frequencies from the low-frequency cone in addition to eliminating the lows from the tweeter. A new Atlas horn is also available in a design which makes it simple to mount in a baffle. Several new models of l-f cones have been introduced, one of the most notable being the RCA MI-6269A, a 10-inch accordion cone of exceptional bass range.