United States Patent

Franssen

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[54] **LOUDSPEAKER**

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[51] **Int. Cl.**.....**G10k 13/00,** G10k 11/10

[58] **Field of Search**.....181/31 R, 31 B, 27 R

[56] **References Cited**

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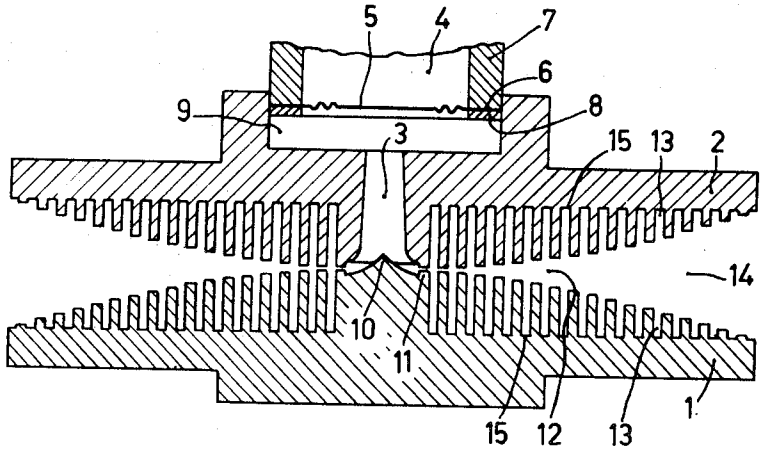
[57] **ABSTRACT**

A loudspeaker, formed by two dish-shaped parts provided with concentric grooves and arranged opposite one another with a vibrating system at the center. The sound channel is annular and of tapered section. The greatest geometric dimension of the channel is smaller than the corresponding acoustic length.

8 Claims, 3 Drawing Figures



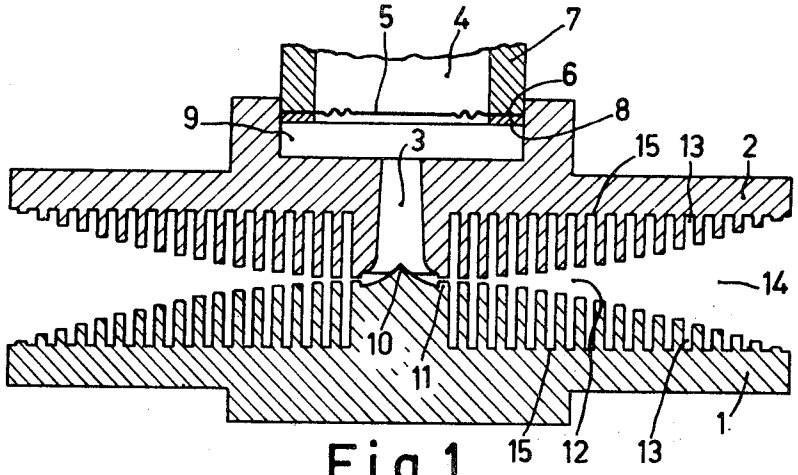


Fig. 1

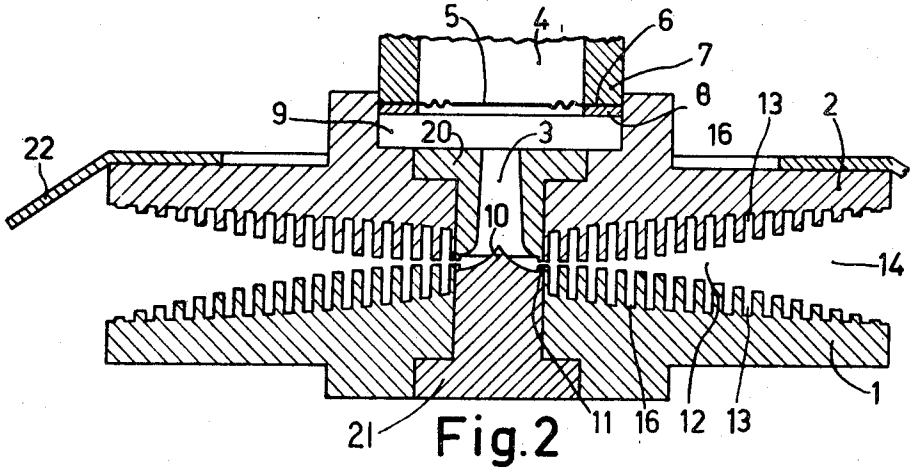


Fig. 2

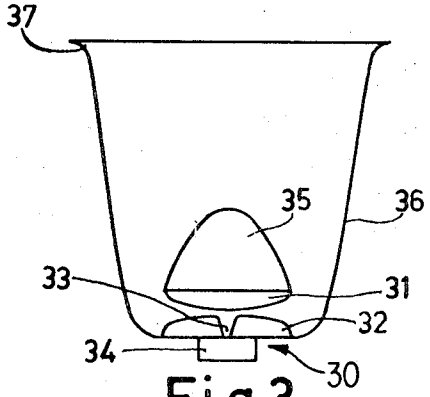


Fig. 3

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LOUDSPEAKER

The invention relates to a device for converting acoustic vibrations into electrical oscillations and conversely, comprising at least one vibrating system having a diaphragm which is connected to a sound channel the largest geometrical dimension of which is smaller than the corresponding acoustic length.

