

6.3. Multiple Single-Cone, Single-Coil Loudspeaker.— Several arrangements for obtaining uniform response, broad directional pattern, adequate power handling capacity, and tolerable efficiency are shown in Fig. 6.12.

The systems of Fig. 6.12A, C, and D consist of a large diameter heavy cone driven by large voice coil for the low-frequency range and a small

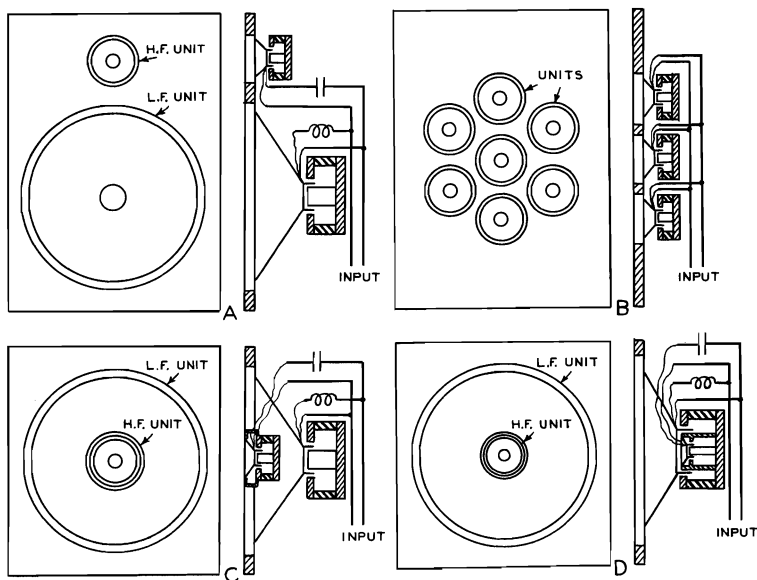


FIG. 6.12. Multiple single-cone, single-coil, direct radiator, dynamic, loudspeaker systems. A, C, and D. Large low-frequency unit, small high-frequency unit, and filter system. B. Seven small units connected in parallel.

diameter light cone and small voice coil for the high-frequency range and a filter system for allocating the power in the high- and low-frequency ranges to the respective low- and high-frequency units. The filter system consists of an inductance in series with the low-frequency unit and a condenser in series with the high-frequency unit. Due to the large inductance of the large voice coil, as shown in Fig. 6.6, it has been found that for most applications the inductance in series with the low-frequency unit may be omitted. On the other hand, if a more elaborate filter system is required, the circuit of Fig. 7.16 may be used.

In Fig. 6.12A the low- and high-frequency units are separated by a relatively large distance. In the overlap frequency region this distance may be more than 1 wavelength. The directional patterns of two sources shown in Fig. 2.3 are applicable to this system. These characteristics show that two separated sources exhibit directional patterns with one or more lobes with very low response between the lobes. The result is frequency discrimination, for points removed from the axis, in the overlap region. This condition is reduced in Fig. 6.12C but is not eliminated. However, a disadvantage of the system of Fig. 6.12C is that sound diffracts around the high-frequency unit and is reflected from the large cone causing a ragged response due to interference between the direct and reflected sound.

The objectional features of Fig. 6.12A and C referred to above have been eliminated in Fig. 6.12D. In this system⁷ the large cone is geometrically a continuation of the small cone. Therefore, in the overlap

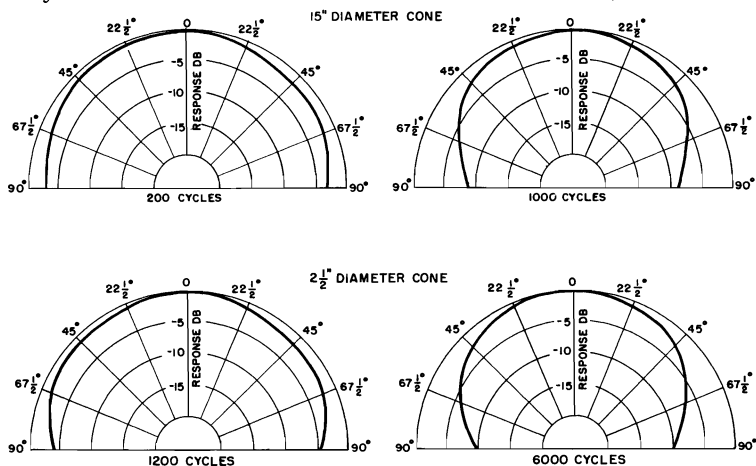


FIG. 6.13. Directional characteristics of direct radiator loudspeakers with cone diameters of 15 inches and 2.5 inches.

region the two cones vibrate together as a single cone. In this way phase and diffraction effects are eliminated.

