

April 1, 1969

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3,435,910

SEMISPHERICAL LOUDSPEAKER

Filed Nov. 22, 1967

FIG. 1

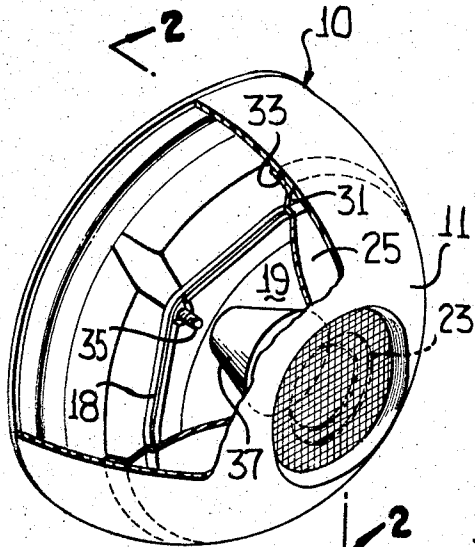


FIG. 2

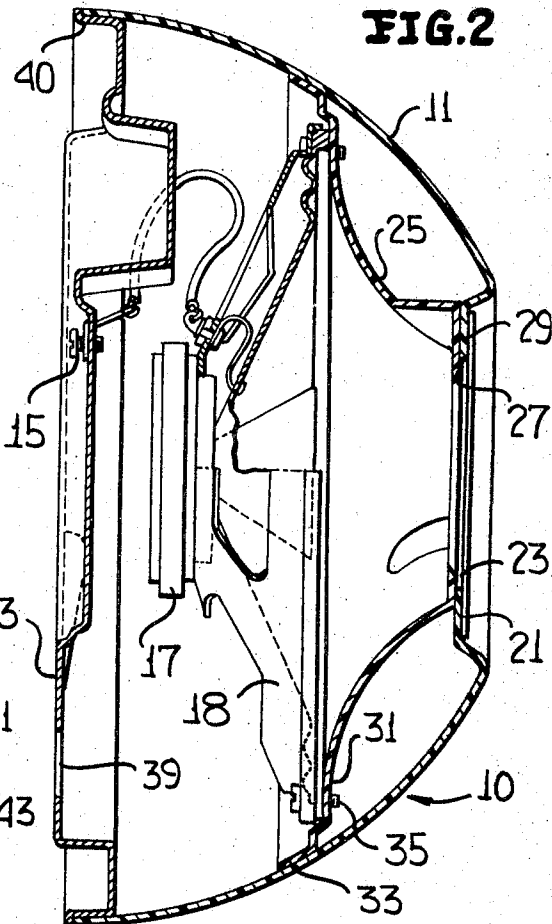


FIG. 4

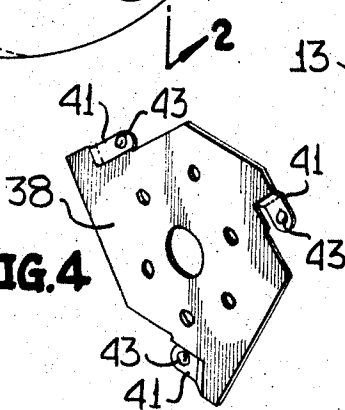
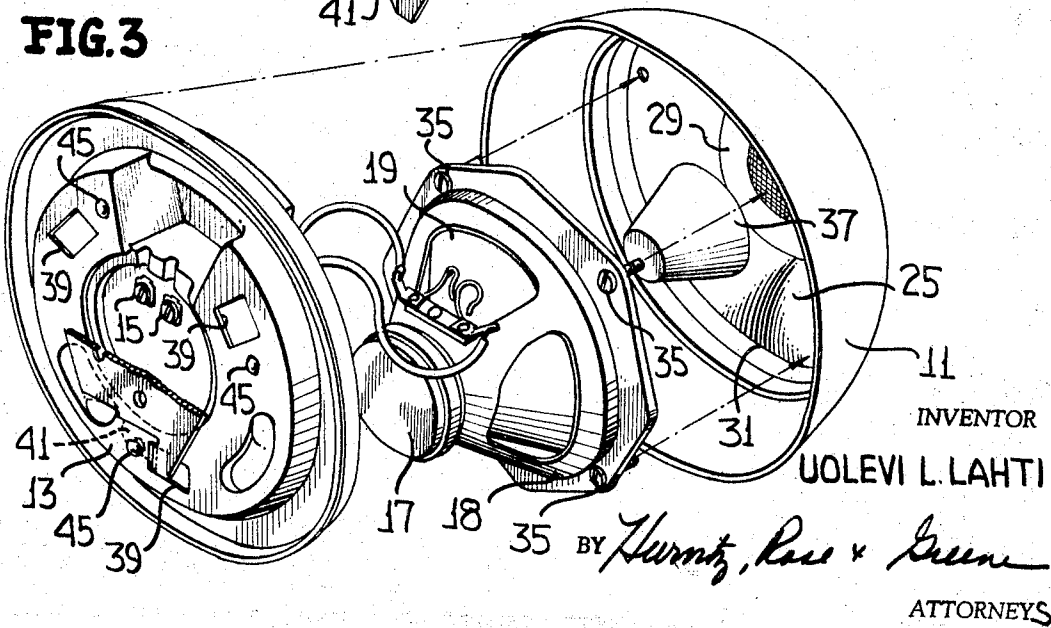


