

Description

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to loudspeaker systems and more particularly concerns an efficient speaker system having a wide dispersion pattern.

2. Description of Related Art

Despite widespread attempts over many years to improve electronics of reproduction of sound, none can be completely successful in the absence of satisfactory loudspeaker systems. Thus the intensive effort for development of electronic sound reproducing systems has been paralleled by comparable efforts for developing sound radiation systems, systems that can properly and realistically transduce the electrical signal received from an electronic amplifier into a radiated sound. In many sound radiating or loudspeaker systems it is highly desirable to radiate sound in a wide dispersion pattern. Speakers capable of radiating sound in a narrow dispersion pattern, patterns having a width on the order of 60° or less, are widely available, but dispersion patterns of 120° or more are difficult to attain with known systems. Some speaker systems having a wide dispersion pattern include an array of a number of speakers, each of which individually has a narrow dispersion pattern, but each of which is pointed in a different direction so as to collectively provide the wider pattern. Horns have been employed for providing a wide dispersion pattern, but these are limited either in frequency or by required physical size at certain frequencies.

Bearing in mind the cost, difficulties and other problems in speaker arrays or horn type arrangements, a variety of baffles or sound reflectors have been devised. Some reflective speaker systems are designed to reflect their radiated sound from walls or room corners to attain desired dispersion patterns. Other systems, such as that shown in U.S. Patent 4,348,549, for example, attain a 360° dispersion by directing speaker radiation vertically upwardly against the exterior surface of a conical reflector pointed downwardly toward the speaker and having its apex positioned at or about the plane of the speaker aperture. Such full cone reflectors are inefficient and introduce certain distortions in the form of interference. Because of the position of the full circular cone, a significant portion of the sound radiated by the speaker, which is radiated in an angular, although relatively narrow, pattern, is radiated in directions parallel to or past the reflective surfaces of the cone, and thus a part

of the sound radiated by the speaker is projected upwardly toward the room ceiling, where it is lost or poorly or improperly reflected. Further, because of the position of the full circular cone, sound radiated from one side of the speaker in a direction generally parallel to the conical reflector surface may interfere with sound radiated directly vertically upwardly from the other side of the speaker and then reflected horizontally along a path intersecting the path of the direct radiated sound. This may cause interference and thus loss of certain sound components. Further, such conical reflectors provide for only a full 360° dispersion and do not readily lend themselves to selective adjustment of dispersion pattern between angles of from 180° to 360°. Other straight, curved or elliptical reflectors fail to provide dispersion patterns of adequate width.

GB-A-830 745 discloses a loudspeaker assembly comprising a sound reflecting surface constituted by the revolution through an angle dependent upon the listening zone of dispersion desired of a portion of a parabola about an axis intersecting the focus of said parabola and at right angles to the axis thereof, and a conical loudspeaker the axis of which is arranged coincident with the axis of revolution, the "source zone" or "point source" of said loudspeaker being positioned at or near the focus of the parabola.

Additionally, US-A-2 993 557 discloses a stereophonic sound system for audio signals comprising a pair of spaced low-frequency speakers for reproducing the lower-frequency portion of the range of the audio signals, means supporting the low-frequency speakers facing toward each other, a pair of spaced high-frequency speakers for reproducing the higher frequency portion of the range of the audio signals, means supporting the high-frequency speakers facing toward each other, and a sound-reflecting surface interposed between the spaced low and high frequency speakers, the sound reflecting surface having the shape of a curve which is symmetrical about the center line between the spaced loudspeakers, the curve having a concave portion opposite each of the low-frequency speakers and having a convex portion opposite each of the high-frequency speakers.

Accordingly, it is an object of the present invention to provide a speaker system having a wide dispersion pattern of a selected width which avoids or minimizes problems mentioned above.

SUMMARY OF THE INVENTION

This object is realized according to the present invention by a system as defined in Claim 1.

In carrying out principles of the present invention, in accordance with a preferred embodiment

thereof, a wide angle dispersion speaker system includes a reflector positioned adjacent the speaker for redirecting sound from the speaker in a plurality of directions extending at an angle to the radiation axis of the speaker. The reflector means has a reflective surface including a plurality of reflector elements, each extending across the speaker aperture at an acute angle with respect to the radiation axis. The reflective surface is defined by motion of a straight line that extends from a first point adjacent the periphery of the speaker aperture through and beyond a second point on the radiation axis at a distance from the plane of the aperture, such motion of the line being defined by motion of the first point along part of the periphery of the speaker aperture. Thus a reflective surface having both concave and convex sections is formed. According to a specific feature of the invention, where a speaker system employs a speaker having a circular aperture, the reflective surface includes a first concave conical reflective surface portion tapering from the plane of the speaker aperture toward an apex displaced from the aperture and a second convex conical reflective surface portion extending from the apex away from the speaker aperture. According to another feature of the invention, the reflector includes a first concave section having an edge substantially coextensive with a section of the periphery of the speaker aperture and having an apex positioned substantially at the apex of a second, but convexly curved, reflective surface which tapers outwardly from its apex away from the speaker.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. 1 is a pictorial illustration of a speaker having a reflector embodying principles of the present invention;