In a two-unit loudspeaker, employing a large cone for the reproduction of the low-frequency range and a small cone for the reproduction of the high-frequency range, a uniform directivity pattern can be obtained over the entire audio-frequency range. This has been described in connection with Figs. 6.6 and 6.7. This is illustrated further in Fig. 6.13 in which the directivity patterns of 15-inch and 2½-inch cone loudspeakers are compared for a six to one ratio of frequency, that is, for a constant ratio of diameter to wavelength. Fig. 6.13 shows that the directivity pattern of a 15-inch loudspeaker at 200 to 1000 cycles corresponds to that of a 2½-inch

⁷ Olson and Preston, *RCA Review*, Vol. 7, No. 2, p. 155, 1946.

loudspeaker at 1200 and 6000 cycles. These relationships were used in designing the two units of the system shown in Fig. 6.12D.

In the loudspeaker^{8,9} shown in Fig. 6.12D, small cones may be attached to the large cone to reduce the velocity of wave propagation in the large cone. Fig. 6.14. This broadens the directivity pattern of the low-frequency cone. In the high-frequency range, the conical domes attached to the surface of the low-frequency cone improve the performance in three ways: by decreasing the angle into which the high-frequency cone feeds, thereby increasing the output of the high-frequency cone; by diffusely reflecting some of the sound emitted by the high-frequency cone, thereby eliminating discrete reflections; and by diffracting some of the sound emitted by the high-frequency cone, thereby broadening the directivity pattern.

The angles into which the high-frequency cone feeds, without and with the conical domes applied to the low-frequency cone of Fig. 6.14, are designated as ϕ_1 and ϕ_2 in Fig. 6.15A and Fig. 6.15B. Since ϕ_2 is smaller than ϕ_1 , the acoustic radiation load upon the cone is greater with the conical domes than without them. When the acoustic radiation load upon a direct radiator loudspeaker is increased, the sound power output is increased. Thus, it will be seen that the conical domes increase the high-frequency sound radiated by the high-frequency cone. In other words, the high-frequency efficiency is improved.

Some of the sound emitted by the high-frequency cone is diffusely reflected by the conical domes, as shown in Fig. 6.16. Without the domes, there would be many similar reflections which would lead to reinforcements and cancellations with the direct radiation. The result would be corresponding peaks and dips in the response of the high-frequency cone. With the domes, the symmetry of the low-frequency cone is upset and there are many reflections in different directions and of different path lengths. The reflections, therefore, cancel out and the net result is a smooth response-frequency characteristic.

Some of the sound emitted by the high-frequency cone is diffracted by the conical domes as shown in Fig. 6.17. By diffraction is meant the bending

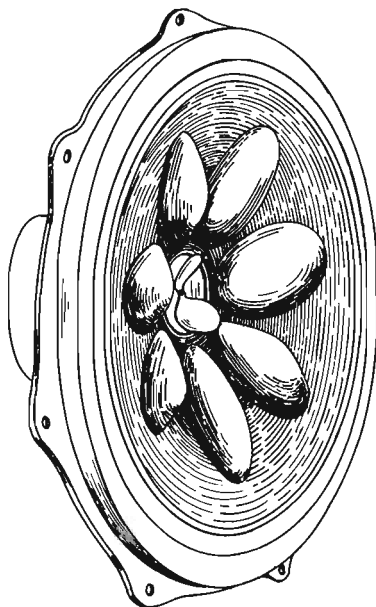


FIG. 6.14. A perspective view of a duo-cone loudspeaker with domes attached to the low-frequency cone. (After Olson, Preston, and May.)

⁸ Olson, H. F., *Radio and Television News*, Vol. 51, No. 2, p. 69, 1954.

⁹ Olson, Preston, and May, *Jour. Aud. Eng. Soc.*, Vol. 2, No. 4, p. 219, 1954.

of the sound around an obstacle. The pencils of sound designated 1 and 2 in Fig. 6.17 are diffracted. The pencils of sound designated 3 to 7, inclusive, are radiated directly from the high-frequency cone. It will be seen that the effect of the diffracted sound is to increase the curvature of the wavefront in the direction of 1, 2, and 3. As a result, the directivity pattern is broadened.

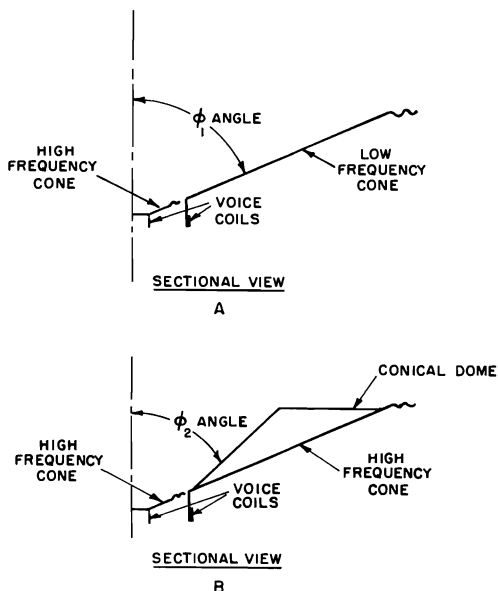


FIG. 6.15. A. Duo-cone loudspeaker with a plain low-frequency cone. B. Duo-cone loudspeaker with domes attached to the low-frequency cone.

