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Direct Radiator Loudspeaker Enclosures

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A comprehensive analysis of the effect of cabinet configuration on the sound distribution pattern and overall response-frequency characteristics of loudspeakers.

THE PRINCIPAL FACTORS which influence the performance of a direct-radiator loudspeaker are the mechanism itself, the acoustical impedance presented to the back of the mechanism by the enclosure, and the outside configuration of the enclosure. The major portion of the work involving cabinet research, development, and manufacture has been directed towards the acoustical impedance presented to the back of the loudspeaker mechanism by the enclosure. The volume of the cabinet and the internal damping means play the most important role in determining the acoustical impedance presented to the back of the loudspeaker. In other words, most of the considerations concerning the design of cabinets for direct-radiator loudspeakers have involved the volume or overall dimensions of the cabinet which—together with the mechanism—determines the low-frequency performance. The third factor, namely, the exterior configuration of the cabinet, influences the response of the loudspeaker system due to diffraction effects produced by the various surface contours of the cabinet. The diffraction effects are usually overlooked and the anomalies in response are unjustly attributed to the loudspeaker mechanism. Therefore, in order to point up the effects of diffraction, it appeared desirable to obtain the performance of a direct-radiator loudspeaker mechanism in such fundamental shapes as the sphere, hemisphere, cylinder, cube, rectangular parallelepiped, cone, double cone, pyramid, and double pyramid. It is the purpose of this paper to present the results of the diffraction studies made upon these fundamental shapes. The response-frequency characteristics of a direct-radiator loudspeaker mechanism mounted in these different housings yield fundamental information regarding the effect of the outside configuration of the cabinet upon the performance of this combination. From this study it is possible to evolve a cabinet shape which has the least effect in modifying the fundamental performance of a direct-radiator loudspeaker mechanism.

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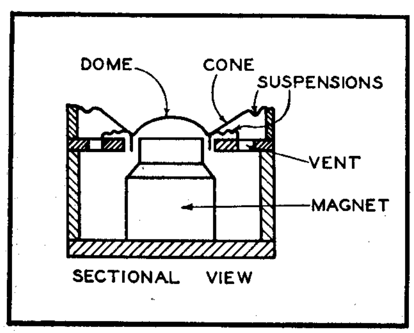

Fig. 1. Sectional view of the loudspeaker mechanism.

Characteristics of the Sound Source

In the experimental determination of the performance of direct-radiator loudspeaker mechanisms in various shaped enclosures, some consideration must be given to the radiating system. These considerations include the directional characteristics of the sound source and the sound power output characteristics of the sound source as a function of the frequency.

In order to obtain the true diffraction effects which are produced by the different enclosures, the radiation emitted by the sound source must be independent of the direction. Since the diaphragm of the direct-radiator loudspeaker mechanism used in these tests is relatively very small, it can be assumed that it is a piston source. The directional characteristics of a piston source are given by

$$R_\alpha = \frac{2J_1\left(\frac{2\pi R}{\lambda}\sin\alpha\right)}{\frac{2\pi R}{\lambda}\sin\alpha} \qquad (1)$$

where R_α = ratio of the pressure for an angle α to the pressure for an angle $\alpha = 0$,

J_1 = Bessel function of the first order,

R = radius of the piston, in centimeters,

α = angle between the axis of the piston and the line joining the point of observation and the center of the piston, and

λ = wavelength, in centimeters.

The upper frequency limit for this investigation will be placed at 4000 cps. The reason for selecting this limit is that the enclosures which will be used are relatively large. For example, the linear dimensions are eight to ten wavelengths at 4000 cps. It will be stipulated that the radiation from the cone of the loudspeaker mechanism at this frequency shall be down not more than 1.0 db for $\alpha = 90$ deg. as compared to $\alpha = 0$ deg. This insures a reasonably nondirectional sound source even at the upper end of the frequency range, that is, at 4000 cps. Of course, at lower frequencies the response discrepancy with respect to angle is much less. To satisfy the above requirements, the diameter of the diaphragm or cone must be ⅞ in. Accordingly a small direct-radiator loudspeaker mechanism employing a cone ⅞ in. in diameter was designed, built, and tested. A sectional view of the loudspeaker mechanism is shown in *Fig.* 1. Measurements indicated that the directional performance agreed with that predicted by equation (*1*).

The next consideration is the sound

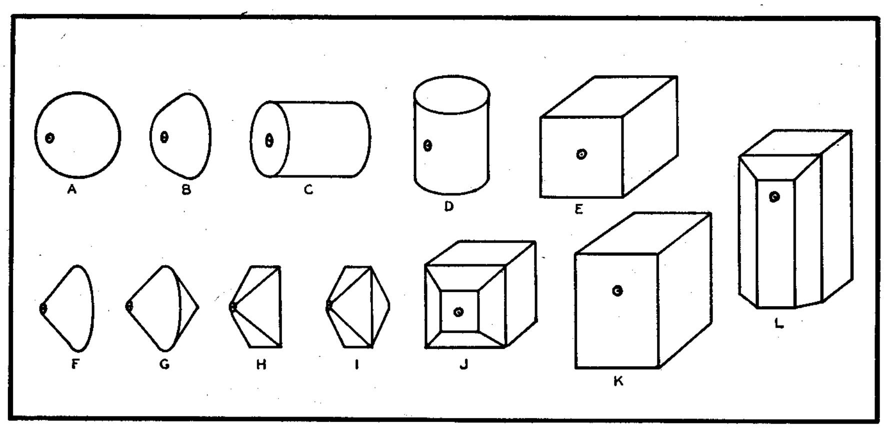

Fig. 2. Direct-radiator loudspeaker mechanism enclosures. The small circle with the dot in the center represents the speaker unit.