Dec. 18, 1962 A. A. W. J. VAN HEDEL 3,068,955

DEVICE FOR THE RADIATION OF SOUND WAVES

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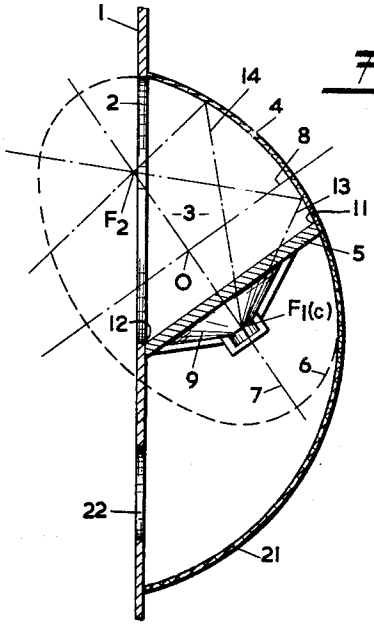
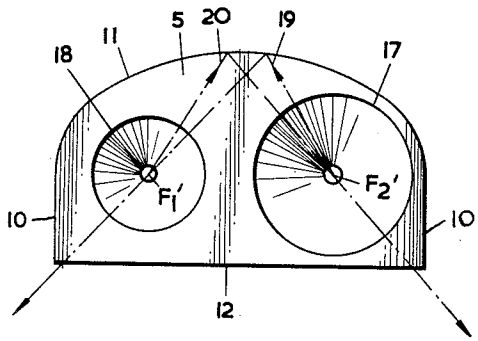


Fig. 1

Fig. 2



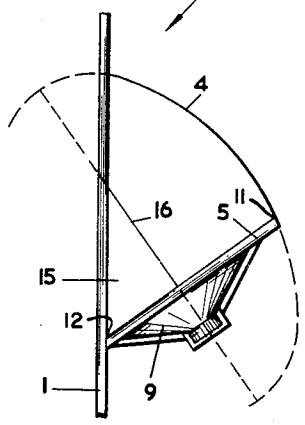


Fig. 3

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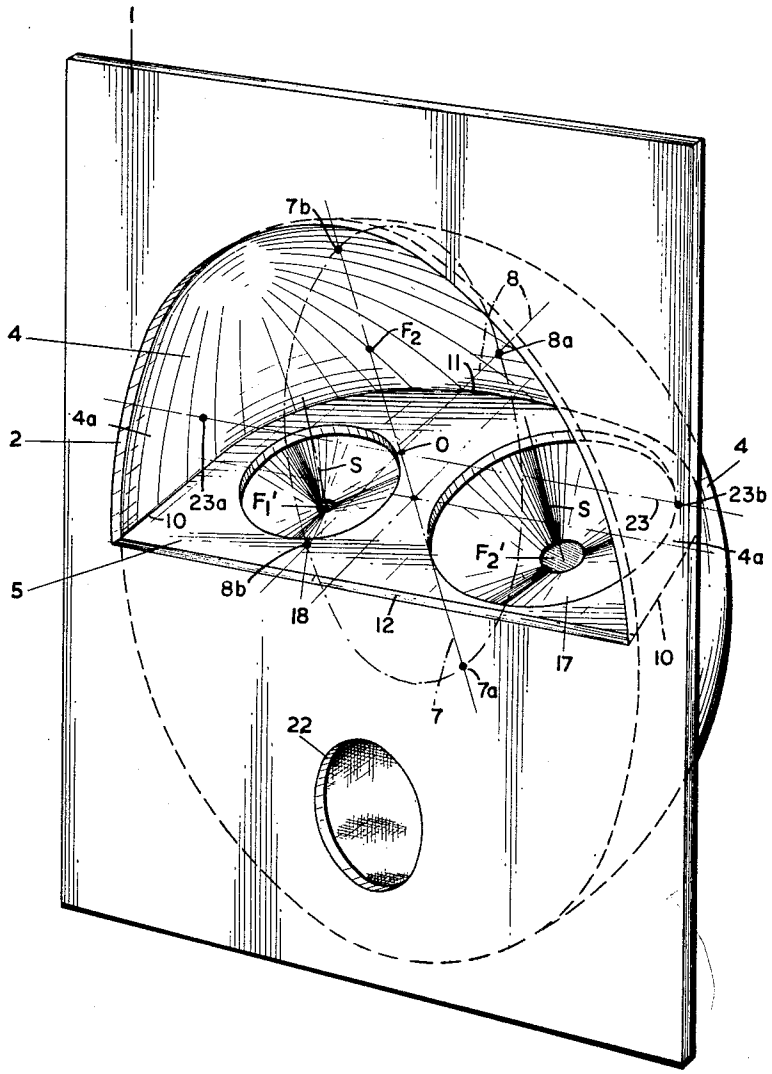
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FIG. 4