Referring to Figs. 6.2 and 6.9 it will be seen that uniform response may be obtained over a wide frequency range by means of a light cone driven by a light coil and resonant at the lower limit of the frequency range. Of course, the power handling capacity of a single unit of this type is inadequate and a multiple set of units must be employed. The number of units required may be determined from the required power output and the allowable excursion together with equation 6.13 and Fig. 6.10. An arrangement of seven small loudspeaker units mounted in a flat baffle with the voice coils connected in parallel is shown in Fig. 6.12B. The voice coils of the loudspeakers may, of course, be connected in parallel, series, or series-parallel. In order to obtain better high-frequency spatial distribution the units may be inclined at various angles, for example, the units may be mounted so that the resulting vibrating surface approximates a spherical surface (see Sec. 2.20).

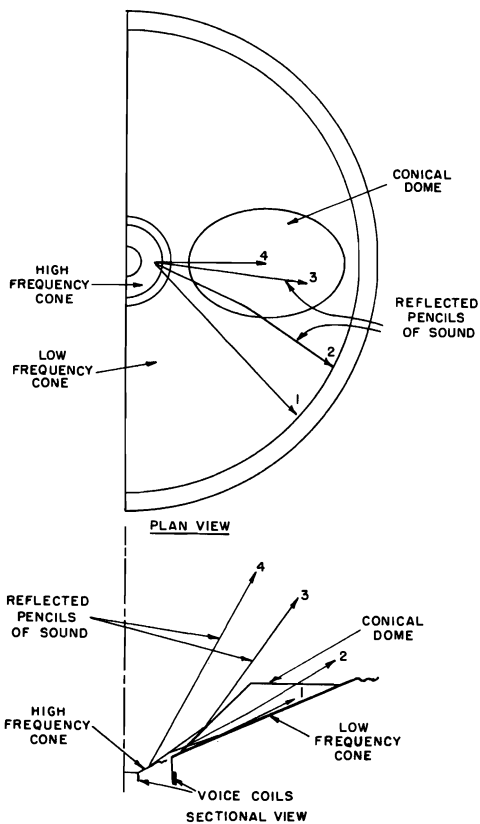


FIG. 6.16. Diffuse reflections of the sound emitted by the high-frequency cone by the domes attached to the low-frequency cone.

The frequency range of a direct radiator loudspeaker may be increased by sectionalizing the coil or cone or both and thereby reducing the mechanical impedance and electrical impedance or both at the higher frequencies. These systems will be considered in the sections which follow.

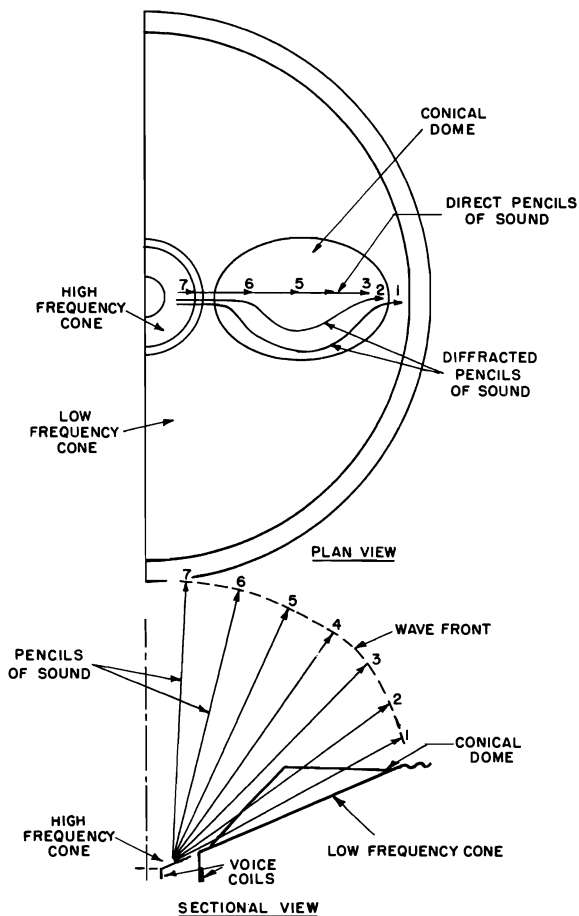


FIG. 6.17. Diffraction of the sound emitted by the high-frequency cone by the domes attached to the low-frequency cone.