(12) UK Patent Application (19) GB (11) 2 147 775 A

(43) Application published 15 May 1985

(21) Application No **8403891**

(22) Date of filing **14 Feb 1984**

(30) Priority data

(31) **539351** (32) **5 Oct 1983** (33) **US**

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(51) INT CL^4
H04R 1/30

(52) Domestic classification
H4X 3G
H4J 30F 33E B

(56) Documents cited
GB A 2088680 **US 4308932**
GB 0227545

(58) Field of search
H4X
H4J

(54) **Defined-coverage loudspeaker horn**

(57) Opposed side walls (20,20) of a loudspeaker horn (12) are constructed to direct portions of a sound beam toward a target over different preselected included angles (32-34), producing an incident beam which is substantially coextensive with the target (26). The side walls (20,20) preferably extend downstream at the preselected angles over a distance at least comparable to a maximum wavelength at which the horn (12) is to be used.

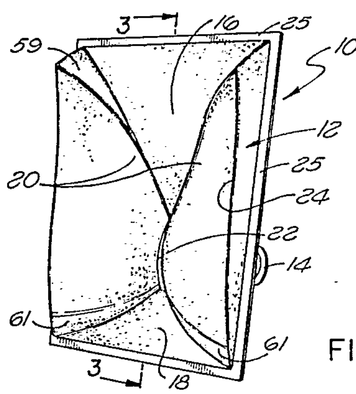

FIG. 1

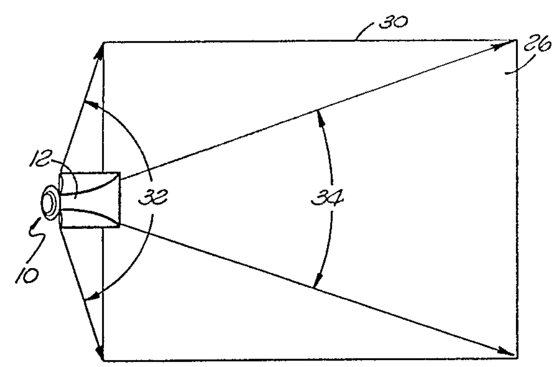

FIG. 2A

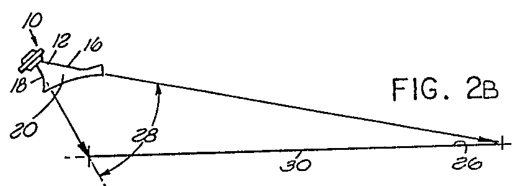

FIG. 2B

GB 2 147 775 A

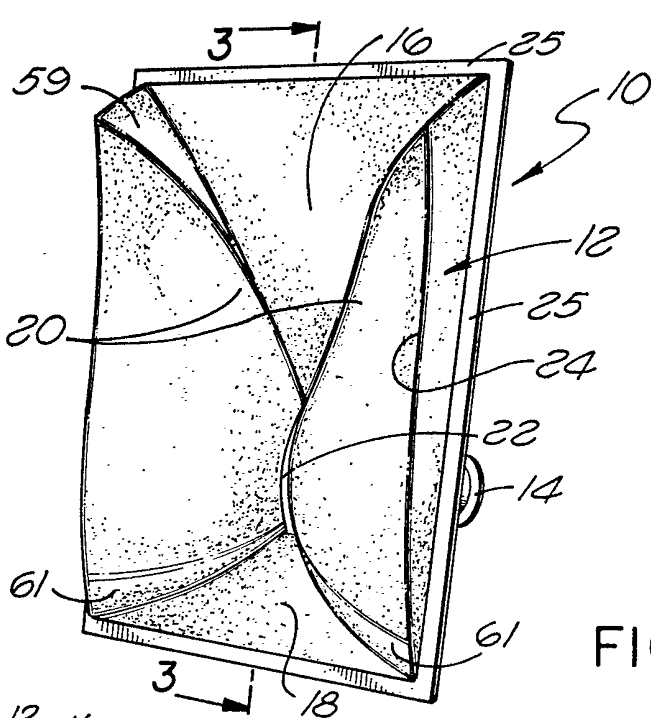

FIG. 1

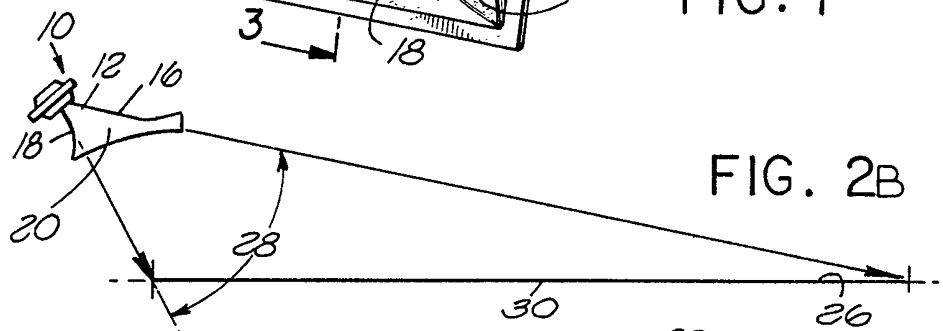

FIG. 2B

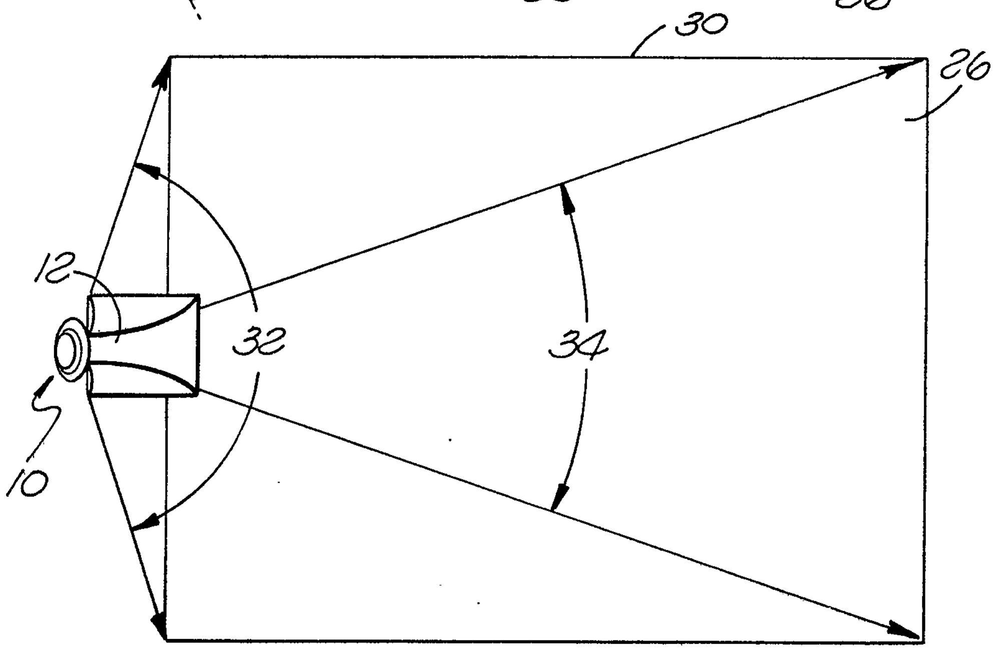

FIG.2A

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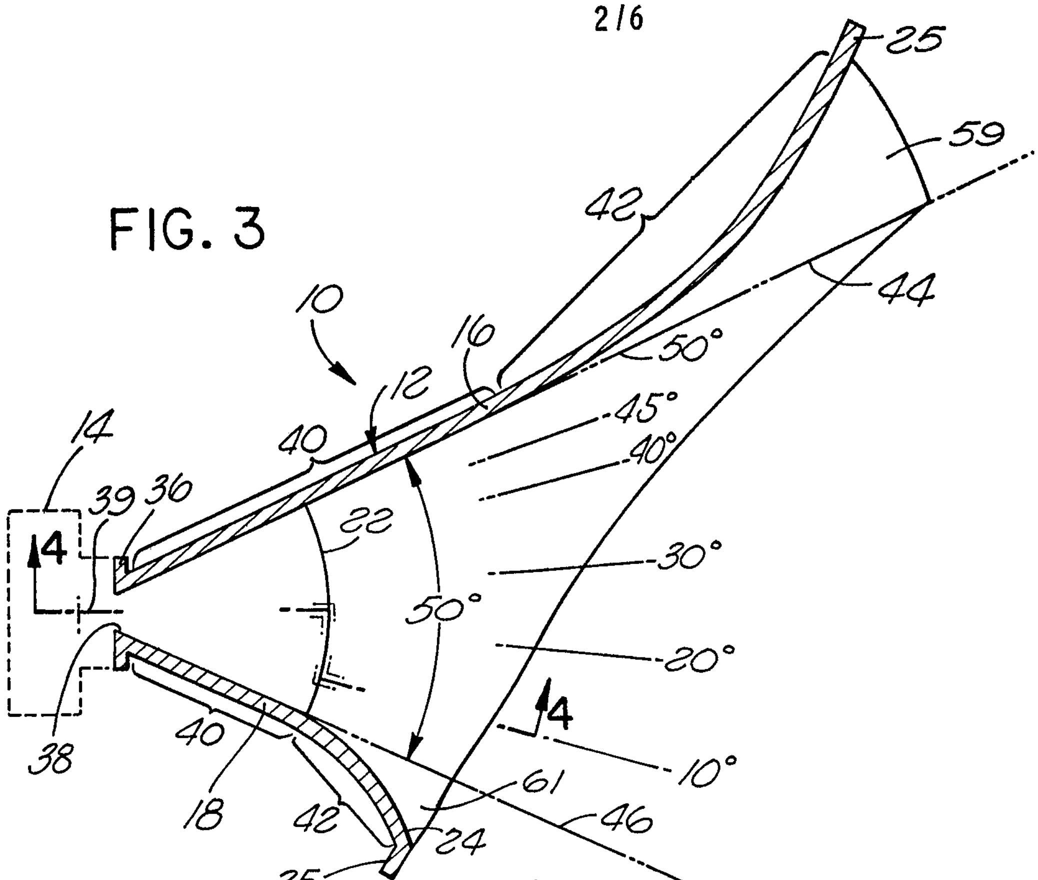