FIG. 3



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SEMISPHERICAL LOUDSPEAKER

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Filed Nov. 22, 1967, Ser. No. 685,043

Int. Cl. G10k 13/00; H04r 7/16

U.S. Cl. 181—31

15 Claims

ABSTRACT OF THE DISCLOSURE

A loudspeaker system comprising a loudspeaker having its basket secured to and its cone acoustically coupled to an inverted exponential horn. The horn is mounted on the concave wall of a semispherical enclosure, the wall having an aperture defined therethrough which is slightly larger than the small opening of the horn, the latter being defined by a sharp edge which spreads the acoustic pattern provided by the horn. A high frequency horn having a rim of about the same size as the small horn opening may be mounted at the apex of the first mentioned diaphragm, whereby the high frequencies transduced by the high frequency diaphragm are radiated through the wall aperture with acoustic spreading due to the sharp edge. The exponential horn provides a rigidifying strut for the enclosure, which is fabricated of thin plastic.

Background of the invention

In my prior U.S. Patent No. 3,136,349 I disclosed a loudspeaker system wherein improved low frequency response and acoustic spreading were achieved without the necessity of large speaker enclosures or large speakers. Specifically, the system described in my prior patent employs an inverted exponential horn mounted at its large end to the rim of the speaker diaphragm, the large end of the horn and the diaphragm rim being of the same size and shape. The air velocity at the small end of the horn is greater than the velocity of air at the diaphragm, the velocity ratio being approximately equal to the ratio of the areas at the large and small openings of the horn. This configuration enables low frequencies to be radiated through the small horn opening without concomitant large movements of the speaker diaphragm. A system of the type described provides efficient operation below 60 cycles per second and has a flat response, ± 6 db, from approximately 55–18,000 cycles per second.

Summary of the invention

In accordance with the principles of the present invention, a loudspeaker enclosure is provided with a semispherical wall having an acoustic radiating aperture defined through its apex. An inverted exponential horn having its smaller opening slightly larger than the wall aperture is mounted on the concave surface of this hemispherical wall with the small opening and the aperture in substantial alignment and in immediate adjacency. The large opening in the horn is of substantially the same size and shape as the opening defined by the rim of a speaker diaphragm deployed within the enclosure. The speaker basket is secured to the wide end of the horn, and the horn is secured to the enclosure both at its large and its small ends to rigidify the enclosure, which is fabricated of thin plastic material. The semispherical enclosure thus provided is lighter, more compact and less obtrusive than the substantially rectangular enclosure disclosed in my aforesaid patent.

In order to improve the high frequency response of the novel speaker enclosure of the present invention, the system may be converted into a "two-way" speaker system. Specifically, a tweeter diaphragm may be affixed to

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the apex area of the diaphragm in the system described above. The tweeter diaphragm is in substantial alignment with and of about the same size as the small opening in the horn.

The tweeter radiates through a sharp edge, which widens its otherwise narrow acoustic radiation pattern.

Brief description of the drawings

The above and still further objects, features and advantages of the present invention will become apparent from consideration of the following detailed description of one specific embodiment thereof, especially when taken in conjunction with the accompanying drawings, wherein:

FIGURE 1 is a view in perspective of a loudspeaker enclosure according to the present invention;

FIGURE 2 is a view in section taken on line 2—2 of FIGURE 1; and

FIGURE 3 is a disassembled view in perspective of the speaker of the FIGURES 1 and 2;

FIGURE 4 is a view in perspective of a mounting plate for the speaker of the present invention.

Detailed description of the invention

Referring now to the accompanying drawings, the reference numeral 10 denotes an enclosure comprising a semispherical plastic wall 11 and a substantially circular steel rear wall 13 secured to the rim of semispherical wall 11. Semispherical wall 11 is fabricated of light weight acoustically imperforate material, specifically plastic, and is less than $\frac{1}{16}$ inch thick. In and of itself, therefore, it is light but not rigid. The diameter of a typical structure may be 12" and the depth $5\frac{1}{2}$ " (outer dimension). A pair of terminals 15 extends through appropriate apertures provided in rear wall 13 and serve to conduct externally supplied audio power interiorly of enclosure 10.

