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Takahashi et al.

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[54] **SOUND GENERATING DEVICE**

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[51] **Int. Cl.** **H04r 17/00**

[58] **Field of Search** .... 310/8.2, 8.3, 8.5, 310/8.6, 9.1–9.4; 179/110 A; 340/10

[56] **References Cited**

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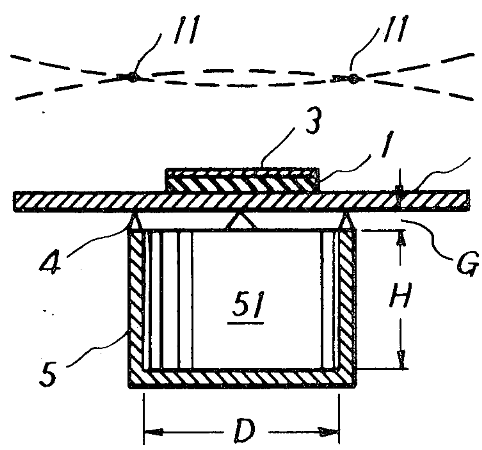
[57] **ABSTRACT**

A piezoelectric sound generator having a diaphragm carrying the piezoelectric element and at least one resonant chamber spaced from said diaphragm with the wall of said chamber being coincident with a node circle on the diaphragm.

1 Claim, 6 Drawing Figures



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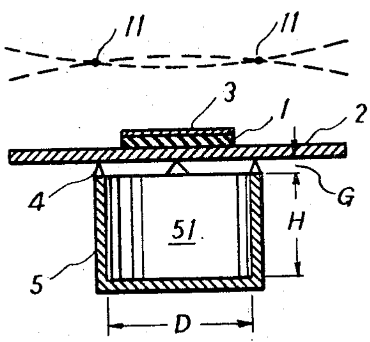

Fig. 1

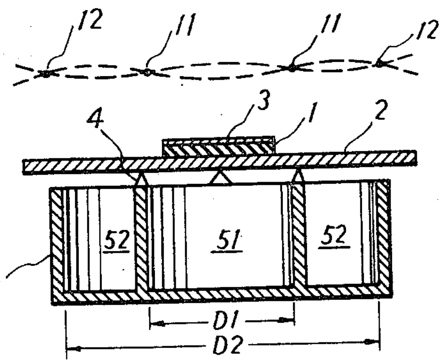

Fig. 3

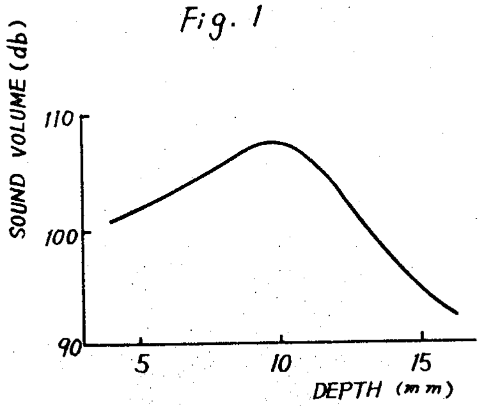

Fig. 2

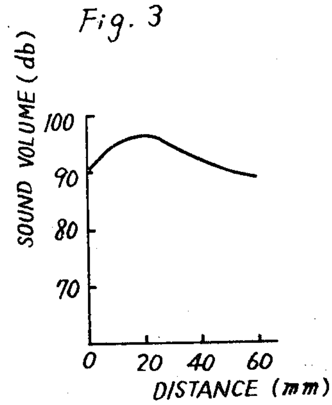

Fig. 6

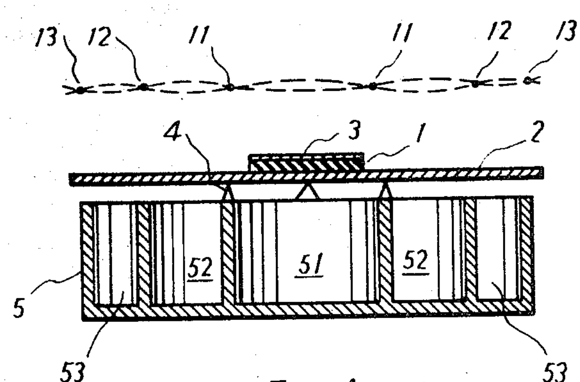

Fig. 4

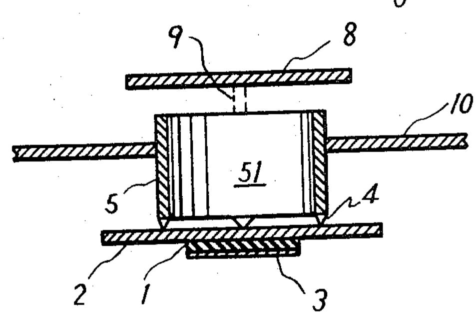

Fig. 5

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SOUND GENERATING DEVICE

This invention relates to a sound generating device including a piezoelectric vibrator element and more particularly to an improved sound magnifying structure.

Various sound generating devices having piezoelectric vibrator elements have been developed but they are generally low in efficiency and almost unusable for alarm devices or the like which require large sound outputs. Accordingly, one object of this invention resides in the provision of an improved sound generating device having a simplified structure but exhibiting a high efficiency.

According to this invention, the sound generating device includes a disc-shaped piezoelectric vibrator element, a circular diaphragm to which the piezoelectric vibrator element is adhered, and a cylindrical resonance chamber having a diameter substantially equal to the diameter of the node circle of vibration of the diaphragm and supporting the diaphragm at or near the node circle.