FIG. 2 illustrates a surface of a figure of revolution which defines a reflector having concave and convex semi-conical sections;

FIG. 3 is a vertical sectional view showing fragments of a speaker panel in which is mounted a speaker having a reflector embodying principles of the present invention;

FIG. 4 is a view of the speaker system of FIG. 3 taken in a plane perpendicular to the plane of the view of FIG. 3;

FIGS. 5 and 6 are sections taken on lines 5-5 and 6-6 of FIG. 3;

FIG. 7 shows a modified embodiment of the speaker system of FIGS. 1 through 6;

FIG. 8 shows a still further embodiment;

FIG. 9 shows another embodiment; and

FIGS. 10, 11, 12 and 13 are sections taken on lines 10-10, 11-11, 12-12, and 13-13 respec-

tively of FIG. 9.

DESCRIPTION OF A PREFERRED EMBODIMENT

As illustrated in FIG. 1, a conventional speaker having a magnet 10 and a speaker frame 12 has mounted therein a conical speaker cone element 14 having a continuous circular peripheral edge portion 16 defining an aperture of the speaker. The speaker generally radiates sound along a symmetrically disposed radiation axis indicated at 18. Mounted to the speaker is a concave, convex baffle in the form of a reflector generally indicated at 20, having a concave reflective surface section 22 and a convex reflective surface section 24. The reflector 20 includes flat triangular support plates 26, 27 extending vertically (assuming axis 18 is vertical) between edges of the concave and convex reflector sections 22, 24. The reflector and its support plates, as presently preferred, are formed of thin, rigid and smooth surface material, such as a rigid vacuum formed or injection molded plastic.

FIG. 2 illustrates the reflector without its supporting plates 26, 27. In general the reflective surface 22, 24 is defined by motion of a line, such as the line BAD, where point A intersects the speaker radiation axis 18 and point D lies on or closely adjacent to the periphery 16 of the aperture of speaker cone 14. In a particular example, point B lies on line AD, and both points in B and D are equidistant from point A. The curved reflective surface is defined by that motion of the line BAD which is caused by moving point D along a portion of the periphery 16 of the speaker aperture from point D through point G to point C. While this motion occurs, point A on the line remains substantially on the radiation axis 18, and, accordingly, point B of the line will trace the arc BFE, which is opposite to but congruent with the arc DGC traced by the line end D. Where the speaker cone is circular and its aperture periphery 16 is circular, as illustrated in FIGS. 1 and 2, arcs BFE and DGC are semicircles, or at least circular arcs. Preferably these arcs subtend an angle of 180° , but reflector surfaces somewhat greater or less than 180° may also be employed. Although circular speaker cones are presently preferred for use with the present invention, thus employing reflector surfaces which are semi-conical concave and convex surfaces, as illustrated at 22 and 24, it will be readily appreciated that principles of the invention may be applied to speakers having apertures of noncircular configurations, such as, for example, elliptical speakers. In such a case, the described motion of the line BAD, retaining point A on the radiation axis 18 and moving point D along a portion of the elliptical aperture of the now elliptical speaker, would still result in a pair of concave and convex

reflector sections, but neither would be semi-conical.

The reflector, having a surface defined by the above-stated motion of the line BAD, has edges 18,30 on the concave section 22 and edges 32,34 on the convex section 24. In the system illustrated in FIG. 1, where the upwardly facing speaker aperture is circular and thus the reflective sections are both semi-conical sections, the described motion of point D of line BAD in defining the curved reflective surfaces 22,24 occurs over one half of the periphery 16 of the speaker cone. That is, point D moves through a semicircle of 180°. In such an embodiment, edges 28,30 lie in a vertical plane containing the vertical radiation axis 18, and similarly edges 32,34 of the convex section 24 lie in the very same plane. It is to these edges, 32,28 on the one hand and 34,30 on the other, that the support plates 26 and 27 respectively are secured, thus fixedly and rigidly connecting and supporting the convex section 24 to the concave section 22. Concave section 22 is provided with a peripheral flange 40 that overlies and is secured to a section of the peripheral flange 12 (see FIGS. 3 and 4) of the speaker frame. As can be seen in FIGS. 3 and 4, the speaker frame is secured by means of its flanges and fastening devices such as screws 46,48 to the edges of a hole in a speaker mounting panel 49, of which only a section is illustrated in FIGS. 3 and 4.