Such a device in the form of a horn loudspeaker is described in German Pat. specification No. 969,766.

Horn loudspeakers have long been known for their high efficiency. Since the lowest frequency to which this applies will be lower as the area of the mouth increases and the rate of variation of the diameter is lower, the associated acoustic length will be very great. Hence, such large horn loudspeakers can only be used in a few special cases.

In order to appreciably reduce the length the horn may be shaped in the form of a cochlea. Alternatively, the horn may be folded, as is known inter alia from the said German patent specification. By folding, the acoustic path length of the sound channel remains the same, but the geometric dimensions will be appreciably smaller than those of a non-folded horn having similar acoustic properties. However, the resultant shortening produces a comparatively complicated shape.

It is an object of the invention to avoid this disadvantage. The invention is therefore characterized in that the channel is composed of a sequential arrangement of acoustic sections each of which comprises a part acting substantially as a mass and a part acting substantially as a compliance.

This is an entirely new line of approach, the object being to considerably shorten the geometrical path length by using concentrated masses and compliances. The sequential arrangement of sections forms an acoustic ladder network, the velocity of propagation of the sound to be transmitted being determined in each section by the mass and compliance thereof.

Very good results have been obtained by the division into sections being effected by the provision of transverse grooves in the wall of the sound channel. The grooves constitute those volume parts which act substantially as compliances only.

Starting with a hyperbolic horn having a long tube, this tube can be appreciably shortened by partly replacing it by an essentially narrow tube (the cross-sectional area of which determines its mass) in which a large number of annular grooves are formed one behind the other.

Obviously, to enable the shortened and non-shortened parts of this horn to emerge it is necessary to reduce the relative shortening factor from a given value to the value 1 at the junction. This results in a shape in which at this junction the inner and outer diameters of the grooves of the shortened part are equal to one another and to the diameter of the non-shortened part.

If, however, the entire horn is shortened, the junction will be located at the mouth. At this location the depths of the grooves are very small and they progressively increase from the mouth for a large part of the grooves.

The sound channel, the acoustic impedance of which at the location of the mouth is substantially real for the larger part of the frequency range to be transmitted, substantially behaves as one of the known horn loudspeakers. Viewed from the throat, i.e. from the end of the sound channel nearer the diaphragm, the acoustic

impedance must be matched to the vibrating system. This may be effected by means of an acoustic transformer. This means that the small-diameter throat merges in a larger-diameter chamber in front of the diaphragm.

A particular embodiment of a device according to the invention is characterized in that the sound channel extends between two opposed disc-shaped parts, the vibrating system being disposed substantially centrally and the grooves in at least one disc-shaped part being arranged substantially coaxially.

This results in a quasi-horn loudspeaker, i.e. a loudspeaker which is substantially flat but which increases the efficiency of the vibrating system in a manner similar to that used in horn loudspeakers.

In the device according to the invention the two disc-shaped parts may be mirror images of one another with respect to their grooved portions.

The grooves are coaxially arranged and may be circular or elliptical. In the latter case, in order to maintain the velocity of propagation equal in all directions in the sound channel from the throat to an arbitrary groove the depth of the grooves and the thickness of the walls will have to vary around the groove circumference.

For a satisfactory operation of the device the dimensions of the disc-shaped parts must be such that at the mouth the distance between them is substantially equal to one half of the wavelength at the highest frequency to be transmitted and the outer circumference of each disc-shaped part must be of the order of the wavelength at the lowest frequency to be transmitted.

The disc-shaped parts may readily be mass-produced from a synthetic material by injection moulding. To enable the disc-shaped parts to be readily dislodged from the mould the grooves should have a slight taper.

When identical disc-shaped parts are used the insertion pieces required to establish a satisfactory sound connection to a vibrating system to be secured to one of the parts may readily be placed in position in the throat during assembly.

The directional characteristics of the device according to the invention may be improved by providing one of the disc-shaped parts with a reflector. This reflector may take the form of a truncated horn while for satisfactory directing of the sound the rear surface of the other dish-shaped part is formed with a domed portion.