FIG. 3

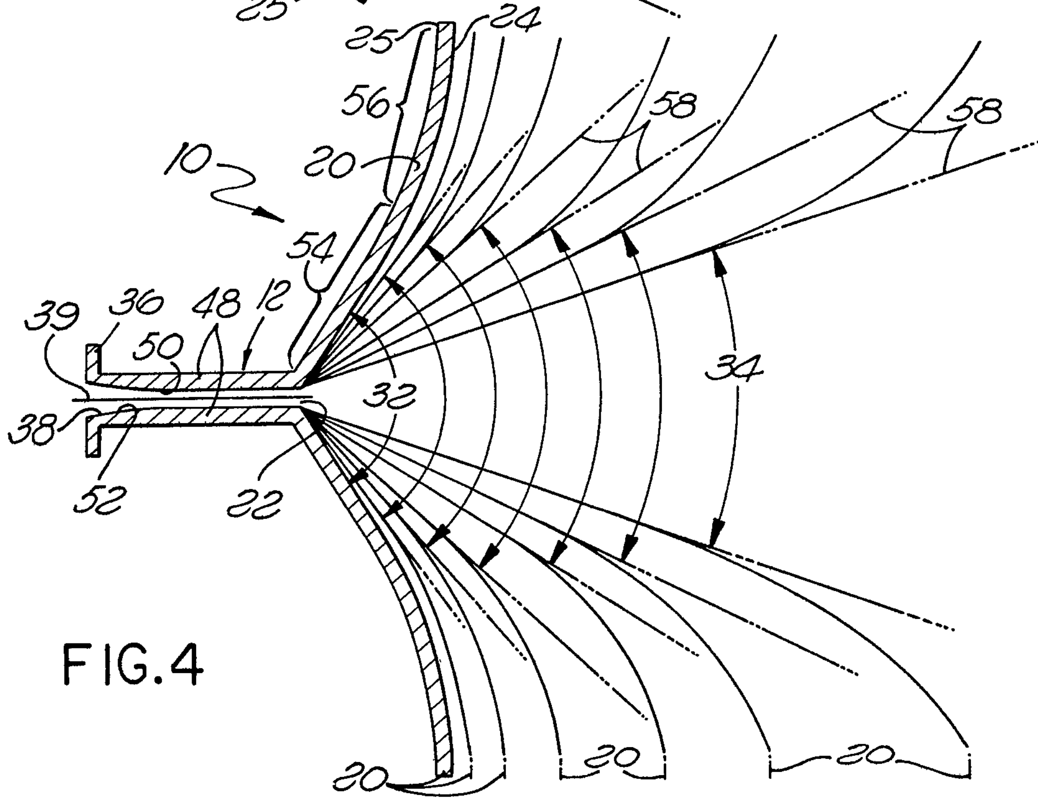

FIG.4

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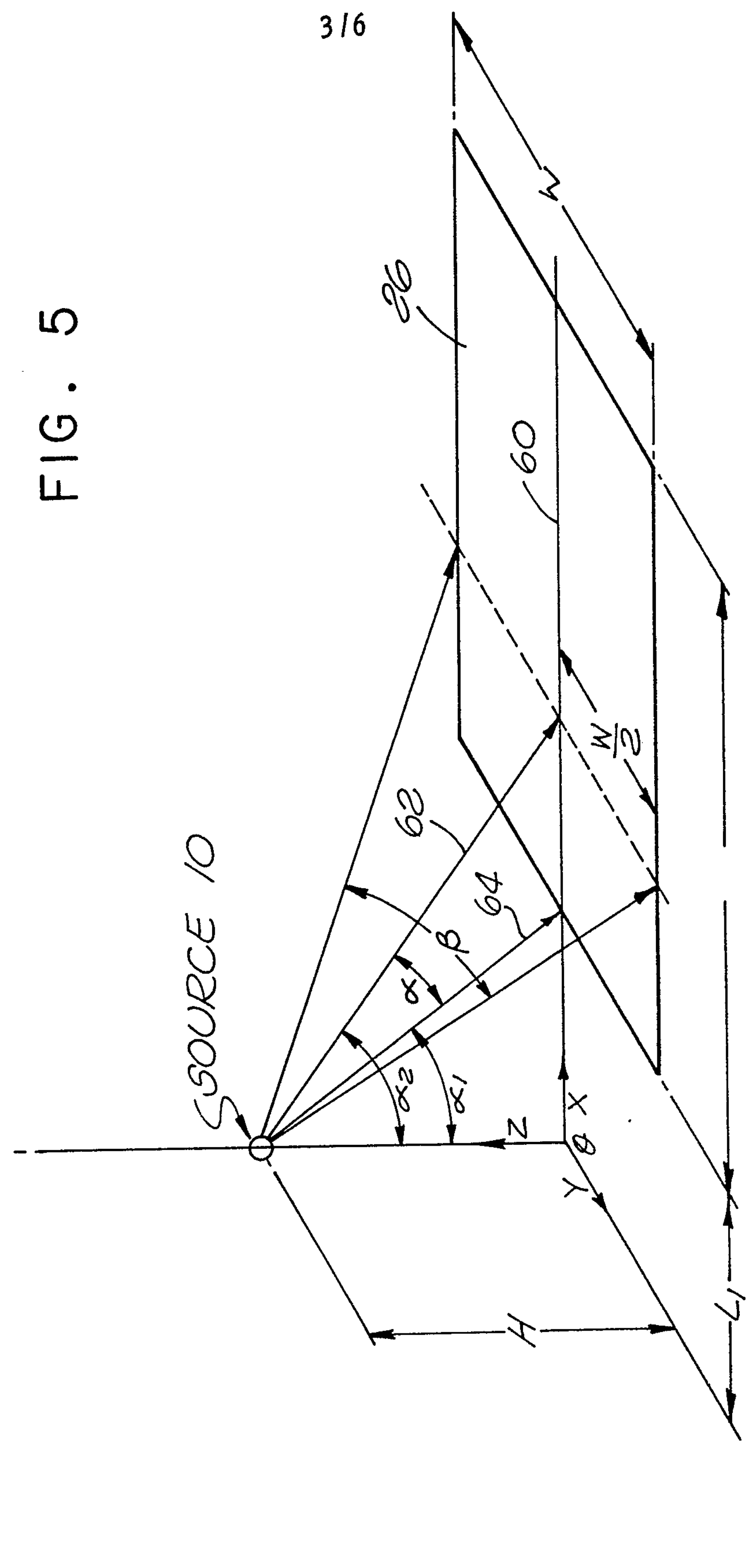


