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LOUDSPEAKER

Filed April 2, 1962

FIG. 1

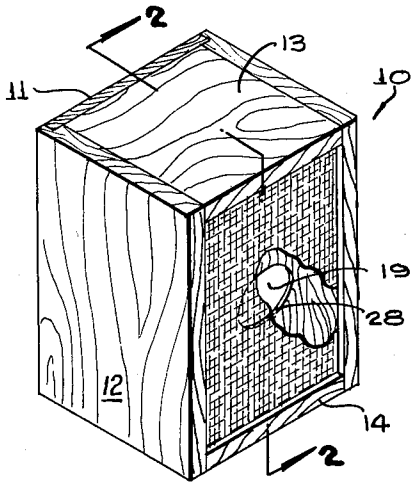


FIG. 2

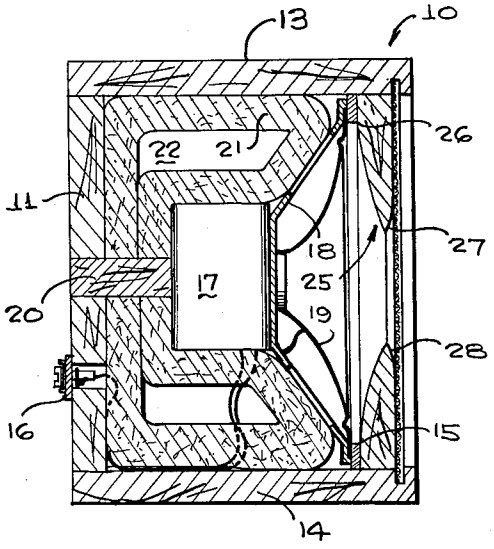
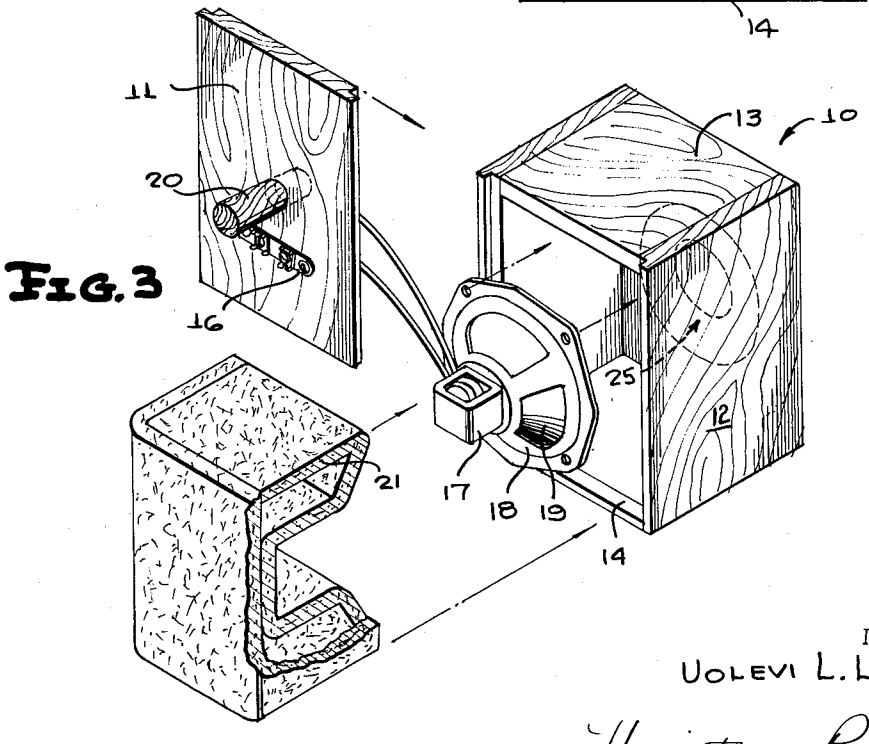


FIG. 3



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LOUDSPEAKER

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The present invention relates generally to loudspeaker enclosures, and more particularly to high fidelity loudspeaker enclosures having extremely low frequency response, which is attainable by means of a very small physical structure.