In this embodiment both dish-shaped parts act as a driving system for the horn-shaped reflector.

Embodiments of the invention will now be described, by way of example, with reference to the accompanying diagrammatic drawings, in which

FIGS. 1 and 2 each are a cross-sectional view of a dish-shaped quasi-horn loudspeaker according to the invention, and

FIG. 3 is a truncated horn provided with a driving system as shown in FIG. 1 or FIG. 2.

The device comprises two substantially identical cylindrical dish-shaped parts 1 and 2 made from a synthetic material by injection moulding.

The part 2 is connected to a vibrating system 4 by a conical channel 3. The vibrating system — which is shown schematically — comprises a diaphragm 5 which is substantially flat and the edge 6 of which is pivotally

suspended between a casing 7 and a thrust ring 8. At the front side of the diaphragm 5, the diameter of which is larger than that of the channel 3, a chamber 9 is located which together with the channel 3 forms an acoustic transformer,

For satisfactory guiding of the sound produced by the diaphragm 5 the part 1 has a domed central portion 10.

The sound reaches an annular very narrow throat 11. The dish-shaped parts 1 and 2 are designed so that they define an annular sound channel 12 the cross-sectional area of which increases exponentially with axial distance.

Both dish-shaped parts are identically formed with a comparatively large number of concentric grooves. The grooves are substantially rectangular in section but are slightly tapered to allow them to be readily dislodged from the mould in manufacture.

Near the mouth 14 the grooves are very shallow. The groove depth increases in the direction towards the throat.

In the loudspeaker shown in FIG. 1 this increase in groove depth continues along the entire grooved portion. The bottoms 15 of the grooves lie in a flat plane.

In the loudspeaker shown in FIG. 2 the increase in groove depth progressively decreases to become a reduction in groove depth starting from a groove 16. In this embodiment the bottoms 15 of the groves form a continuously curved rotation-symmetrical surface. The dish-shaped parts 1 and 2 are identical. They are provided with insertion pieces 20 and 21 respectively. The insertion piece 20 contains the channel 3 and the insertion piece 21 is formed with a dome-shaped central portion 10. The part 2 is provided with a reflector 22 to obtain a unidirectional characteristic.

FIG. 3 is a cross-sectional view of a horn loudspeaker in which the reflector 22 of the embodiment shown in FIG. 2 forms a truncated horn 36. The remainder of the horn has been replaced by a driving system 30 of the kind shown in FIGS. 1 and 2. This driving system 30 comprises dish-shaped parts 31 and 32, a sound channel 33 and a vibrating system 34 connected thereto. The dish-shaped part 31 is formed with a dome-shaped portion 35 at its real surface for directing the sound.

It will be appreciated that in such horn loudspeakers the mouth 37 is very wide but the length is appreciably shortened by the provision of the driving system 30.

What is claimed is:

1. A device for converting acoustic vibrations into electrical oscillations and conversely comprising a pair of opposed dish-shaped parts forming a sound channel therebetween at least one vibrating system having a diaphragm connected to said channel and located substantially centrally thereof, the largest geometrical dimension of said channel being smaller than the corresponding acoustic length, said channel having a throat located closest to said vibrating system and a mouth located most remote therefrom, the cross-sectional area of said channel increasing exponentially with axial distance from said throat to said mouth, a sequential arrangement of transverse grooves increasing in depth from said mouth toward said throat formed on the wall of at least one of said dish-shaped parts of said channel forming a sequential arrangement of acoustic sections, each of said sections having a portion substantially acting as a mass and a portion substantially acting as a compliance.

2. The device according to claim 1 wherein both of said dish-shaped parts have a sequential arrangement of transverse grooves formed in the wall thereof, the grooved wall of one of said dish-shaped parts being a mirror image of the grooved wall of the other dish-shaped part.

3. The device according to claim 2 wherein said throat is connected to said diaphragm by an acoustic transformer.

4. The device according to claim 3 wherein the acoustic impedance at the mouth of said channel is substantially real for the larger part of the frequency range to be transmitted, and wherein the acoustic input impedance of said throat matches the vibrating system.

5. The device according to claim 3 wherein the distance between said dish-shaped parts at the mouth of said channel is substantially equal to one-half of the wavelength of the highest frequency to be transmitted.

6. The device according to claim 5 wherein the outer circumference of each of said dish-shaped parts is approximately equal to the wavelength of the lowest frequency to be transmitted.

7. The device according to claim 3 further comprising a reflector attached to one of said dish-shaped parts.

8. The device according to claim 7 wherein said reflector forms a truncated horn for obtaining satisfactory directional pattern of the sound, and further comprising a dome-shaped portion connected to the other of said dish-shaped parts.

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