FIG. 5

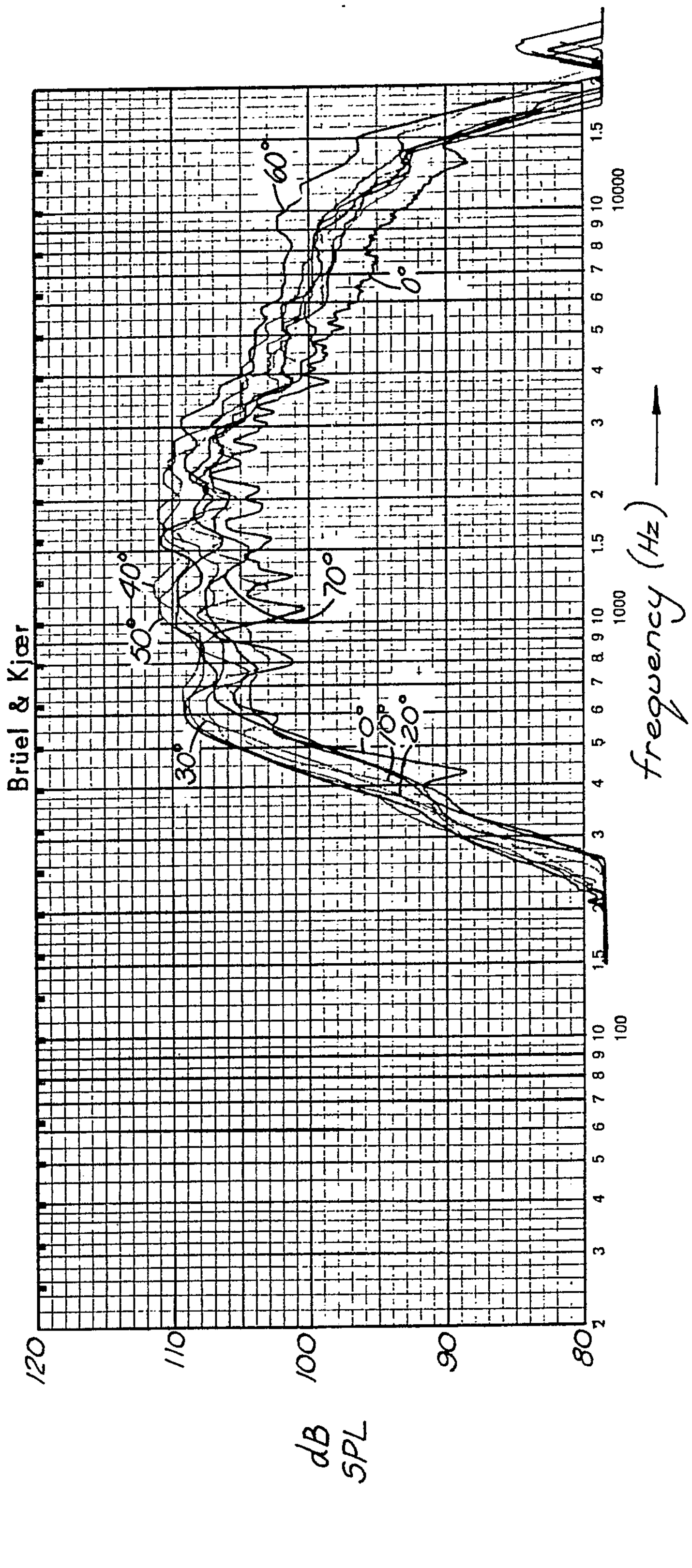
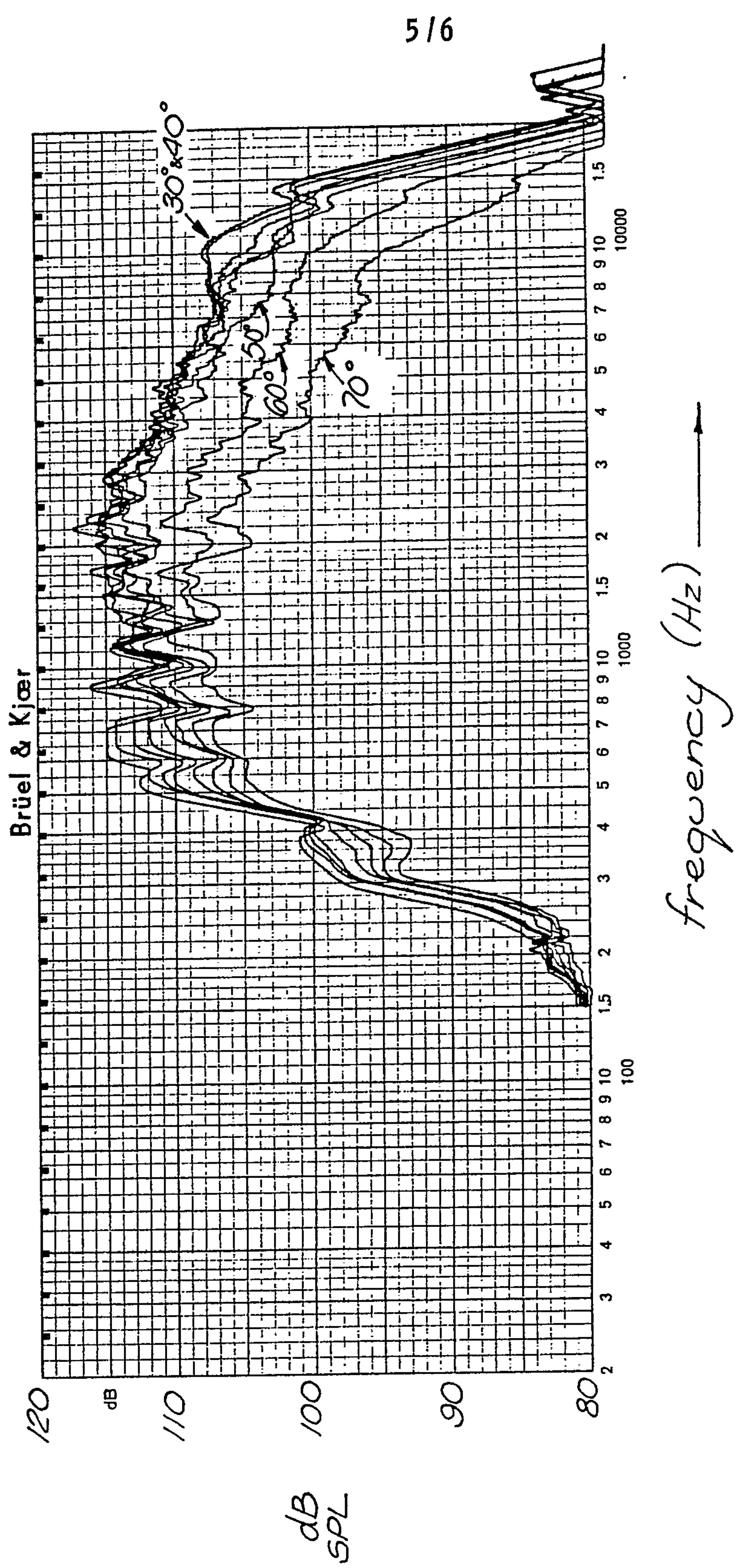

Brüel & Kjær
dB SPL
120
110
100
90
80
2
3
4
5
6
7
8
9
10
100
1.5
1000
10000
frequency (Hz)
0°
10°
20°