The speaker itself includes a motor 17, a spider or basket 18, and a flexible diaphragm 19 secured to the spider. The speaker is a conventional permanent magnet speaker of the type which may be readily purchased on the open market. Any such speaker is suitable for the purposes of the present invention.

Spherical wall 11 is symmetrically truncated at its apex to form a substantially flat annular portion 21 which is recessed slightly from the plane of truncation to extend inwardly of the enclosure. For a semicircular wall of 12 inch diameter, the diameter of recess 21 may typically be 5 inches. A circular aperture 23 is defined through wall 11 centrally of recess 21.

An exponential horn 25, fabricated of the same material as wall 11, is disposed interiorly of enclosure 10 with its smaller opening 27 immediately adjacent to and symmetrically disposed relative to aperture 23 in wall 11. Specifically, the smaller end of horn 25 terminates in an annular wall 29 having a diameter slightly larger than the diameter of aperture 23 in wall 11. Small circular opening 27 of horn 25 is formed in annular wall 29 and is somewhat smaller in diameter than aperture 23 and is provided with a sharp edge. In a typical structure wherein the diameter of semispherical wall 11 is 12", aperture 23 is $2\frac{3}{8}$ " in diameter and opening 27 has a $2\frac{3}{8}$ " diameter. Annular wall 29 is secured to the inner surface of recess 21 by means of any suitable adhesive.

The large end of exponential horn 25 flares out into an annular shoulder 31 which in turn is extended to form a rim 33 configured to extend in contact with a segment of the inner portion of wall 11. Rim 33 is secured to this portion of wall 11 in the same manner as annular wall 29 is secured to the inner surface of recess 21. The spider 18 is secured to the shoulder 31 at the large end of the

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horn by means of screws 35. The larger end of horn 25 defined by shoulder 31 conforms approximately in size and shape with the opening defined by the rim of diaphragm 19. Since the enclosure 11 and horn 25 are concave relative to each other, each forms a strut for the other, and the structure is rigid despite the fact that it is fabricated of thin relatively flexible plastic.

The small outer opening 27 of horn 25 tapers from the inner surface to the outer surface of annular wall 29 thereby providing a sharp edge. It has been found empirically, as discussed in my Patent No. 3,135,349, that the sharp edge of opening 27 improves the performance of the system with regard to quality of sound and spread of the sonic pattern, both in respect to high and low frequencies.

A tweeter diaphragm 37 of generally frusto-conical configuration has its truncated end secured at the apex of diaphragm 19 by means of suitable glue, epoxy, or the like. Diaphragm 37 is substantially smaller than diaphragm 19 and is made of somewhat more rigid material than diaphragm 19 so as to render tweeter diaphragm 37 more suitable for high frequency reproduction. Tweeter diaphragm 37 is of necessity more concave than the diaphragm 19. Tweeter diaphragm 37, in accordance with the principles of the present invention, terminates in an outer rim which is of about the same size as the small opening 27 in horn 25. On the other hand, the horn serves to increase the velocity of air displaced by diaphragm 19, the air velocity being increased by a factor of approximately four or five times at opening 27. This velocity amplification factor represents the ratio of the large to small areas of the horn openings. The increase of velocity simulates the large diaphragm excursions required of a low frequency speaker, doing so in a small speaker in which such excursions are quite small. At the same time the air displaced by diaphragm 19 is smoothly collected by the horn and the horn is acoustically impedance matched at all frequencies with the speaker. The improved high frequency response achieved by means of diaphragm 37 serves to enhance the high frequency response characteristic of the speaker of the present invention.

Rear wall 13 of enclosure 10 is provided with apertures 39 defined therethrough suitable for receiving nails, hooks, or other similar wall mounting elements whereby enclosure 10 can be mounted unobtrusively to a wall or ceiling with rear wall 13 flush against the mounting surface.

An alternative mounting arrangement for speaker 10 is provided by means of mounting plate 38 illustrated in FIGURE 4, and in partial cutaway in FIGURE 3. Mounting plate 38 is fabricated of the same material as wall 13 and is of generally equilateral triangular configuration (although this configuration is not to be construed as limiting). The apices of the triangle are truncated and are provided with tab members 41 recessed slightly from the plane of plate 38. The tabs 41 are arranged to engage rear wall 13 of speaker 10 between the tabs and the main body of plate 38. Specifically, when tabs 41 are aligned within holes 39 and speaker 10 is rotated clockwise, wall 13 is appropriately engaged. The tabs are provided with small projections 43 which are adapted to mate with appropriately provided notches 45 in wall 13 to lock the speaker in position relative to the mounting plate. Suitably provided holes in the mounting plate enable it to be mounted as desired. Plate 38 thus provides three-point suspension mounting for speaker 10.