The combination of concave and convex reflective surfaces of the reflector 20, when used with a speaker having a circular aperture, may also be described as a surface of revolution defined by rotation of a line, such as line BAD of FIG. 2 about the vertical axis 18. Such a line, when rotating about the vertical axis 18, will sweep two conical surfaces, the semi-conical concave reflective surface 22 and the semi-conical convex reflective surface 24. Preferably the angle of the cone, that is, the angle between an element of the cone such as an element along the line BAD and the conical or radiation axis 18, is 45° or less. Thus each element of the reflective surfaces 22,24 must make an angle with the plane of the speaker aperture (a horizontal plane in an upwardly directed speaker) that is not less than about 45°. If such an angle of the reflective surface with respect to a horizontal plane is less than 45°, sound radiated from the speaker is reflected in a direction having a downwardly pointed component (toward the plane of the speaker aperture), which is undesirable. If the angle between the reflective surface and the horizontal plane is somewhat greater than 45°, sound will be reflected with a slightly upwardly directed component, which is preferable to a downwardly directed component. Of course where the speaker is mounted so that its radiation axis is somewhat tilted to

the vertical, the angle of the reflective surface with respect to the radiation axis will vary so as to direct the reflected sound in a plane extending in the desired direction, but preferably not toward the plane of the speaker aperture.

Assuming the radiation axis 18 of the speaker to be vertical, and the reflective surfaces 22,24 to have all of their elements extending at an angle of 45° with respect to a horizontal plane, sound radiated from the speaker cone 14 is radiated and reflected as indicated by the arrows shown in FIGS. 3, 5 and 6. Thus dotted direction line 50 of FIG. 3 indicates that sound radiated from one portion of speaker cone 14 is reflected from the concave reflective surface 22 in the horizontal direction of line 50, and sound radiated from another portion of the speaker cone is reflected from the convex surface 24 along a horizontal direction line 60. Therefore, vertically radiated sound of the speaker, which is reflected from the reflector, is projected from the reflective surface along and is substantially horizontal planes. More specifically it is projected in a pattern centered vertically on a substantially horizontal plane. Importantly, as can be seen in the sectional views of FIGS. 5 and 6, the sound is widely dispersed (in azimuth) within such horizontal planes.

Thus FIGS. 5 and 6 illustrate the capability of the described reflector to provide wide dispersion from the upper, on convex, reflector section, while still collecting and reflecting sound by the concave reflector section. For example, the section illustrated in FIG. 5 shows by arrows 51,52,53,54,55,56 and 57 reflection of vertically radiated sound from concave section 22 in a plurality of different directions all in a substantially horizontal plane, and all pointed toward the speaker radiation axis 18. As can be seen in FIG. 6, on the other hand, vertically directed sound reflected from the convex section 24 is reflected in the directions indicated by lines 61,62,63,64,65,66 and 67, which are all directed radially outwardly of the speaker radiation axis 18 and thus provide a pattern of dispersion of a full 180° in the horizontal direction. Effectively the reflector is composed of a number of reflective elements that collectively define the reflector surface. Each element has a sound reflecting surface positioned in a plane that extends at a respective, different angle relative to a reference plane containing the radiation axis. Each element has a first section (on one side of the cone apex) that cooperates with other elements on that side to define the concave reflective surface. Each element also has a second section (on the other side of the cone apex) that cooperates with other elements on such other side of the apex to define the convex reflector surface. Each element, when projected on a plane perpendicular to the radiation axis, extends at

a different angle to the radiation axis.

The described system employs a reflector that is a pure reflector and has a flat response for all frequencies. The embodiment described to this point provides a radiation dispersion pattern of 180° . As will be understood as the description proceeds, and as illustrated in connection with FIGS. 7, 8 and 9, principles of the invention can be applied to speaker systems which provide dispersion patterns of greater than 180° , and in fact of any width between 180° and 360° .

Illustrated in FIG. 7 is a speaker arrangement, with reflectors incorporating principles of the present invention, that is set up to provide a full 360° sound dispersion pattern. In this arrangement first and second mutually opposed and vertically oriented upper and lower speakers 70 and 72 are mounted in a speaker enclosure having speaker panels 74 and 76 which are fixedly connected to one another so that the speakers are mounted in direct alignment with one another, each radiating its sound vertically. Upper speaker 70 radiates its sound vertically downwardly, and lower speaker 72 radiates its sound vertically upwardly. A reflector 80, which may be identical to the reflector 20 illustrated in FIGS. 1 through 6, includes a first semi-conical section 82 and a second semi-conical section 84. The two are joined to one another at their common apex, an intermediate point 86, on the common radiation axis 88 of both speakers. Reflector section 82 is a semi-conical section that is equivalent to, and in fact may be identical to, section 22 shown in FIG. 1. Similarly section 84 may be equivalent or identical to speaker reflector section 24 of FIG. 1. The two sections may be connected together by flat plates in the manner of the plates 26,28 of FIG. 1. The sections 82,84 respectively have flanges by which both sections are secured to the mounting flanges of the respective speakers in the same manner that reflector 20 is secured to speaker frame 12 by reflector flange 40.