It is known in the art to provide wide band loudspeaker enclosures, and various expedients have been adopted to extend the response characteristics downwardly in frequency. It has usually been considered that low frequency response requires large physical structures. The latter structures may be resonators of one type or another, associated with a speaker or with part of an enclosure.

It is an object of the present invention to provide a miniature enclosure, in relation to its low frequency cut-off frequency, which shall be relatively flat in frequency response over a wide frequency range, specifically from below 60 c.p.s. to about 18,000 c.p.s.

It is known in the art to provide a speaker mounted in a partition located between two chambers, one of which is completely enclosed. The latter may be resonant mid-range of the audio band, or may be highly damped, and the other of the chambers may contain an opening for acoustic radiation and be resonant at the lowest frequencies of interest. The latter chamber then acts as a resonator, which extends the low frequency range of the system. It is also known to couple a speaker to air by means of a horn, to provide wide band impedance matching. In the latter structures the horn flares outwardly to its radiating end.

According to the present invention, a speaker is mounted in a wall of a closed enclosure which contains damping material, so that one side of the speaker diaphragm sees a highly damped enclosure and the other side is open to atmosphere. Coupling of the other side of the diaphragm to atmosphere is accomplished by means of an inverted horn, i.e. one having its small end as a radiating element and its large end directly coupled with the diaphragm. Thereby the entire loudspeaker diaphragm can be directly coupled with the entire area of the large end of the horn, which is of the same size and shape as the diaphragm. At the small end of the horn, i.e. the radiating end, air velocity is higher than the velocity of the diaphragm, in a ratio roughly equal to the ratio of large to small end areas of the horn. This enables low frequencies to be radiated without concomitant large movements of the speaker diaphragm, which, according to the usual teaching, is required for efficient low frequency radiation. The use of a horn configuration to couple the diaphragm to the radiating aperture assures absence of resonances, as well as a loading effect on the speaker, which serves to balance its rearward loading, and to broaden its response by damping out resonances. This much is true of conventional horn coupling. Use of an inverted horn amplifies air velocity and leads to a small horn volume, for a given speaker size.

It is, accordingly, a broad object of the invention to couple a speaker diaphragm to a radiating aperture via an inverted horn, to cause an increase in acoustic velocity over that available from the speaker itself.

It is another object of the invention to provide a novel coupling between a vibrating member and an acoustic load, which shall effect an impedance transformation without introducing mismatch or resonance, the transformation involving a decrease of impedance.

It is a further object of the invention to couple a large

speaker to a small acoustically radiating aperture, without impedance mismatch.

The above and still further objects, features and advantages of the present invention will become apparent upon 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 loud speaker enclosure according to the invention;

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

FIGURE 3 is a disassembled view of the speaker of FIGURES 1 and 2.

Referring now to the drawings, the reference numeral **10** denotes a case fabricated of heavy fiber-board, perhaps ¾" thick. The case **10** includes rearward wall **11**, side walls **12**, top wall **13**, and bottom wall **14** and front wall **15**. Total height of a typical structure may be 9¼", depth 7¾" and width about 7¾", outside dimensions. In the rear wall **11** is provided a terminal board **16**, for providing audio power to the speaker, which, however, does not present an acoustic opening.

The speaker itself includes a motor **17**, a spider **18** and a diaphragm **19** secured to said spider. The speaker is a conventional permanent magnet speaker, which is purchased on the open market. Any such speaker is suitable.

The forward edges of the speaker are pressed against the inside surface of wall **15** by means of a wooden plug **20**, which extends through rear wall **11** and stiffens the latter by pressing against motor **17**. Internally of the case **10** is located a large mass of acoustic damping material **21**, such as glass wool, formed by bending a strip of material into a shape generally conforming with the outline of the case **10** and the motor **17** and spider **18**, and lying adjacent thereto, but leaving a central mass of air, **22**.