30°
40°
50°
60°
70°

FIG. 6


Brüel & Kjær
dB
120
110
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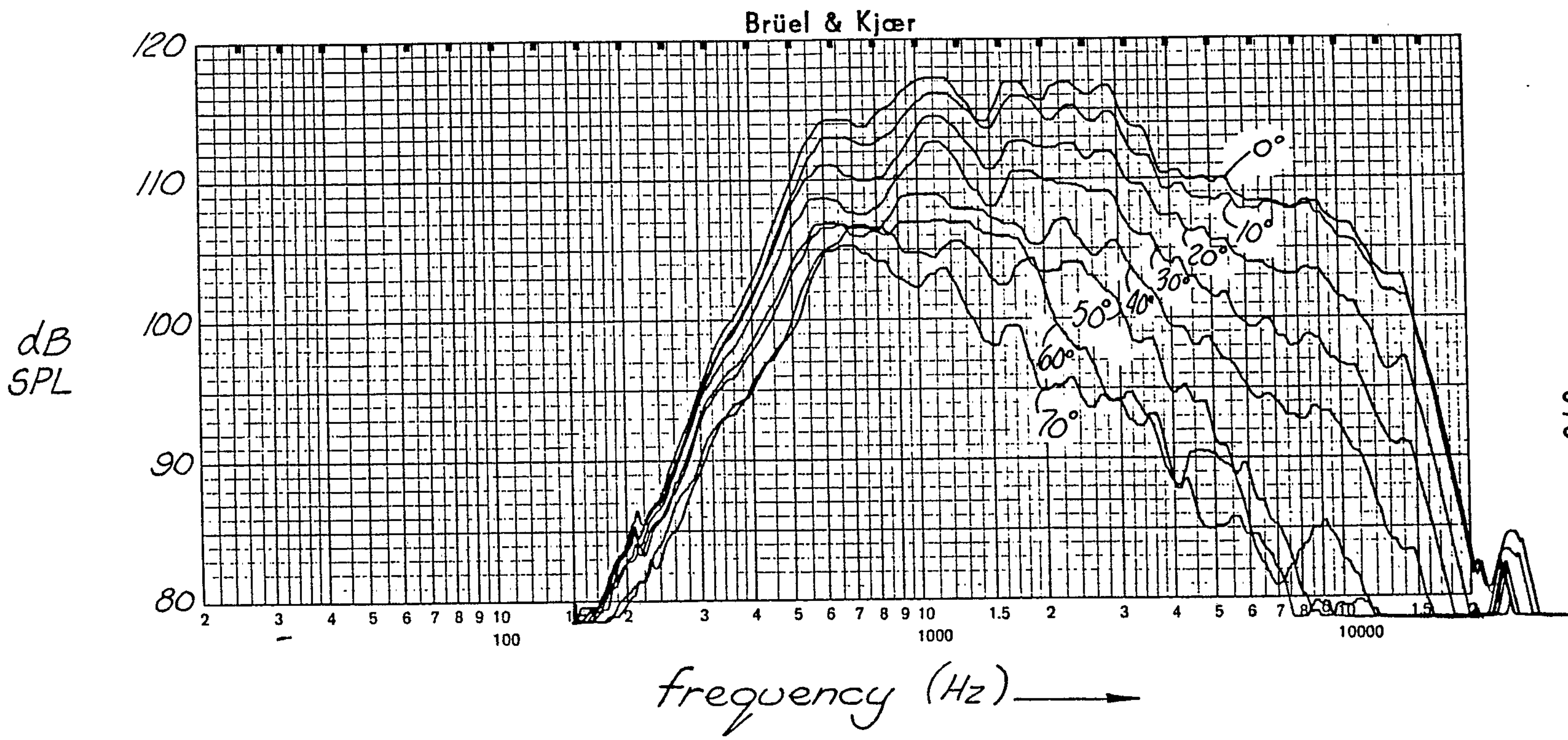
dB SPL
30°&40°
50°
60°
70°
frequency (Hz)

