

[54] **SPHERICAL LOUDSPEAKER**

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[51] Int. Cl. **G10k 13/00, H04r 1/28**

[58] Field of Search **181/31 B, 31 R, 32 R**

[56] **References Cited**

UNITED STATES PATENTS

1,730,532	10/1929	Robbins	181/31 B
3,135,349	6/1964	Lahti	181/31 B
3,435,910	4/1969	Lahti	181/31 B

3,456,755	7/1969	Walker	181/31 B
3,500,953	3/1970	Lahti	181/31 B

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[57] **ABSTRACT**

A loudspeaker including a radiating cone speaker in a spherical flexible sealed enclosure which is capable of radiating sound in response to variations of internal acoustic waves, and having an inverted impedance matching horn located between the radiating cone and the external environment and radiating via an opening in the enclosure.

2 Claims, 4 Drawing Figures

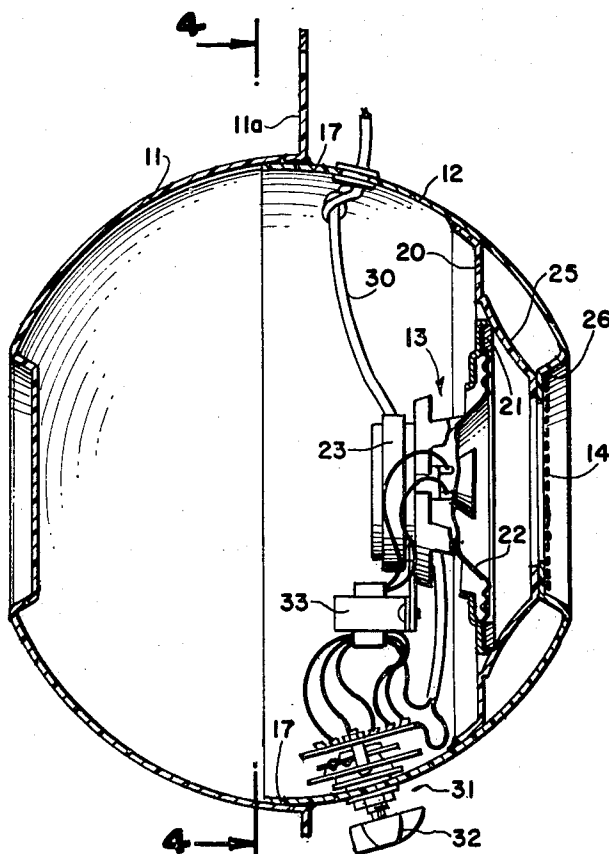


FIG. 1

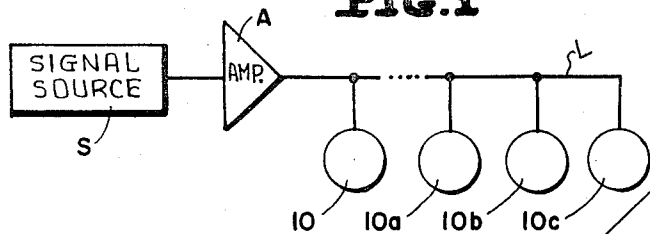


FIG. 2

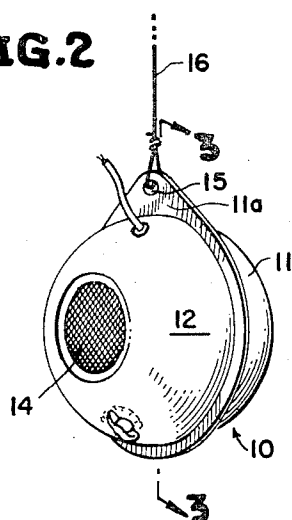
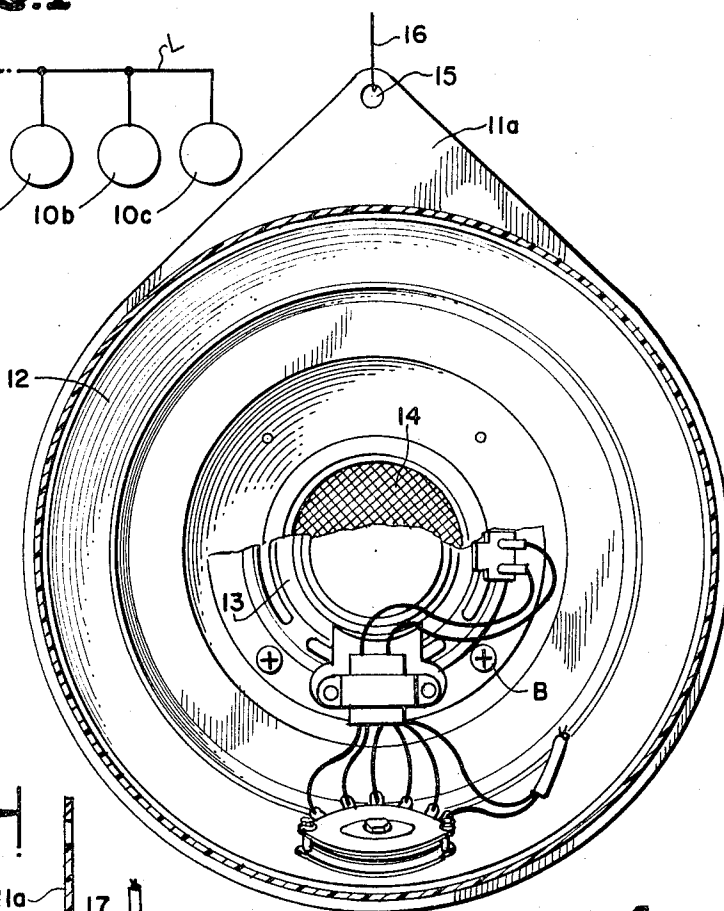