Since the reflector is made of rigid, thin material and is smooth on both sides, both sides of both speaker sections 82 and 84 are operable in this system. Thus, with respect to speaker 72, reflector section 82 provides a concave reflector surface 90 that reflects vertically upwardly directed sound in horizontal directions 92, and a convex reflective surface 94 that reflects vertically upwardly directed sound from speaker 72 in horizontal directions 96. Thus the speaker 72 and the reflector 80 provide a 180° dispersion pattern, in the same manner as is shown in FIGS. 1, 3, 5 and 6.

With respect to upper speaker 70, upper reflective section 84 provides a conical reflective surface 98 (on the side of reflector section 84 opposite reflective surface 94) that reflects vertically down-

wardly directed sound in horizontal directions 100, which are opposite to the directions indicated by line 96 for reflection of sound from speaker 72. Similarly, reflector section 82 provides a convex reflective surface 104 for vertically downwardly directed sound from speaker 70 to be reflected in horizontal directions indicated by line 106, which is directly opposite to the direction indicated by line 92. Thus the same reflector 80 that reflects sound from the lower speaker 72 employs its opposite surfaces as a combination of concave and convex reflective surfaces for dispersion of sound from upper speaker 70. Collectively the two speakers 70 and 72 provide a dispersion of sound from the single common reflector 80 through a full 360° pattern, the sound from speaker 70 being dispersed through a first half of a full circle, and the sound from speaker 72 being dispersed through the other half of the same full circle.

As shown in FIG. 8, the 360° dispersion system of FIG. 7 may be modified to include a pair of small high frequency speakers so that the system will include a pair of low range speakers 110,112, mounted respectively in speaker panels 114,116 that are fixedly connected to one another in a single unitary speaker enclosure, the two speakers being mutually aligned and vertically directed downwardly and upwardly just as in the arrangement of FIG. 7. Two of small size high frequency speakers 118,120 are mounted together in opposed relation by means of a structural spider or equivalent support structure 122, with the two high frequency speakers being mutually aligned with the common radiation axes of the lower frequency speakers 110,112, and having their radiation axes directed respectively upwardly and downwardly. A first reflector 130, having a first semicircular conical section 132 and a second semi-conical reflector section 134, is mounted to the rim of upper speaker 110 by a suitable mounting flange. Reflector 130 may be identical to the combined convex, concave reflectors illustrated in FIGS. 1 and 7, with the upper surface of this reflector redirecting sound projected vertically downwardly from upper speaker 110 in horizontal directions indicated at 136,138. The other side of this same reflector operates to redirect vertically upwardly directed sound from high frequency speaker 118 and project such sound in horizontal directions indicated at 142,143. Similarly, a reflector 150, identical to reflector 130, has its lower conical circular edge fixed to a peripheral flange 152 of the lower speaker 112, and extends upwardly toward the downwardly directed high frequency speaker 120 to provide a concave reflective surface that redirects vertically upwardly directed sound from speaker 112 in horizontal directions indicated at 154,156. The surface of reflector 150, which faces toward the right as viewed in

FIG. 8, provides a concave semi-conical section having a concave surface 151 for reflection of sound from speaker 112 and having a convex surface 153 for reflection of sound from speaker 12. The opposite sides of this same reflector 150 provide a reflective surface 157 that is convex toward the left for reflecting sound radiated vertically downwardly from high frequency speaker 120 to be projected in horizontal directions indicated by line 158. This other surface of the reflector 150 also provides a concave reflective surface 159 that receives vertically downwardly directed sound radiated from high frequency speaker 120 to be redirected along horizontal directions indicated at 160. Thus the upper reflector 130 directs sound from upper speaker 110 in a 180° dispersion pattern projected toward the left and also directs sound from the upper high frequency speaker 118 in a 180° pattern directed toward the right. In a similar manner the lower reflector 150 directs sound from lower speaker 112 in a 180° pattern directed toward the right and reflects sound from the second high frequency speaker 120 in a 180° pattern directed toward the left. The arrangement therefore provides a 360° pattern of sound projected from both low and high frequency speakers.

From the description set forth above it will be readily appreciated that by selective choice of relative orientations (about the cone and speaker radiation axes) of a pair of reflectors of the type described herein, each mounted upon a respective one of a pair of speakers, the total pattern of sound dispersion may be chosen to provide any angle between the 180° arrangements of individual speakers and individual cones, shown in FIGS. 1 - 6, and the 360° pattern of two or more speakers with one or more cones, as shown in FIGS. 7 and 8. Moreover, merely by varying relative orientations of a pair of axially aligned reflectors, a pattern may be selected to cover any angle between 180° and 360°. For example, to obtain a 270° wide dispersion pattern as illustrated in FIG. 9, upper and lower speakers 161, 162, mounted on panels 164, 166 respectively, are fixedly connected to one another in a unitary speaker enclosure. Each has secured to a portion of its peripheral flange 168, 170, respectively, a reflector 172, 174 of the type described above and illustrated in FIGS. 1 and 8 for example. The two speakers are mutually aligned and have a common radiation axis indicated at 176. The two reflectors 172, 174 are rotated through 90° relative to one another about the common radiation and reflector cone axis 176. This 90° relative orientation is best seen by comparing the sections of FIGS. 10 and 11 with the sections of FIGS. 12 and 13. In FIGS. 10 - 12 speaker connection wires 175, 177 are shown to indicate a point of common orientation for all sections.