FIG. 7


Brüel & Kjær
dB
SPL
120
110
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10°
20°
30°
40°
50°
60°
70°
100
1000
10000
frequency (Hz)

FIG. 8

SPECIFICATION

Defined-coverage loudspeaker horn

Background of the invention

The present invention relates generally to the loudspeaker field and, more particularly, to a defined-coverage loudspeaker horn.

Early systems for directing sound over a predefined area typically involved a number of cone-type loudspeakers grouped together, as in linear, two-dimensional and phased arrays. However, such systems were only modestly successful at distributing high frequency sound. They were also costly, particularly when the area was large or irregularly shaped.

Horns were first introduced to increase the efficiency at which sound is produced in an audio system. Efficiency was of primary concern because amplifiers were very costly and limited in output. However, recent advances in amplification systems have shifted the emphasis from efficiency to considerations of coverage, directivity and frequency response. Two horns addressing these considerations are disclosed in U.S. Patent No. 2,537,141 to Klipsch and U.S. Patent No. 4,308,932 to Keele, Jr.

The Klipsch patent if directed to a radial horn of "astigmatic" construction, wherein expansion of an acoustic signal takes place initially in a single plane before commencing at right angles to that plane. This is desirable to maintain the phase of the signal over the mouth of the horn, such that the wavefront is a substantially spherical surface independent of frequency. The Klipsch device is well suited to circumstances calling for a radial wavefront of constant directivity, but is incapable of generalized coverage control.

The Keele patent discloses an improvement to the Klipsch horn, wherein two opposing side walls are flared outwardly according to a power series formula to enhance low frequency and midrange response. The horn of the Keele patent achieves directional characteristics substantially independent of frequency, but is limited in attainable coverage patterns in the same manner as the Klipsch horn.

Most recently, designers of loudspeaker horns have focused on attaining a uniform direct-field sound pressure level at all listener positions. Uniform sound pressure is difficult to obtain because most listener areas do not match the polar patterns of available loudspeakers. Even when the output of a single source is high enough to cover an area, the source will not suffice if it lacks proper directional characteristics. In addition, the phenomenon of "inverse rolloff", i.e., the decrease in sound pressure with increasing beam area, typically causes pressure to vary drastically over an area covered by a single source. Directivity and rolloff considerations can be addressed with clusters of short, medium and long throw horns directed to different portions of the area, but such systems are significantly more expensive than a single loudspeaker.

Therefore, it is desirable in many applications to provide a horn for directing sound from a single driver over a defined area at substantially constant directivity and pressure level.

Summary of the invention

A loudspeaker horn for directing sound from a driver to a target area comprises: means for radiating a sound beam generated by the driver; and opposed side walls extending outwardly from the radiating means, the side walls being constructed and arranged to direct a first portion of the beam toward a first portion of the target over a first preslected included angle, and to direct at least one other portion of the beam toward another portion of the target over a different preselected included angle. In a preferred embodiment, the target portions are located different distances from the radiating means, and the included angles are chosen such that each portion of the beam, i.e., "beamlet", is substantially coextensive with the respective target portion at a location of incidence thereon. The side walls substantially define the included angles over regions extending downstream of the radiating means a distance at least comparable to the maximum wavelength at which the loudspeaker is to operate. In one embodiment, the side walls comprise first and second pairs of opposed walls extending outwardly from the radiating means for controlling sound dispersion in first and second directions, respectively, and the first pair of side walls defines different included angles at lateral cross sections displaced angularly from each other about an axis located upstream of the wall means. In a further embodiment, the radiating means defines an elongated radiating gap with the second pair of side walls located at opposite ends thereof. The second walls then define a substantially constant included angle.

In the horn of the present invention, the angle of the path provided by the walls is determined by the line of sight path between the radiating source and the boundary of the target. The walls define a relatively narrow path to a remote portion of the target so that the beamwidth will correspond substantially to the width of the target area at the time of incidence. If the beam to a remote portion of the target were not initially narrow, it would be far too wide upon reaching the target. At the same time, the narrow conductive path causes sound energy passing along it to be compressed relative to sound directed along a wider path. This enhances the pressure level at the remote location and counteracts inverse rolloff of pressure with distance. When the target has a constant width, the sound pressure is substantially uniformally distributed over the area.

Although the most dramatic results are achieved in the case of rectangular target areas in which the horn of the present invention is positioned over a longitudinal axis of the area, the defined-coverage concept of the invention is believed applicable to areas of any outline, whether regular or irregular. In such cases, the configuration of the side wall surface is determined essentially by the line of sight relationship, but the sound pressure level may be less uniform than in the case of rectangular target areas. When an area is too large for a single loudspeaker, a number of the horns can be utilized at different locations, treating each smaller area as a separate target plane.