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DEVICE FOR THE RADIATION OF SOUND WAVES

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This invention relates to an improved construction for apparatus for radiating sound waves from a source of sound such as, for example, the well known type of conical diaphragm loud-speaker. More particularly, the invention relates to an improved arrangement for a plurality of loud-speakers in combination with a shell-like reflecting surface therefor constituted by a portion of an elliptically generated surface.

An object of the invention is to provide an improved arrangement for loud-speakers and a partially ellipsoidal shell-like reflecting surface therefor which provides a more realistic reproduction of the sound thereby enhancing the pleasure of listening. The improved construction is not to be confused with a stereophonic system but the arrangement of the two loud-speakers in combination with the ellipsoidal reflector surface is such that the mixing effect of the sound waves emanating from both loud-speakers gives the listener the distinct impression that it originates from a single loud-speaker but with considerable depth which enhances the overall, desirable "spatial" acoustical effect imparted to the listener and which approximates the actual rendering of, e.g. music in a concert room in an excellent manner.

The two loud-speakers may be either of the same or similar characteristics and dimensions so far as diaphragm size is concerned or they may have different dimensions and characteristics. One loud-speaker may be of comparatively large size to reproduce particularly well the lower frequency tones and the other loud-speaker may be of considerably smaller size so as to similarly well produce the tones in the upper frequency range. It is also possible to employ loud-speakers of the same size if their response over the whole frequency range to be produced is sufficiently good.

The use of a loud-speaker in conjunction with an ellipsoidal type of reflecting surface is not broadly new but one prior known construction is subject to disadvantages. For example, in British Patent No. 719,969 dated December 8, 1954, and which was granted to the Societe "Elipson," a single loud-speaker is fitted with a reflector which has, at least partly, the shape of part of an ellipsoid of revolution. The lower end of the reflector is terminated by a bottom wall in which is mounted the loud-speaker. The sound radiating member, i.e. the cone of the loud-speaker is so located that its apex, which is the point forming the virtual acoustic source is located at an adjacent focus of the ellipsoid whereas the other focus lies outside of the reflecting surface. Moreover, the axis of symmetry of the sound radiating member of the loud-speaker makes an acute angle with a line joining the two foci of the ellipsoid, and thus intersects the surface of the reflector with the result that a major portion of the high frequency tones is affected by the reflector and leads to a certain amount of acoustic separation between the high and low frequency tones which results, under some circumstances, in a perceptible deficiency of bass tones.

According to the present invention, the partly ellipsoidal reflecting surface for the sound emanating from the loud-speaker element is not part of the surface of an ellipsoid of revolution, but rather of an ellipsoid in which the three principal axes are of different length, so that a part of the circumference of the bottom wall which joins with the partly ellipsoidal reflecting surface is also elliptical. Two loud-speakers are mounted in spaced relation on this bottom wall with their respective axes of symmetry located perpendicular to the bottom and which pass, respectively through the two foci of an elliptical plane surface which would be developed by the full circumference of the bottom wall were the latter to be entirely elliptical. The acoustic centers of the two loud-speakers are located in a plane below the bottom wall which is parallel to the latter and which plane contains the adjacent focus of the ellipsoid. Moreover, the bottom wall is so inclined to the front wall having the opening through which the sound emanates, the ellipsoidal reflecting wall and bottom wall being secured to the front wall, that the other focus of the ellipsoid is located in the vicinity of the front wall opening and the axes of symmetry of the loud-speakers also pass through this opening.

By means of this novel construction, a radiation of sound in different directions is obtained, in consequence of which the sound is reflected in a favorable way by the ceiling and the walls of the space in which the device is used, which must be considered to be responsible for the said spatial effect of the device according to the invention. Since a part of the sound originating from one speaker is reflected by the reflector in such a direction that it appears to originate from the other speaker, and vice versa, the impression is created as if the sound is produced by one instead of by two speakers. This is due to the location of the speakers at the foci of the bottom ellipse and to the shape of the ellipsoid reflector, which has been constructed in conformity with the elliptic-like bottom. The distortion of the sound reproduced is extremely small.