FIGS. 10 and 11 are sections taken through the lower conical reflector 174, showing in FIG. 10 the reflection of sound from speaker 162 from the semi-conical reflector surface of reflector 174 in directions indicated by arrows, such as arrows 180, and the reflection of sound from the convex surface of reflector 174 in the widely dispersed directions indicated by arrows 184. Thus the reflector 174 redirects sound radiated vertically upwardly by speaker 162 in horizontal directions generally directed toward the left in FIGS. 10 and 11.

FIGS. 12 and 13 show sections of the upper reflector 172, with FIG. 13 indicating by arrows 186 reflection of vertically downwardly radiated sound of speaker 161 from the concave reflecting surface of reflector 172. Similarly FIG. 12 indicates the direction of sound radiated vertically downwardly from speaker 161 and reflected in horizontal directions indicated at 188 from the convex section of this reflector. The sections of all of FIGS. 10, 11, 12 and 13 are shown in the same relative orientation with respect to one another, speaker orientation being indicated by connection wires 175, 177. Thus it can be seen that the lower reflector 174, having sound reflection directions toward the left as seen in FIGS. 10 and 11, provides 180° wide dispersion of sound from speaker 162 in a pattern that is centered along a line extending directly to the left in FIGS. 9, 10 and 11. With respect to FIGS. 12 and 13, it will be seen that the upper reflector 172, being angularly displaced about common radiation axis 176 through 90° relative to lower reflector 174, reflects sound radiated vertically downwardly from speaker 161 in generally horizontal directions indicated by arrows 186, 188 which are centered along an axis extending upwardly in the plane of the paper as viewed in FIGS. 12 and 13. As viewed in FIG. 9, sound radiated vertically downwardly from speaker 160 is reflected in a horizontal plane in a pattern centered generally along a line extending perpendicular to the plane of the paper as viewed in FIG. 9. Thus, referring again to FIGS. 10 through 13, the lower reflector 174 provides a 180° pattern centered on a line toward the left as viewed in these figures, whereas the upper reflector 172 provides a redirection of sound in a 180° pattern centered on a generally upwardly directed direction as viewed in FIGS. 12 and 13, providing a net pattern width of 270°, with the sound being reinforced in the common 90° sector by which the two 180° patterns of FIGS. 10 and 11 on the one hand and FIGS. 12 and 13 on the other overlap.

Also shown in the arrangement of FIG. 9 is the mounting of a high frequency speaker or tweeter 190, 192 to the speakers 161, 162 being suspended symmetrically in the cone of speakers and lying substantially in the plane of the respective speaker

aperture. The same concave and convex surfaces of reflector 174, which reflect the vertically radiated sound from low frequency speakers 161,162 in 180° patterns operate to reflect sound that is radiated vertically from the tweeters 190,192 and reflect this sound in 180° patterns that are oriented just the same as the 180° patterns of sound reflected from the larger speakers.

The reflectors of the several embodiments of FIGS. 7, 8 and 9 each includes semi-conical concave and convex sections fixedly secured to each other by support plates corresponding to support plates 26,27 of FIGS. 1 - 6. Such support plates are intended only to be illustrative of many different ways of physically connecting the two sections to each other or for fixedly mounting them in the described positions and relations without necessarily connecting one section to the other.

Claims

1. A wide angle dispersion speaker system comprising:

a speaker having a sound radiating element (14) defining a speaker aperture having a plane, said sound radiating element having a circular periphery (16) of a first diameter and having a radiation axis (18) normal to said plane along which sound is projected from the sound radiating element (14), and

reflector means (20) for redirecting sound from the speaker in a plurality of directions extending at an angle to said radiation axis, said reflector means (20) comprising a reflective surface having a convex section (24) spaced from the speaker aperture and a concave section (22) between the speaker aperture and said convex section (24), said surface being the locus of rotation about said radiation axis of a line which intersects said axis, characterized in that said line is straight, thereby defining part-conical convex and concave reflector sections (24;22), and in that said concave section (22) has an inner part-circular edge (40) having a diameter not less than said first diameter and is attached to said speaker.

2. The speaker system according to claim 1 in which the convex and concave reflector sections (24;22) are semi-conical.
3. The speaker system of claim 1 wherein said concave semi-conical reflector section has a semi-circular edge (40) positioned at a portion of the edge of said speaker aperture.
4. The speaker system of claim 1 including a second speaker (120) having a speaker ap-

erture lying in a plane spaced from said first mentioned aperture and having a radiation axis aligned with said first mentioned radiation axis, said concave reflector section (82) being spaced from said second speaker aperture and said convex reflector section (84) extending between the plane of said second speaker aperture and said concave section (82).