Brief description of the drawings

The above and other features of the present invention may be more fully understood from the following detailed description, taken together with the accompanying drawings, wherein similar reference characters refer to similar elements throughout and in which:

Figure 1 is an isometric frontal view of a loudspeaker horn constructed according to one embodiment of the present invention;

Figures 2A and *2B* are schematic representations of the coverage characteristics of the horn of Figure 1 relative to a predetermined rectangular area, as seen from the top and side of the area, respectively;

Figure 3 is a vertical cross-sectional view taken along the line 3-3 of Figure 1;

Figure 4 is a composite sectional view taken along a plurality of lines 4-4 of Figure 3, the portions at the right hand side of Figure 3 being displaced angularly relative to each other to illustrate the varying lateral wall angles of the horn as a function of the elevational angle;

Figure 5 is a schematic depiction of an acoustic source positioned at a generalized location relative to a rectangular target area;

Figure 6 is a composite set of frequency response curves of a horn constructed according to the present invention, taken at different elevational angles relative to the horn; and

Figures 7 and *8* are composite curves showing the lateral off-axis frequency response at elevational angles of zero and 70 degrees, respectively.

Description of the preferred embodiments

Referring now to the drawings, Figure 1 illustrates a loudspeaker assembly 10 made up of a horn 12 and a compression driver 14. The horn has a pair of upper and lower opposed side walls 16 and 18, respectively, and a pair of opposed lateral side walls 20, providing a divergent path from a gap outlet 22 to an open mouth 24. According to the teachings of the present invention, the lateral side walls 20 define an included angle which varies with the angle of elevation along the gap outlet. A peripheral flange 25 facilitates mounting of the horn.

As seen in Figures 2A and 2B, the loudspeaker 10 is positionable above and to the rear of a rectangular target area 26 to direct sound uniformly over the target. The upper and lower side walls of the horn direct sound over a constant angle 28 to cover the entire length 30 of the target area, and the side walls 20 define different lateral coverage angles for different points along the length 30. In the direction of the near end of the target, the side walls are configured to direct sound over a coverage angle 32. For convenience, this direction is defined as that of zero degrees (0°) elevation, with the maximum angle of elevation being toward the remote end of the target plane. As the elevation angle increases toward its maximum, the lateral coverage angle defined by the sidewalls decreases. This concentrates sound toward the remote regions of the target and produces a beam of appropriate width at those regions. The coverage angle defined by the walls 20 decreases continuously in the illustrated embodiment from the maximum value 32 to a minimum value 34 to account for broadening of the beam and "inverse rolloff" of intensity as the beam travels through air. In all cases, the horn walls near the gap conform rather closely to the surface defined by line of sight between each point on the gap outlet and the corresponding point on the target periphery.

The structure of the horn 12 is shown in more detail in Figures 3 and 4. The compression driver 14 is suitably affixed to a mounting flange 36 of the horn 12 for application of acoustic signals to a throat 38 of the horn along a principal axis 39. The upper and lower side walls diverge from the throat 38 at the vertical coverage angle 28 (Figure 2B) over respective linear regions 40. They then flare out more rapidly over outer regions 42. The linear regions 40 may be of different lengths, but are always at least comparable to the longest wavelength for which the horn is to be used. This enables sound to be expanded uniformly over the linear region and directed as a beam substantially conforming to the wall angle. Thus, sound exits the horn substantially over the constant angle defined by the broken lines 44 and 46.

Figure 4 illustrates the configuration of the horn 12 in a direction perpendicular to Figure 3. Sound from the driver 14 is confined laterally by a pair of substantially parallel walls 48 which define a gap 50 extending from the throat 38 to the outlet 22 of the gap. The width of the gap is comparable to or less than the minimum wavelength with which the horn is to be used, so that sound is radiated in a lateral direction as if the outlet 22 were the sound source. In the embodiment shown, the gap 50 is narrower than the throat 38, requiring a short transition portion 52 at that location.

The gap 50 permits expansion in the vertical direction, between the upper and lower walls 16 and 18, while confining the sound in the lateral direction. Lateral expansion commences further downstream, when the sound is effectively radiated in the lateral direction by the gap outlet. At that location, the sound is bounded by the lateral side walls 20 which define different included angles for different elevational directions. The side wall configurations at seven representative elevational angles are shown together in Figure 4. For clarity, the different lateral cross sections are depicted only for locations downstream of the gap outlet 22, with the gap itself shown as it appears along the axis of the throat 38. In actuality, the lateral side walls 20 vary in angle through a continuum of values between the angles 32 and 34.

As seen clearly in Figure 4, each cross section of the lateral side walls 20 is composed of a linear region 54 adjacent to the gap outlet 22, and a flared region 56 in the area of the mouth 24. Like the linear regions 40 of the upper and lower side walls, the regions 54 extend downstream a distance at least comparable to the longest wavelength with which the horn is to be used. This assures that sound produced by the driver 14 will be directed from the horn as a beam having included angles similar to the linear regions 54 in the respective elevational directions. Thus, the beam at each cross section is substantially the same as if the linear regions were extended outwardly in the manner of the dashed lines 58. The flared regions 56 are similar to the outer regions 52 of the upper and lower side walls.

Referring now to Figures 1 and 3, a deviation from the described structure is present at the upper and lower ends of the side walls 20. Because the operative elevational angles are located exclusively between the broken lines 44 and 46, there is no need to vary the angle of the lateral side walls beyond the values at those locations. However, the outward flare of the portions 42 causes the upper and lower side walls to extend away from the directions 44 and 46, leaving a gap between each pair of adjacent walls. In the embodiment 10, the gaps are closed by adding surfaces defined by swinging the lateral wall profiles at those locations about a point 57 at the apex of the side walls. The resulting surfaces are designated 59 and 61, respectively, in the drawings.

Figure 5 is a schematic depiction of the loudspeaker 10 obliquely oriented with respect to the rectangular target area 26. It is included to define the various angular and dimensional relationships of the preferred embodiment. The target area 26 corresponds generally to the ear plane of a group of listeners, such as an audience in a rectangular meeting hall or other room. A source (loudspeaker 10) is located a distance H above the plane of the target area, and directly over a longitudinal axis 60 of the target area. The longitudinal direction of the horn is preferably located within a plane which is perpendicular to and contains the axis of the target. In Figure 5, the source is H units above the target plane and L_1 units behind the target area. The target area is W units wide and L units long. The elevation angle is alpha (α), defined with zero degrees (0°) given as the direction of the near end of the target area. The total included horizontal coverage angle at each angle of elevation is beta (β).