The front wall **15** is cut to provide an inverted exponential horn **25**, fabricated of the wall material, itself. The inner opening **26** of the horn **25** conforms approximately in size and shape with the opening of the diaphragm **19**. The outer opening **27** is much smaller. Assuming an 8" speaker, the outer opening is 2¾", and is provided with a sharp edge **27**, set back from the outer surface of wall **15** by about ⅛", and from which an expanding taper **28** proceeds to the outer surface of wall **15**.

It has been found empirically that the sharp edge **27** and taper **28** improve the performance of the system, although the reason is not clear. The use of an inverted horn serves to increase the velocity of air proceeding from the opening at **27**, by a factor of about 4 to 5, which represents the ratio of large to small areas of the horn. This increase of velocity is necessary to simulate action of a low frequency speaker where actual diaphragm excursions, in a small speaker, are quite small. At the same time all the air moved by the diaphragm is smoothly collected by the horn, and the horn is acoustically impedance matched at all frequencies with the speaker.

The dimensional relations employed were arrived at by experiment, including degree of taper, depth and outer opening, of the horn. In terms of performance, the system provides efficient operation down below 60 c.p.s., and flat response, ± 6 db, from about 55–18,000 c.p.s.

The typical difficulty in utilizing small speakers is to obtain adequate low frequnency response. The present speaker provides a loud, clear signal at 60 c.p.s., with a small excursion of the cone or diaphragm, and to a rough approximation operates as effectively as a 12" speaker, not in terms of total power transduced, but in terms of peak amplitude of radiated sound.

Although a circular horn is employed in the illustrated

and preferred embodiment of the invention, this is not an essential feature in that other shapes may be utilized.

It is found that sine wave distortion is lower, utilizing the inverted horn of the invention, than in the case of the speaker by itself radiating with a full opening. The preferred size of the opening can be reduced with reduction of amplitude of mid-range frequencies. The preferred size is therefore arrived at as a compromise.

While I have described and illustrated one specific embodiment of my invention, it will be clear that variations of the details of construction which are specifically illustrated and described may be resorted to without departing from the true spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. A loudspeaker system, comprising a loudspeaker having a diaphragm having a concave side, a spider supporting said diaphragm and a motor for driving said diaphragm, an enclosure having a front wall, a rear wall, top and bottom walls and side walls, said rear wall, top and bottom walls and side walls being acoustically imperforate, a passage in said front wall extending from approximately the forward surface of said front wall to the rearward surface of said front wall, said passage being exponential horn shaped and having its smaller opening in said forward surface and its larger opening in said rearward surface, said larger opening conforming in shape and size to the shape and size of said diaphragm and facing and acoustically coupled to the concave side of said diaphragm and said smaller opening having less than one half the area of said larger opening.

2. The combination according to claim 1 wherein said smaller opening has a sharp edge.

3. The combination according to claim 2 wherein said horn is exponential.

4. The combination according to claim 3 wherein is provided layers of sound absorbent material for acoustically damping said loudspeaker, said material being located internally of said case.

5. A loudspeaker system, comprising an air-tight enclosure, one wall of said enclosure being a flat panel having an opening forming an exponential horn, said horn having its large end facing internally of said enclosure and its small end facing externally of said enclosure, said small end being sharp edged, a loudspeaker located internally of said enclosure and having a diaphragm, said diaphragm sealing said opening and being acoustically coupled to said horn, said diaphragm being concave as seen from said opening.

6. A loudspeaker system, comprising a closed air-tight enclosure, a loudspeaker having a concave diaphragm completing one wall of said closed enclosure, said diaphragm having its concave side facing outwardly of said closed enclosure, said one wall including a horn having a large end and a small end, said large end facing said diaphragm, wherein said horn has a large end substantially matching the configuration of said diaphragm and acoustically coupled to said diaphragm in acoustic matching relation, wherein said small end of said horn terminates in a sharp edge, and wherein said one wall is a rigid panel, having an opening constituting said horn.

7. The combination according to claim 6 wherein the axial depth of said horn is approximately ¾", a diameter of the large end of said horn is approximately 7¼" and a diameter of the small end of said horn is approximately 2¾", said horn being exponential.

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