5. The speaker system of claim 1 including a second speaker having a speaker aperture spaced from said first mentioned speaker aperture and having a second radiation axis aligned with said first mentioned radiation axis, second reflector means (130) connected to the second speaker for redirecting sound from the second speaker in a plurality of directions extending at an angle to said second radiation axis, said second reflector means (130) comprising a reflective surface having a second convex section (134) spaced from the second speaker aperture and a second concave section (132) extending between the plane of said second speaker aperture and said second convex section (134).

6. The speaker system of claim 5 wherein said first (174) and second (172) reflector means are angularly oriented relative to one another about the radiation axes of said speakers.

7. The speaker system of claim 5 wherein the first mentioned reflector means (174) provides a dispersion pattern having a first pattern axis extending in a first direction in a plane substantially parallel to said first mentioned speaker aperture, and wherein said second reflector means provides a dispersion pattern having a second pattern axis extending at an angle with respect to said first pattern axis that is between 180° and 360°.

8. The speaker system of claim 4 wherein the first mentioned speaker is a relatively low frequency speaker, and wherein said second speaker is a relatively high frequency speaker (120), whereby sound from said low frequency speaker is reflected from one side of said reflector means (80) and sound radiation from the high frequency speaker is radiated from the other side of said reflector means (80).

9. The speaker system of claim 1 including a second high frequency speaker (190), having a radiation axis aligned with that of said first mentioned speaker, which is mounted between said first mentioned speaker and said reflector means (174).



aperture. The same concave and convex surfaces of reflector 174, which reflect the vertically radiated sound from low frequency speakers 161,162 in 180° patterns operate to reflect sound that is radiated vertically from the tweeters 190,192 and reflect this sound in 180° patterns that are oriented just the same as the 180° patterns of sound reflected from the larger speakers.

The reflectors of the several embodiments of FIGS. 7, 8 and 9 each includes semi-conical concave and convex sections fixedly secured to each other by support plates corresponding to support plates 26,27 of FIGS. 1 - 6. Such support plates are intended only to be illustrative of many different ways of physically connecting the two sections to each other or for fixedly mounting them in the described positions and relations without necessarily connecting one section to the other.

Claims

1. A wide angle dispersion speaker system comprising:

a speaker having a sound radiating element (14) defining a speaker aperture having a plane, said sound radiating element having a circular periphery (16) of a first diameter and having a radiation axis (18) normal to said plane along which sound is projected from the sound radiating element (14), and

reflector means (20) for redirecting sound from the speaker in a plurality of directions extending at an angle to said radiation axis, said reflector means (20) comprising a reflective surface having a convex section (24) spaced from the speaker aperture and a concave section (22) between the speaker aperture and said convex section (24), said surface being the locus of rotation about said radiation axis of a line which intersects said axis, characterized in that said line is straight, thereby defining part-conical convex and concave reflector sections (24;22), and in that said concave section (22) has an inner part-circular edge (40) having a diameter not less than said first diameter and is attached to said speaker.

2. The speaker system according to claim 1 in which the convex and concave reflector sections (24;22) are semi-conical.
3. The speaker system of claim 1 wherein said concave semi-conical reflector section has a semi-circular edge (40) positioned at a portion of the edge of said speaker aperture.
4. The speaker system of claim 1 including a second speaker (120) having a speaker ap-

erture lying in a plane spaced from said first mentioned aperture and having a radiation axis aligned with said first mentioned radiation axis, said concave reflector section (82) being spaced from said second speaker aperture and said convex reflector section (84) extending between the plane of said second speaker aperture and said concave section (82).

5. The speaker system of claim 1 including a second speaker having a speaker aperture spaced from said first mentioned speaker aperture and having a second radiation axis aligned with said first mentioned radiation axis, second reflector means (130) connected to the second speaker for redirecting sound from the second speaker in a plurality of directions extending at an angle to said second radiation axis, said second reflector means (130) comprising a reflective surface having a second convex section (134) spaced from the second speaker aperture and a second concave section (132) extending between the plane of said second speaker aperture and said second convex section (134).
6. The speaker system of claim 5 wherein said first (174) and second (172) reflector means are angularly oriented relative to one another about the radiation axes of said speakers.
7. The speaker system of claim 5 wherein the first mentioned reflector means (174) provides a dispersion pattern having a first pattern axis extending in a first direction in a plane substantially parallel to said first mentioned speaker aperture, and wherein said second reflector means provides a dispersion pattern having a second pattern axis extending at an angle with respect to said first pattern axis that is between 180° and 360°.
8. The speaker system of claim 4 wherein the first mentioned speaker is a relatively low frequency speaker, and wherein said second speaker is a relatively high frequency speaker (120), whereby sound from said low frequency speaker is reflected from one side of said reflector means (80) and sound radiation from the high frequency speaker is radiated from the other side of said reflector means (80).
9. The speaker system of claim 1 including a second high frequency speaker (190), having a radiation axis aligned with that of said first mentioned speaker, which is mounted between said first mentioned speaker and said reflector means (174).