Assuming a rectangular coordinate system centered below the source on the target plane, with the positive "x" axis coinciding with the longitudinal axis 60, the horizontal coverage angle defined by the walls 20 of the present invention is given as:

$$\beta = 2\tan^{-1}\left(\frac{W}{2\sqrt{x^2+H^2}}\right) \quad \text{where } L_1 \leq x \leq [L+L_1].$$

L_1 can be positive or negative depending upon where the source is placed over the centerline of the target. The expression for the angle β is derived from the geometry of Figure 5, in which $\beta/2$ is the arctangent of one-half the target width divided by the length of a vector 62 from the source to the axis 60. The vector 62 is, of course, equal to

$$\sqrt{x^2+H^2} \qquad \text{Thus, } \beta/2 = \tan^{-1}\frac{W}{2\sqrt{x^2+H^2}}$$

$$\text{and} \quad \beta = 2\tan^{-1}\frac{W}{2\sqrt{x^2+H^2}}$$

Similarly, the elevation angle alpha (α), as measured from a vector 64 directed to the end line of the target, is equal to $\alpha_2 - \alpha_1$. Since

$$\alpha_2 = \tan^{-1}(x/H) \quad \text{and} \quad \alpha_1 = \tan^{-1}(L_1/H),$$

$$\alpha = \tan^{-1}(x/H) - \tan^{-1}(L_1/H).$$

It will be understood that, while α and β are expressed herein as functions of the running parameter "x", each angle could be expressed in terms of the other by solving one equation for x and substituting the solution into the other equation. However, the formulas have been left in the present form for simplicity.

Although the formulas presented above correspond only to the case of a rectangular target area with the source located directly above its axis, similar expressions can be derived for differently shaped target areas or differently oriented sources. The basic considerations are the same in all cases, i.e., the side walls of the horn must correspond substantially to the line of sight between each point on the source and the corresponding point on the periphery of the target area. The beam produced by the source then coincides generally in breadth with the target area at each location of the target, efficiently distributing sound from the source.

In the specific case of Figures 1, 2, 3 and 4, the rectangular target area is 2.645 by 2.0 normalized units in size, and the radiating gap of the loudspeaker 10 is to be located 0.61 units above the target plane and 0.33 units behind the end of the target area. Thus, $L = 2.645$, $W = 2.0$, $H = 0.61$ and $L_1 = 0.33$. The elevational angle varies from zero to 50 degrees over the length of the target area, and the expressions above can be used to calculate the lateral coverage angle (β) for each elevational angle (α) within the range. Values of the included coverage angles in the illustrated embodiment are given in Table I for five degree increments in elevation. The table shows that the included coverage angle varies from a maximum of 110.5 degrees at zero degrees elevation, to a minimum of 36.5 degrees at 50 degrees elevation. The expression for the coverage angle can be used in this way to determine the continuum of angles defined by the side walls 20.

TABLE I

x (normalized)	*Elevational Angle (α)* (degrees)	*Included Coverage Angle (β)* degrees)
.330	0.0	110.5
.402	5.0	107.7
.484	10.0	104.2
.577	15.0	100.0
.687	20.0	94.8
.822	25.0	88.7
.992	30.0	81.3
1.219	35.0	72.5
1.542	40.0	62.2
2.048	45.0	50.2
2.975	50.0	36.5

A horn having essentially the configurations described above has been fabricated of wood and subjected to preliminary audio testing for sound pressure level (SPL) distribution. Prior to that, a slightly different wooden horn was fabricated. The earlier horn was designed to cover a rectangular target area 2.0 by 2.7 normalized units in size, from a location 1.0 unit above the middle of an end line of the area. The total elevational angle in that case was 70 degrees. Audio testing for frequency response was conducted at various angular orientations relative to the horn, all measurements being taken at equal distances (approximately 3 meters) downstream of the source at a nominal power input of 1 watt per meter. Representative results of such tests are illustrated in Figures 6, 7 and 8, wherein sound pressure level (SPL) is expressed in terms of "dB SPL" with respect to a reference point of twenty (20) micro-pascals (μPa).

Figure 6 contains a set of frequency response curves taken at different elevational angles relative to the horn, all at zero degrees lateral deflection. While a conventional radial source would ideally have identical response over its angular range at a uniform downstream distance, the defined coverage horn of the present invention should exhibit a markedly non-uniform response. That is, the greater the elevational angle, the higher the sound pressure level. It can be seen from Figure 6 that the horn behaved in the expected manner. The 40, 50 and 60 degree curves were the highest in pressure level, with the 70 degree curve slightly lower. The high pressure level in the 40, 50 and 60 degree directions confirms the sound concentrating feature of the invention, while the lower level at 70 degrees shows that the horn is not perfect. If the measurements were taken on the target plane itself, rather than at equal distances downstream of the horn, the result would be a nearly uniform sound pressure level along the axis.

Figures 7 and 8 are the lateral off-axis frequency response curves of the early horn, taken at zero and 70 degrees elevation, respectively, at increments of 10 degrees from the axis. A comparison of these curves shows that the horn is much more directive at 70 degrees elevation than at zero degrees. Thus, the high frequency portions of the 70 degree curves drop off more rapidly as the probe is moved off the axis. The beamwidths, defined by the 6dB-down points, are located roughly at the edge of the target at both elevations. Referring specifically to Figure 8, the 6dB down points are approximately 20 degrees off-axis. This corresponds to the edge of the target, which is a total of 40 degrees wide at 70 degrees elvation. If extrapolated to the target plane, this beamwidth would nicely cover the width of the target area.

Although the sound distribution of Figures 6-8 is not perfect, it is far superior than that obtainable with any other known horn. Similar experimental data has been extracted for locations off the longitudinal axis for representative elevational angles. This data clearly demonstrates the advantages of the invention in distributing sound over a target area in an even and efficient manner. Preliminary testing has also been conducted with the more recent horn constructed using the angular relationships described in Table I. Such testing, although not complete, bears out the observations made above.

Although the side walls of the present invention are described herein as being defined substantially by the line of sight between the source and the periphery of the target area, the actual distribution of sound may deviate somewhat from the line of sight case. However, such deviations are relatively minor and, in any event, are readily calculable for correction purposes. For example, the line of sight approximation applies most closely to the case in which the walls of the horn 12 continue outwardly at a constant angle, as shown by the broken lines 44, 46 and 58 of Figures 3 and 4. However, it has been found to be advantageous to flare the side walls outwardly at locations adjacent the mouth 24, for purposes of improving coverage and directivity. This phenomenon is described fully in U. S. Patent No. 4,308,932 to Keele, Jr. which calls for flaring the walls outwardly in accordance with the function:

$$y = a + bc + cx^n,$$

where "x" is the axial distance from the source and "y" is the lateral displacement of the side wall. The constants "a" and "b" are determined by the slope of the linear portion of the horn wall, while the constant "c" and the power "n" determine the extent of curvature desired. Application of this formula to determine the contours of the flared regions 42 and 56 is evident from the '932 patent, which is hereby incorporated by reference. In the case illustrated in the drawings, the power "n" has a value of seven, but in other cases the value can vary between approximately four and eight.