FIG. 3

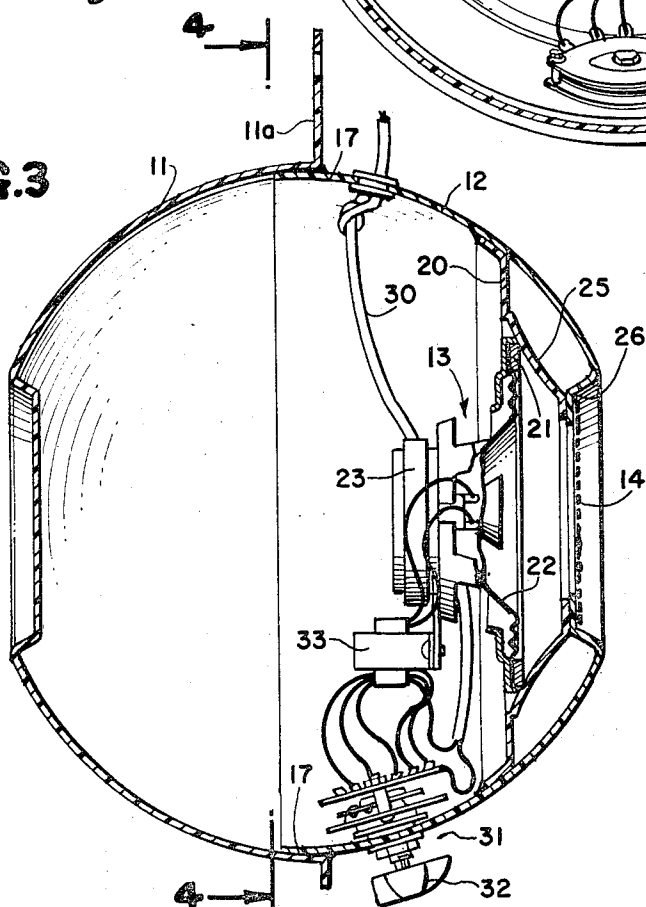


FIG. 4

SPHERICAL LOUDSPEAKER

BACKGROUND OF THE INVENTION

It is well known in the prior art to couple the cone radiator of an electromagnetic speaker to the external environment via an inverted impedance matching horn. An example of a U.S. Pat. disclosing such a device is U.S. Pat. No. 3,135,349, issued to the present applicant on June 2, 1964. Spherical loudspeaker enclosures are also old, as in U.S. Design Pat. No. 210,538 and U.S. Pat. No. 3,500,953, issued to the present applicant on Mar. 19, 1968, and Mar. 17, 1970, respectively. It is further well known to provide a radiating sphere loudspeaker, made of flexible hard rubber, as in U.S. Pat. No. 1,730,532 to Robbins. The latter patent contains no speaker which radiates to the outside world, and therefore is not analogous to the present system, but would provide an omnidirectional radiation pattern in azimuth. Use of an inverted horn impedance matching device, i.e., an exponential horn having its large end directly connected to the cone or diaphragm of an electromagnetic speaker, and its small end radiating into space, provides air velocity at the small end of the horn which is higher than the velocity of the cone, and therefore permits low frequencies to be radiated without concomitant large movements of the speaker cone and also serves to provide front loading of the speaker and thereby to reduce resonances. In the present invention, an additional improvement accrues, in that front end loading of the cone serves to increase acoustic pressure internally of the flexible spherical enclosure, and thereby to achieve increased acoustic radiation from the enclosure itself.

It is found that the loudspeaker of the present application has an omni-directional radiation pattern in azimuth which reasonably approximates a circular pattern, but that additionally the frequency response curve of the speaker, which may be a 6 inch or an 8 inch speaker, far exceeds the normally expected response, i.e., considerable response exists at 25 Hz, whereas the normal 8 inch speaker in a rigid enclosure cuts off at about 80. Hz., and further in that total radiated energy per watt of power into the speakers, in the case of the present speaker, exceeds that measured from a conventional speaker by about 30 db. in the range of 80. Hz. to 300 Hz. On an economic or cost basis, coverage of an area per dollar of cost via conventional enclosures is about three times that achieved by using the present system.

The spherical enclosure of the present system can be hung above the area into which it is to radiate, and can be readily concealed above a ceiling, so long as that ceiling is reasonably transparent acoustically, for the reason that its radiation pattern is omnidirectional, and nearly uniform in all directions.

SUMMARY OF THE INVENTION

A loudspeaker system employing an acoustically flexible spherical enclosure and an electromagnetic speaker having a cone which radiates via an inverted horn, thus both extending the low frequency response of the cone and of the enclosure and increasing its radiated acoustic energy per watt of input signal by a large factor, while achieving a omni-directional radiation pattern.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic illustration of a plurality of loudspeaker enclosures, hung from a common support, and driven in parallel from a common signal source;

FIG. 2 is a view in perspective of a loudspeaker according to the invention;

FIG. 3 is a view in section taken on the line 3—3 of FIG. 2; and

FIG. 4 is a view in section taken on the line 4—4 of FIG. 3.

DETAILED DESCRIPTION

Referring to FIG. 2 of the accompanying drawings, 10 is a spherical enclosure fabricated of two conjoined hemispheres 11 and 12 made of flexible plastic about 0.040 to 0.090 inches thick. The front hemisphere 12 serves to mount an electro-dynamic loudspeaker 13, which radiates via a grill 14. The rearward hemisphere includes an integral annulus 11a extending outwardly of the enclosure 10, and having an opening 15 from which the sphere may be suspended via a wire 16. It is of course not essential that the sphere be hung. It may be supported on a standard (not illustrated).