Patentansprüche

1. Ein Lautsprechersystem mit weitwinkliger Dispersion enthaltend:

einen Lautsprecher mit einem schallabstrahlenden Element (14), das eine Lautsprecheröffnung mit einer Ebene bestimmt, wobei das schallabstrahlende Element einen kreisförmigen Umfang (16) mit einem ersten Durchmesser und eine Strahlachse (18) hat, die in der Normalen der Ebene liegt, entlang welcher Schall vom schallabstrahlenden Element (14) projiziert wird, und

eine Reflektoreinrichtung (20) zur Umleitung des Schalls vom Lautsprecher in eine Vielzahl von Richtungen, die sich in einem Winkel zu der Strahlachse ausbreiten, wobei die Reflektoreinrichtung (20) eine reflektierende Oberfläche mit einem konvexen Bereich (24), der von der Lautsprecheröffnung beabstandet ist und einem konkaven Bereich (22) enthält, der zwischen der Lautsprecheröffnung und dem konvexen Bereich (24) liegt, wobei die Oberfläche den geometrischen Ort einer um die Strahlachse rotierenden Achse, die die Strahlachse schneidet, beschreibt, dadurch gekennzeichnet,

daß diese Achse gerade ist, wodurch teilkonische konvexe und konkave Reflektorbereiche (24, 22) definiert werden, und daß der konkave Bereich (22) eine innere teilkreisförmige Kante (40) mit einem Durchmesser nicht kleiner als der erste Durchmesser hat und am Lautsprecher angebracht ist.

2. Das Lautsprechersystem gemäß Anspruch 1, in dem der konvexe und der konkave Reflektorbereich (24, 22) halbkonisch sind.

3. Das Lautsprechersystem gemäß Anspruch 1, in welchem der halbkonische, konkave Reflektorbereich eine teilkreisförmige Kante (40) hat, die an einem Abschnitt der Kante der Lautsprecheröffnung angeordnet ist.

4. Das Lautsprechersystem gemäß Anspruch 1 mit einem zweiten Lautsprecher (120), der eine Lautsprecheröffnung hat, die in einer Ebene liegt, welche von der ersten Öffnung beabstandet ist und der eine Strahlachse hat, die mit der ersten Strahlachse fluchtet, wobei der konkave Reflektorbereich (82) von der zweiten Lautsprecheröffnung beabstandet ist und der konvexe Reflektorbereich (84) sich zwischen der Ebene der zweiten Lautsprecheröffnung und dem konkaven Bereich (82) erstreckt.

5. Das Lautsprechersystem gemäß Anspruch 1 mit einem zweiten Lautsprecher, der eine Lautsprecheröffnung hat, die von der ersten Lautsprecheröffnung beabstandet ist und der eine zweite Strahlachse hat, die mit der ersten Strahlachse fluchtet, einer zweiten Reflektoreinrichtung (130), die am zweiten Lautsprecher zur Umleitung des Schalls vom zweiten Lautsprecher in eine Vielzahl von Richtungen, die sich unter einem Winkel von der Strahlachse erstrecken, angebracht ist, wobei die zweite Reflektoreinrichtung (130) eine reflektierende Oberfläche mit einem zweiten konvexen Bereich (134), der von der zweiten Lautsprecheröffnung beabstandet ist und einen zweiten konkaven Bereich (132), der sich zwischen der Ebene der zweiten Lautsprecheröffnung und dem zweiten konvexen Bereich (134) erstreckt, aufweist.

6. Das Lautsprechersystem gemäß Anspruch 5, in welchem die erste (174) und die zweite (172) Reflektoreinrichtung unter einem Winkel um die Strahlachsen der Lautsprecher relativ zueinander ausgerichtet sind.

7. Das Lautsprechersystem gemäß Anspruch 5, in welchem die erste Reflektoreinrichtung (174) ein Ausbreitungs- bzw. Dispersionsmuster mit einer ersten Musterachse zur Verfügung stellt, die sich in eine erste Richtung in eine Ebene im wesentlichen parallel zur erst erwähnten Lautsprecheröffnung erstreckt, und in welchem die zweite Reflektoreinrichtung über ein Ausbreitungsmuster mit einer zweiten Musterachse verfügt, die sich unter einem Winkel zwischen 180° und 360° zur ersten Musterachse erstreckt.

8. Das Lautsprechersystem gemäß Anspruch 4, in welchem der erste Lautsprecher ein verhältnismäßig niederfrequenter Lautsprecher ist, und in welchem der zweite Lautsprecher ein verhältnismäßig hochfrequenter Lautsprecher (120) ist, wodurch Schall vom niederfrequenten Lautsprecher von einer Seite der Reflektoreinrichtung (80) umgeleitet wird und Schallabstrahlung vom hochfrequenten Lautsprecher von der anderen Seite der Reflektoreinrichtung (80) abgestrahlt wird.