In operation, the horn 12 is coupled with the compression driver 14 and mounted permanently in a desired orientation relative to the target area 26. Because the target area is the listener's ear plane of a room or other structure within which the horn is to be used, the target area remains constant and therefore the horn always occupies the same position. The horn may be attached by suspension or direct mounting, as known in the art. When the horn is directly mounted to the ceiling or other surface of a room, such attachment is made through the peripheral flange 25.

From the above, it can be seen that there has been provided an improved horn arrangement for directing sound produced by an acoustic driver over a suitable defined target area. The frequency response of the horn indicates a very well behaved constant-directivity which gets progressively narrower as the vertical elevation angle is increased. The horn's lateral directional pattern is quite well matched with beamwidth angles to the target area, as seen by the horn at each elevational angle. This defined-coverage horn can be substituted for several conventional horn-driver combinations that would normally be required to adequately cover a rectangular region, however, it can only be used where the acoustical output capabilities of a single driver are adequate. In the case of a rectangular target area, the horn partially compensates for the inverse rolloff of sound pressure with distance in the forward-backward direction.

While certain specific embodiments of the present invention have been disclosed as typical, the invention is of course not limited to these particular forms, but rather is applicable broadly to all such variations as fall within the scope of the appended claims. As an example, the target area need not be rectangular in shape, need not be symmetric about a longitudinal axis, and need not have straight ends. In any case, a desired beam shape can be achieved by configuring opposite side walls of the horn to define appropriate included angles at each cross section. The material of the horn may be any suitable material having sufficient rigidity for use as a loudspeaker horn. Such materials include glass fiber reinforced resin and certain structural foams, including polycarbonate foam.

CLAIMS

1. A loudspeaker horn for directing sound from a driver to a target area comprising:

means for radiating a sound beam generated by the driver; and

opposed side wall means extending outwardly from the radiating means, the wall means being constructed and arranged to direct a first portion of the beam toward a first portion of the target over a first preselected included angle, and to direct at least one other portion of the beam toward another portion of the target over a different preselected included angle.

2. The loudspeaker horn of claim 1 wherein:

the target portions are located different distances from the radiating means; and

the included angles are chosen such that each portion of the beam is substantially coextensive with the respective target portion at a location of incidence thereon.

3. The loudspeaker horn of claim 2 wherein:

the side wall means substantially define said included angles adjacent to the radiating means.

4. The loudspeaker horn of claim 3 wherein:

the loudspeaker is designed for use primarily within a wavelength range having preselected maximum and minimum values; and

the side walls substantially define said included angles over regions extending downstream of the radiating means a distance at least comparable to the maximum wavelength value.

5. The loudspeaker horn of claim 4 wherein:

the side wall means flare outwardly more rapidly than the included angles downstream of said regions.

6. The loudspeaker horn of claim 3 wherein:

the side wall means comprises:

a first pair of opposed side walls having a plurality of opposed side wall portions which substantially define said included angles; and a second pair of opposed side walls joining the ends of the first side walls to define a conduit having a first open end adjacent to the radiating means and a second enlarged open end substantially opposite to the radiating means.

7. The loudspeaker horn of claim 6 wherein:
the first pair of side walls defines a continuum of said included angles

8. The loudspeaker horn of claim 7 wherein:
the first pair of side walls is substantially symmetric about a preselected axis; and
the radiating means comprises elongated radiating gap means having a longitudinal direction parallel to said axis.

9. A loudspeaker horn for directing sound from a driver having a principal axis of propagation to a target area having a preselected longitudinal axis, comprising:
means for radiating sound from the driver in first and second directions normal to the axis of propagation, the radiating means being positionable so that the second direction is coplanar with the axis of the target; and
conductive side wall means having first and second pairs of opposed side walls extending outwardly from the radiating means for controlling sound dispersion in the first and second directions, respectively;
the first pair of side walls defining different included angles at lateral cross sections displaced angularly from each other about an axis which is parallel to the first direction and is located upstream of the wall means.

10. The loudspeaker horn of claim 9 wherein:
the target area comprises a plurality of target portions located different distances from the radiating means; and
the different included angles of the first pair of side walls are chosen to direct sound toward the different target portions as beamlets of different preselected angles, such that each beamlet is substantially coextensive with one of the target portions at a location of incidence thereon.

11. The loudspeaker horn of claim 10 wherein:
the radiating means defines an elongated radiating gap having a longitudinal direction parallel to said second direction.

12. The loudspeaker horn of claim 11 wherein:
the second pair of side walls define an included angle which is substantially constant over said first direction.

13. The loudspeaker horn of claim 12 wherein:
the first pair of side walls are substantially symmetrical with each other.

14. The loudspeaker horn of claim 10 wherein:
the loudspeaker is designed for use primarily within a wavelength range having preselected maximum and minimum values; and
the first pair of side walls substantially defines said included angles over regions extending downstream of the radiating means a distance at least comparable to the maximum wavelength value.

15. The loudspeaker horn of claim 14 wherein:
the side wall means flare outwardly more rapidly than the included angles at locations downstream of said regions.

16. A loudspeaker horn for use with a driver having a principal axis of propagation to direct sound from the driver to a substantially horizontal rectangular target area having preselected longitudinal and lateral axes, comprising:
means for radiating sound from the driver in first and second orthogonal directions normal to the axis of propagation, the radiating means comprising a throat which leads to an elongated gap portion such that sound is radiated in the second direction within the throat and is radiated in the first direction upon emission from the gap, the radiating means being positionable so that the second direction is located within a plane perpendicular to the target area and containing its longitudinal axis; and
first and second pairs of opposed side walls extending outwardly from the radiating means to control sound dispersion in the first and second directions, respectively;
the side walls of the first pair being symmetrical with each other and defining different included angles at lateral cross sections displaced angularly from each other about an axis parallel to the first direction and coinciding with the outlet of the throat; and
the side walls of the second pair defining an included angle which is substantially constant over said first direction.

17. The loudspeaker horn of claim 16 wherein:
the included lateral angle (β) of the first pair of side walls is defined by the expression:

$$\beta = 2 \tan^{-1} \frac{W}{2\sqrt{X^2 + H^2}}$$

where W is the lateral dimension of the target, H is the height of the radiating means above the plane of the target, and X is the distance in the plane of the target between a point directly below the radiating means and a point of interest along said longitudinal axis of the target.

18. A loudspeaker horn substantially as hereinbefore described and as shown in the accompanying drawings.

Printed in the UK for HMSO, D8818935, 3/85, 7102.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.