Rear wall 13 is fabricated of metal, by stamping. In terms of radial impression it is rigid and since the large end of enclosure 11 is cemented to an axially extending annulus 40 which terminates wall 13, the rigidity of wall 13 is imparted to enclosure 11 over its surface of larger diameter. The open or large side of spider 18, which is secured near the large end of horn 25, is also fabricated of metal and assists in rigidifying the enclosure 11. The overall structure, then, despite the fact that it is fabricated

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of thin walled flexible plastic material, i.e., is rigid. Rigidity is thus secured with lightness of weight and also the advantage that the plastic material damps acoustic waves well, so that resonances, and consequence vibrations of the enclosure and horn, do not occur.

I claim:

1. A loudspeaker system comprising:

a loudspeaker having a diaphragm with a concave side terminating in a substantially planar rim, a spider for supporting said diaphragm, and a motor for driving said diaphragm;

an enclosure including a wall having a concave side disposed inwardly of said enclosure and terminating in a rim, the rim of said wall being substantially larger than the rim of said diaphragm, said wall having an apical aperture,

a horn of exponential configuration having one end terminating in a small opening defining an area which is less than one half the area defined by the rim of said diaphragm, the aperture in said wall being of approximately the same size as said small horn opening, said horn having a second end terminating in a large opening conforming approximately to the size and shape of the rim of said diaphragm;

means for securing said horn to the concave side of said wall with the small opening of said horn adjacent to and in alignment with said aperture;

means for securing said loudspeaker to the large end of said horn with the rim of said diaphragm adjacent to and in alignment with the large opening of said horn and with the concave side of said diaphragm facing said large opening in said horn.

2. The combination according to claim 1 wherein said wall is of semispherical configuration.

3. The combination according to claim 1 wherein said aperture and the smaller opening of said horn are circular.

4. The combination according to claim 3 wherein said wall is of semispherical configuration.

5. The combination according to claim 4 wherein said small opening of said horn has a sharp edge.

6. The combination according to claim 1 wherein said loudspeaker further comprises a high frequency diaphragm having a concave side terminating in a rim of nearly the same size as the small opening in said horn, said high frequency diaphragm being secured to the apex of said first mentioned diaphragm with the concave side of said high frequency diaphragm facing said horn, the rim of said high frequency diaphragm being in axial alignment with the small opening of said horn.

7. The combination according to claim 6 wherein the rim of said high frequency diaphragm is of substantially the same shape as the small opening of said horn.

8. The combination according to claim 7 wherein said wall is semispherical and said large and small openings of said horn are circular.

9. A loudspeaker enclosure including a hemispherical thin walled relatively flexible enclosure having a circular apical opening,

an inverted exponential horn having its large end secured to said enclosure internally thereof and its small end secured to said enclosure adjacent said opening, said exponential horn providing a strut for rigidifying said enclosure.

10. The combination according to claim 9 wherein is further provided a loudspeaker located interiorly of said enclosure and having a basket, said basket having a rim secured directly to said inverted exponential horn in acoustically sealed relation thereto.

11. The combination according to claim 10 wherein said loudspeaker further includes a tweeter cone located interiorly of said basket and having a rim diameter approximately equal to the diameter of said apical opening, said apical opening being provided with a sharp

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edge to broaden the acoustic radiation pattern of said enclosure.

12. The combination according to claim 9 wherein said inverted exponential horn terminates at its small end in a wall extending perpendicularly of the axis of said inclosure and terminated in a sharp edge serving to spread the acoustical radiation pattern provided by said inverted exponential horn.

13. The combination according to claim 9 wherein said enclosure and said horn are fabricated of identical flexible plastic material of about 1/16" thickness, whereby said enclosure imparts rigidity to said horn.

14. The combination according to claim 9 further comprising a substantially rigid rear wall secured to said enclosure diametrically opposite said apical opening, said rear wall providing an additional strut for rigidifying said enclosure.

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15. The combination according to claim 14 wherein a plurality of holes are provided in said rear wall, and further comprising a mounting plate having resilient tab members arranged to engage said rear wall between said tab members and the mounting plate adjacent said holes.

References Cited

UNITED STATES PATENTS

1,755,636	4/1930	Dubilier	181—31
2,615,995	10/1952	Voigt	179—115.5
3,135,349	6/1964	Lahti	181—31
3,170,538	2/1965	Detrick	181—31

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U.S. Cl. X.R.

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