It may be observed that the same effect of sound being reflected from different directions by the ceiling and the walls of the space in which the sound is produced can also be obtained in another way. In this connection attention may be drawn to the familiar experiments with so-called high-fidelity equipment, in which several speakers are mounted in special places in the room in such a way that they radiate in very well-defined directions. Both the position and the direction of radiation have to be chosen with care, and the desired effect usually is not ensured in every place within the room. Such equipment involves the further drawback that the position and the direction of radiation of the individual speakers can afterwards be altered (by a non-expert), in consequence of which the effect may be marred.

The present invention, on the other hand, provides a convenient structural unit with an optimum effect, which has been achieved by the correct design and selection of the dimensions by an expert, which cannot afterwards by altered in any way.

The invention will be elucidated more fully with reference to the drawing, in which

FIGURE 1 is a vertical cross-section through a special embodiment of a device according to the invention;

FIGURE 2 is the plan view of the bottom of the device;

FIGURE 3 is the side elevation of the device without the lower part thereof;

FIGURE 4 is a view in perspective of the complete device.

The front of the device, as shown in FIG. 1, includes a front planar wall **1** containing an opening **2**. Behind the wall **1** a chamber is formed which is bounded at the back by the curved surface of reflector **4** and on the lower side by the bottom **5**. The bottom **5** is provided with two speaker openings **17** and **18**. One speaker **9** is secured to the bottom with its front facing the opening **17** and the other speaker facing the opening **18**. The surface **4** is a part of an ellipsoid, whose intersection with the plane of the drawing is formed by the ellipse **6**, the major and minor axes of which are denoted respectively by **7** and **8**. Since

the plane of the drawing coincides with one of the planes of symmetry of the ellipsoid, the axes 7 and 8 are, at the same time, two principal axes of the ellipsoid. The bottom 5 is placed perpendicular to the principal axis 7 in a point situated on this principal axis in the vicinity of one of the foci, F_1, in such a way that the acoustic centre C of each of the speakers, i.e. the centre of the sound-radiating member, thus a point close in front of the moving coil, is situated on a line through this focus F_1 perpendicular to the plane of the drawing. In other words, these acoustic centres lie in a plane below the bottom wall and which intersects the principal axis 7 of the ellipsoid at right angles approximately in the focus F_1. For simplicity's sake it has been assumed in the drawing that the acoustic centre coincides with the front of the moving coil, but in reality this centre will be situated at some distance in front of the moving coil.

Although in the embodiment illustrated in the drawing two speakers of different size have been used, e.g. one reproducing in particular the lower frequency tones and the other reproducing in particular the higher frequency tones, it is also possible to employ two speakers of the same size if their response over the whole frequency range to be reproduced is sufficient.

The bottom wall 5 is bounded at the back edge by the ellipsoid and at the front edge by the wall 1. In FIGURE 2, the line of intersection between the bottom and the ellipsoid is indicated by the semi-elliptical edge 11, and the foci of this semi-ellipse by F_1' and F_2'. The front wall 1 is perpendicular to the plane of symmetry of the ellipsoid, formed in FIGURE 1, by the plane of the drawing and intersects the bottom in the straight edge 12, which extends as close as possible to the rim of the larger speaker opening. The side edges 10 of the bottom wall 5 are straight and extend to the front wall 1 perpendicular to the major axis of the semi-ellipse formed by the back edge 11. The wall 1 includes with the bottom 5 an acute angle of such a size that the second focus F_2 of the ellipsoid is situated on the principal axis 7, closely in front of the wall 1, i.e. that the wall 1 intersects this principal axis in a point between the focus F_2 and the centre O of the ellipsoid. Moreover, the said angle between the bottom and front walls is also such that the respective axes S of symmetry of said loud-speakers which pass through the foci F_1' and F_2' also pass through the opening in the front wall.

In the present embodiment the distance between the foci F_1' and F_2' of the ellipse formed by the rear edge of the bottom is equal to the distance between the foci F_1 and F_2 of the ellipsoid. This distance has to be determined experimentally in order to attain the optimum effect, and may e.g. correspond to a wavelength at an average frequency within the frequency range to be reproduced, to which the sensitivity of the human ear is greatest, e.g. 1–3 kc./s.

In connection with the elliptic properties of the back of the reflector, the sound radiated by the acoustic sources, the centres of which are located at the level of the focus F_1, and reflected by the back of the reflector will invariably be directed to a line that is perpendicular to the plane of the drawing in the focus F_2. In FIGURE 1, two sound paths are shown, denoted by lines of dots and dashes 13 and 14, from which this concentration of the reflected sound in the focus F_2 is quite clear.