The two hemispheres are sufficiently flexible, or are of sufficiently different diameters, that one, in this case the front hemisphere 12, may internally overlap the other, as at 17, and the two hemispheres may be joined by a suitable cement or by applying a suitable solvent for the plastic to the areas of overlap, which leaves those areas cemented together when the solvent dries.

A chordal annular support 20, made of the same material as the sphere, is cemented to the interior of the hemisphere 12, and serves to maintain the rim 21 of a loudspeaker diaphragm 22 of loudspeaker 13 in place, and the electromagnetic motor 23 of the loudspeaker 13 is thus supported, as is the usual practice in mounting loudspeakers in conventional enclosures. The annular support 20 is integral with an inverted exponential horn 25, the small end of which is cemented to the internal wall of the hemisphere 12, at 26. Thereby, acoustic energy radiated by the diaphragm 22 is conveyed externally of the enclosure via the inverted horn 25.

The rearward surface of diaphragm 22 radiates into the interior of the enclosure 10, which serves to load the loudspeaker, but the interior of the enclosure 10 contains no damping material, as is usual. Loading is nevertheless present in that the walls of the enclosure are flexible and therefore absorb acoustic energy by vibrating acoustically. In so doing they reradiate and impart to the system an omni-directional radiation pattern.

The loudspeaker diaphragm 22 is loaded in two distinct ways; one is front loading due to the action of the inverted horn 25. The other is rear loading due to the action of the enclosed airspace behind the enclosure, and that effect is enhanced by the flexibility of the enclosure 10, i.e., the energy radiated directly by the enclosure must be supplied by the loudspeaker.

It has been found that the concurrent utilization of both loading expedients results in a response for an 8 inch speaker which extends to 25. Hz., and that an enhanced response in the frequency range of 80. Hz. to about 300. Hz. occurs, in comparison with the response of one well-known commercial 8 inch speaker and en-

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closure, by about 30. db. is found to exist. The latter cuts off at about 80. Hz. Further the recited frequency response of the present system occurs omnidirectionally from about 25. Hz. to about 16. KHz. Response below 25. Hz., which undoubtedly occurs, could not be measured because the measuring equipment employed cut off at 25. Hz.

The motor 23 of loudspeaker 13 is supplied with current via lead 30. Thirty-one represents a switch actuated by external knob 32, for controlling the tops of a power transformer 33.

The present system has been constructed, in one example, with a 12 watt, 6 inch diameter, high compliance edge mounted cone, normally of 8. ohms impedance and having a free air resonance of below 50. Hz. The enclosure 10 is of 12 inch diameter containing a 610 cubic inch volume, and the inverted exponential horn has a 3 inch diameter opening at its small end. These specific dimensions are exemplary only, and it is clear that larger or smaller speakers, horn openings and enclosure volumes might have been employed within the principles of the invention, as above set out.

As indicated in FIG. 1, plural ones of enclosures 10, identified as 10, 10a, 10b, 10c, can be connected in parallel via a line L to a source of audio signal S via an amplifier A. The source may be a tape reproducer, a

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disc record reproducer, a radio receiver, or piped in music.

The loudspeaker 13, having a metallic spider or rim is secured directly to the horn 25 by bolts B.

What I claim is:

1. A loudspeaker having a rimmed diaphragm having a concave side, a spider supporting said diaphragm and a motor for driving said diaphragm, a substantially spherical enclosure, said enclosure having a thin resilient and acoustically radiative but acoustically impermeable wall, a horn extending from the rim of said diaphragm to said wall, said horn being an exponential horn and having its smaller end at said wall and its larger opening at said diaphragm, said larger opening being approximately the size of said diaphragm and said small opening having substantially the size of an opening in said wall and mating with said opening in said wall, said enclosure being substantially undamped internally and radiating acoustic energy substantially omnidirectionally in response to acoustic vibrations of said diaphragm.

2. The combination according to claim 1, wherein said horn and said spherical enclosure are fabricated of plastic.

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