9. Das Lautsprechersystem gemäß Anspruch 1 mit einem zweiten hochfrequenten Lautsprecher (190), der eine Strahlachse hat, die mit der des ersten Lautsprechers fluchtet, der zwischen dem ersten Lautsprecher und der Reflektoreinrichtung (174) angebracht ist.



Revendications

1. Système de haut-parleur à grand angle de diffusion, comportant :

un haut-parleur ayant un élément (14) de rayonnement des sons définissant une ouverture de haut-parleur ayant un plan, ledit élément de rayonnement des sons ayant une périphérie circulaire (16) d'un premier diamètre et ayant un axe (18) de rayonnement normal audit plan le long duquel des sons sont projetés à partir de l'élément (14) de rayonnement des sons, et

un moyen réflecteur (20) destiné à rediriger des sons provenant du haut-parleur dans plusieurs directions formant un angle avec ledit axe de rayonnement, ledit moyen réflecteur (20) présentant une surface réfléchissante ayant une partie convexe (24) espacée de l'ouverture du haut-parleur à une partie concave (22) entre l'ouverture du haut-parleur et ladite partie convexe (24), ladite surface étant le lieu d'une rotation autour dudit axe de rotation d'une ligne qui intersecte ledit axe, caractérisé en ce que ladite ligne est droite, définissant ainsi des parties de réflecteur convexe et concave partiellement coniques (24 ; 22), et en ce que ladite partie concave (22) comporte un bord intérieur partiellement circulaire (40) ayant un diamètre qui n'est pas inférieur audit premier diamètre et est relié audit haut-parleur.

2. Système de haut-parleur selon la revendication 1 dans lequel les parties convexe et concave (24 ; 22) du réflecteur sont semi-coniques.

3. Système de haut-parleur selon la revendication 1, dans lequel ladite partie concave semi-conique du réflecteur comporte un bord semi-circulaire (40) placé à une partie du bord de ladite ouverture du haut-parleur.

4. Système de haut-parleur selon la revendication 1, comprenant un second haut-parleur (120) ayant une ouverture de haut-parleur s'étendant dans un plan espacé de ladite ouverture citée en premier et ayant un axe de rayonnement aligné avec ledit axe de rayonnement cité en premier, ladite partie concave (82) du réflecteur étant espacée de ladite ouverture du second haut-parleur et ladite partie convexe (84) du réflecteur s'étendant entre le plan de ladite ouverture du second haut-parleur et ladite partie concave (82).

5. Système de haut-parleur selon la revendication 1, comprenant un second haut-parleur ayant une ouverture de haut-parleur espacée de ladi-

te ouverture citée en premier et ayant un second axe de rayonnement aligné avec ledit axe de rayonnement cité en premier, un second moyen réflecteur (130) relié au second haut-parleur pour rediriger des sons provenant du second haut-parleur dans plusieurs directions formant un angle avec ledit second axe de rayonnement, ledit second moyen réflecteur (130) présentant une surface réfléchissante ayant une seconde partie convexe (134) espacée de l'ouverture du second haut-parleur et une seconde partie concave (132) s'étendant entre le plan de ladite ouverture du second haut-parleur et ladite seconde partie convexe (134).

6. Système de haut-parleur selon la revendication 5, dans lequel lesdits premier (174) et second (172) moyens réflecteurs sont orientés angulairement l'un par rapport à l'autre autour des axes de rayonnement desdits hauts-parleurs.

7. Système de haut-parleur selon la revendication 5, dans lequel le moyen réflecteur (174) cité en premier présente un diagramme de diffusion ayant un premier axe de diagramme s'étendant dans une première direction dans un plan sensiblement parallèle à ladite ouverture du haut-parleur cité en premier, et dans lequel ledit second moyen réflecteur présente un diagramme de diffusion ayant un second axe de diagramme formant un angle avec ledit premier axe de diagramme qui est compris entre 180° et 360°.

8. Système de haut-parleur selon la revendication 4, dans lequel le haut-parleur cité en premier est un haut-parleur à fréquence relativement basse, et dans lequel ledit second haut-parleur est un haut-parleur (120) à fréquence relativement élevée, de manière que des sons provenant dudit haut-parleur à basse fréquence soient réfléchis depuis un premier côté dudit moyen réflecteur (80) et que des sons rayonnants dudit haut-parleur à haute fréquence soient rayonnés à partir de l'autre côté dudit moyen réflecteur (80).

9. Système de haut-parleur selon la revendication 1, comprenant un second haut-parleur (190) à haute fréquence, ayant un axe de rayonnement aligné avec celui dudit haut-parleur cité en premier, qui est monté entre ledit haut-parleur cité en premier et ledit moyen réflecteur (174).