The centres of the openings 17 and 18 i.e. the axes of symmetry of the loud-speakers coincide with the foci F_1' and F_2' respectively. Sound that is radiated by the speaker mounted behind the opening 17, e.g. along the path indicated by the line of dots and dashes 19 (FIGURE 2) in the direction of the arrow, will be reflected by the back of the reflector in a plane which is perpendicular to the plane of the drawing in the focus F_1', so that the impression is created that this sound proceeds from the speaker behind the opening 18. Conversely a part of the sound from the speaker behind the opening 18 will be reflected, e.g. along the path indicated by the line of dots and dashes 20, in the direction of a plane which is perpendicular to the plane of the drawing in the focus F_2', i.e. as if it proceeded from the speaker behind the opening 17. In this way a distinct "depth" is given to the sound radiated by the speakers, in consequence of which it produces a spatial effect.

It is observed that the part (FIGURE 3) of the reflector wall which is located between the wall 1 and the line of intersection 16 of the ellipsoid with its plane of symmetry, which has been placed perpendicular to the plane of the drawing and through the principal axis 7, is formed by a plane the generators of which are parallel to the principal axis 8 and touch the ellipsoid in the line of intersection 16. Consequently the circumference of the bottom 5 is established in the form of a semi-ellipse with a rectangle attached thereto. In fact, it is preferable for the reflector wall 4 not to follow the ellipsoid up to the front wall, so that the reflector would narrow towards the front, since this may entail reflection of the sound towards the interior of the reflector. Thus, as seen in FIG. 4, the reflecting wall 4 is seen to be established by a part of an ellipsoid standing on the semi-elliptical rear edge 11 of the bottom wall 5 and which merges into sides 4*a* in the form of surfaces which have their generators parallel to the straight sides edges 10 of the bottom wall. FIG. 4 also shows the three principal axes of the ellipsoid which are of different length, these being axes 7, 8 and 23. The ends of axis 7 are designated 7*a*, 7*b*; the ends of axis 8 are designated 8*a*, 8*b*; and the ends of axis 23 are designated 23*a*, 23*b*.

If the sound proceeding from the back of the speaker diaphragms is also desired to be utilized, it is possible in accordance with known practice to provide at the lower side of the bottom wall a hole through which the sound originating from the back of the speaker diaphragms is directed in such a way that it is able to emerge through a second opening in the front wall. This is shown in FIGURE 1, where the wall 21 has been provided, while the front wall 1 has been extended in the downward direction and furnished with a second opening 22 below the opening 2.

I claim:

1. In a device for radiating sound waves, a loudspeaker enclosure comprising a front wall having an opening therein, a bottom wall inclined at an acute angle with respect to the front wall and extending rearwardly therefrom, the front edge of said bottom wall being located adjacent the lower part of said opening, a reflecting wall having its upper edge located adjacent the upper part of said opening and its lower edge joined to the rear edge of said bottom wall, the surface of said reflecting wall being essentially a portion of the surface of an ellipsoid of the type wherein the three principal axes are of different length, said rear edge of said bottom wall being in part of elliptical configuration conforming to a plane section of said ellipsoid normal to the principal axes thereof, a pair of loudspeakers mounted on said bottom wall with their respective axes of symmetry located perpendicular to said bottom wall and at the foci of an ellipse defined by said rear elliptical edge thereof, the acoustical centers of said loudspeakers being located in a plane parallel to said bottom wall and which plane contains the adjacent focus of said ellipsoid, the inclination of said bottom wall relative to said front wall being such that the axes of symmetry of said loud-speakers are parallel to the principal axis of said ellipsoid which is normal to said bottom wall whereby the other focus on said principal axis is located in front of said opening in said front wall.

2. A device as defined in claim 1 for radiating sound waves wherein the rear edge of said bottom wall is a semi-ellipse, the side edges of said bottom wall being straight and extending to said front wall perpendicular to the major axis of said semi-ellipse, and wherein said reflecting wall is established by the part of an ellipsoid standing on the

semi-elliptical rear edge of said bottom wall and which merges into sides in the form of surfaces which have their generators parallel to said straight side edges of said bottom wall.

3. A device as defined in claim 1 for radiating sound waves wherein the distance between the acoustic centers of said loud-speakers is substantially equal to the distance between the foci of said ellipsoid.

4. A device as defined in claim 1 for radiating sound

waves wherein said loud-speakers have conical diaphragms mounted at the underside of said bottom wall concentric with openings therein.

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