The invention will be described in detail hereinunder with reference to the accompanying drawings.

FIG. 1 is a cross-sectional view of an embodiment of a sound generating device according to this invention;

FIG. 2 is a graph used for explaining the operation of the device of FIG. 1;

FIG. 3 is a cross-sectional view of a second embodiment of a sound generating device according to this invention;

FIG. 4 is a cross-sectional view of a third embodiment of a sound generating device according to this invention;

FIG. 5 is a sectional view of a fourth embodiment of a sound generating device according to this invention; and

FIG. 6 is a graph used for explaining the operation of the device of FIG. 5.

Throughout the drawings like reference numerals are used to corresponding structural elements.

Referring to FIG. 1, the sound generating device includes a disc-shaped electromechanical transducer element 1 made of piezoelectric material such as barium titanate and electrodes 2 and 3 are attached to the faces thereof. In this embodiment the electrode 2 is in the form of a circular thin metal plate which is much larger than the element 1 so as to function as a diaphragm of the sound generating device. However, the diaphragm may be made as a separate body and, moreover, may be made of a different material such as synthetic resin.

When an a.c. sound signal of an appropriate frequency is applied between the electrodes 2 and 3, the electrode or diaphragm 2 initiates vibration as shown schematically by dashed curves in the upper part of the drawing and forma a node circle 11 on the diaphragm 2.

The device also includes a cylindrical cup-shaped resonance chamber 5 containing a resonance cavity 51 and the diaphragm 2 is supported by a plurality of supporting edges 4 provided on the open end of the resonance chamber 5 at or near the node circle 11. While the diaphragm 2 is supported by a plurality of pointed edges 4, it is spaced from the end of the resonance chamber 5 by a gap G. The gap G is preferably about 1.5 millimeters. It is evident from the drawing that the diameter D of the resonance cavity 51 should be substantially equal to the diameter of the node circle 11 but the depth H thereof must be determined experimentally. FIG. 2 shows the result of experimental measurements of sound volume with respect to the depth H of the resonance cavity 51 having a diameter of 32 millimeters. In this case, a metal diaphragm of 50 millimeters in diameter and 0.5 millimeters in thickness, a piezoelectric element 36 millmeters in diameter and 0.5 millimeters in thickness and a driving frequency of 2.6 killoherzs were adopted. As shown in the drawing, the maximum sound volume was obtained with a depth H of about 10 millimeters. Such optimum depth varies with various parameters. For example, when the diameter of the diaphragm was 70 millimeters, the diameter of the resonance cavity was 46 millimeters and the driving frequency was 1.0 killoherz, the optimum depth was 26 millimeters.

In order to obtain the best efficiency, the diameter of the diaphragm should be selected properly. It has been found experimentally that the diameter D of the resonance cavity 51 should preferably be 65% ± 1% of the diameter of the diaphragm 2.

The inventor has found that the efficiency of the device of FIG. 1 can be further improved by providing the resonance chamber 5 with an additional resonance cavity 52 arranged concentrically with the original resonance cavity 51, when the vibration has a secondary mode as shown by dashed curves in the upper part of FIG. 3. As shown in the drawing, this vibration has two node circles 11 and 12 and it has been found that the maximum efficiency can be obtained when the cylindrical walls of both resonance cavities 51 and 52 are disposed in coincidence with the node circles 11 and 12 respectively. The optimum percent ratios of the diameters D1 and D2 of the resonance cavities 51 and 52 to the diameter of the diaphragm 2 have been found experimentally to be about 47 percent and 90 percent respectively. As in the case of the device of FIG. 1, the depths of both resonance cavities must be determined experimentally.

According to the same principle, the device can be modified for a multiplex mode of vibration. For example, FIG. 4 represents a modification of the device of FIG. 3 for a tertiary mode of vibration having three node circles 11, 12 and 13 as shown in the upper part of the drawing. The device includes a resonance chamber containing three resonance cavities 51, 52 and 53 arranged concentrically and having respective cylindrical walls disposed in coincidence with the node circles 11, 12 and 13 respectively.

Referring to FIG. 5 representing a special modification of the sound generating device of FIG. 1, a piezoelectric element 1, electrodes 2 and 3 and a resonance chamber 5 are arranged substantially similarly to those in FIG. 1 but the base of the resonance chamber 5 is open and a reflector plate 8 is disposed facing thereto. The reflector plate 8 is supported by an appropriate supporting member 9 as shown in phantom and preferably has a diameter somewhat greater than that of the resonance cavity 51.

FIG. 6 shows an experimental result representing the relation between the distance between the reflector plate 8 and the open end of the resonance chamber 5, and sound volume corresponding to the efficiency of the device. It is evident from the drawing that the maximum efficiency is obtained at the distance of about

15–20 millimeters and the efficiency increase is as much as 10 percent or so. The efficiency can be further improved by providing a second reflector plate **10** facing to the first reflector plate **8.** The reflector plate **10** may be preferably used also as the face plate of the housing of the device.

What is claimed is:

1. A sound generating device comprising a diaphragm, a piezoelectric electromechanical transducing element attached to said diaphragm, means supporting said diaphragm at one of node circles of vibration formed on said diaphragm, a cylindrical resonance chamber positioned in closely spaced relationship to one side of said diaphragm and consisting of a plurality of resonance cavities having cylindrical walls arranged concentrically and having diameters substantially equal to the diameters of said node circles respectively, the cylindrical walls of said resonance cavities being disposed in coincidence with said node circles respectively and diaphragm supporting means extending from one edge of a wall of one of said cavities, said supporting means being aligned with a node circle and carrying said diaphragm.

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