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(54) **Focal sonic or ultrasonic radiator to apply to high-intensity fluids.**

(57) The object of the present patent application is a new type of radiator for sonic and/or ultrasonic frequencies consisting basically of a plate which has discontinuous profiles on both surfaces and which vibrates flexurally on excitation by a vibrator that may be piezoelectric, magnetostrictive, etc. in nature. The dual discontinuous profiles enable regulation of the amplitude and phase of the energy radiated, thereby achieving a high concentration of energy around a predetermined point.

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Description

A FOCALIZED SONIC OR ULTRASONIC RADIATOR FOR HIGH-INTENSITY APPLICATIONS IN FLUIDS

The object of the present patent application is a new type of sonic or ultrasonic radiator that produces a high concentration of acoustic energy in a localized area of the medium being irradiated. The said radiator is designed to operate in fluids.

This new type of radiator consists basically of a plate which has discontinuos profiles on both its faces and which vibrates flexurally when excited by a vibrator that may be piezoelectric magnetostrictive, etc. in nature.

In a plate vibrating in its flexural modes, the internodal zones move alternately in opposite phases. As a result of these phase differences, the spatial distribution of the radiation emitted by a flat flexural radiator tends to be extremely irregular. The present invention relates to a new type of flexural radiator of variable thickness with a discontinuous profile on its radiating surface, by means of which most of the energy radiated reaches a previously selected point (focus) in phase. The said profile is obtained by suitably displacing the various internodal zones along the axis of the plate. Moreover, since the distribution of the amplitudes of vibration affects the resulting focalized acoustic field, the amplitude distribution can be regulated by balancing the masses of the differente internodal zones. To this end, the profile on the back surface of the plate is also discontinuous, such that the different thicknesses of the internodal zones, due to the effect of mass, give rise to similar amplitudes of vibration in each zone. The result is a new type of acoustic radiator in which both amplitude and phase are regulated by the dual discontinuous profiles, such that the energy radiated is concentrated around a predetermined point. In addition, the resulting uniform amplitude distribution helps maximize the power capacity of the emitter by preventing the build-up of fatigue-producing stresses in specific regions.

The principles underlying this new design can be applied to plates of any shape (circular, rectangular, square, etc.) and for any frequency.

Design of the profile on the radiante surface must take into account that the distance beween each of the internodal zones and the focal point must be such that the radiation reaches the said focal point, located in the near field of the radiator, in phase. Thus, given that the internodal zones vibrate alternately in opposite phases, for a typical instance of a plate vibrating axisymmetrically, internodal zone thickness (h_i) is determined by the relations (see Figure 1):

$d_o = z_o$

$d_i = PA_i = [(z_o + h_i)^2 + r_i]^{1/2}$

$d_i - d_{i-1} = /2$

where $i = 1,2,... n$; $n =$ the number of nodal circles; and

$=$ the wavelength of the radiation in the medium.

Plate profiles carculated in the way tend to be complex. In actual practice, profiles can be simplified with only minor effects on focalization. One simplification procedure consists of eliminating the condition $d_i - d_{i-1} = /2$ for internodal zones whose contribution to the total radiation is negligible.

The goal of the back-surface profile design is to regulate the amplitudes of vibration via distribution of mass. Such distribution is based on the fact that, generally speaking, the smaller the thickness the larger the amplitude of vibration obtained. Given that, in a flexurally vibrating plate of constant thickness excited at the centre, the vibration amplitudes in the peripheral regions are lower than at the centre, amplitude distribution can be made uniform by ensuring that plate thickness is greater at the centre than at the periphery. Figure 2 illustrates an example of a rear profile obtained by applying this principle.

In accordance with this design procedure, a number of prototype radiators were built from circular plates excited at the centre by piezoelectric vibrators. A radiator for use in gases 500 mm in diameter designed to vibrate at at a frequency of 21 kHz in its seventh axisymmetrical mode (seven nodal circles) may be taken by way of example. Figure 3 presents a diagramme of such a radiator. The energy concentration effect becomes quite clear when the axial field distribution of the new radiator is compared with that of an equivalent flat radiator, under the assumption that the maximum values of velocity at the centres of the plates are the same. Figure 4 despicts the variation in the amplitude of the acoustic pressure radiated along axis P (in arbitrary units) with distance D (in cm) from the centre of the plate for a radiator built according to the innovations covered by the present patent application. Figure 5 shows the same amplitude variation for a flat radiator. Using the prototype radiator illustrated in Figure 3, it is possible to concentrate energy along the axis in a focal volume which, for a drop in accoustic pressure less than or equal to 3 dB, is approximately 15 cm in lenght by 2.4 cm in diameter.

Claims

1) "A FOCALIZED SONIC OR ULTRASONIC RADIATOR FOR HIGH-INTENSITY APPLICATIONS IN FLUIDS", charaterized in that it consists of a plate of any shape (circular, rectangular) which is discontinuously variable in thickness and which, excited by a mechanical or electromechanical vibrator, vibrates flexurally in one of its modes.

2) A sonic or ultrasonic radiator in accordance with claim 1, further characterized in that the profile of

the radiant surface of the plate is variable in thickness in the different internodal zones. The profile is designed so that the radiation emitted by each and every internodal zone follows a path such that it reaches a predetermined point (focus) in the field in the vecinity of the radiator in phase, thereby resulting in a high concentration of energy at the focus.

3) A sonic or ultrasonic radiator in accordance with the preceding claims, further characterized in that the back surface of the plate is designed such that varying the thickness of the different internodal zones on the plate modifies the balance of mass, so as to regulate the distribution of the amplitudes of vibration and, in consequence, the acoustic field in the focal zone and the power capacity of the radiator. In the specific case in which a uniform distribution of amplitudes is required, the thicknesses decrease from the central zone of excitation outwards to the periphery; such uniform distribution augments the power capacity of the radiator, since the power capacity is essentially dependent upon maximum displacement attainable without breakage of the plate.

4) A sonic or ultrasonic radiator in accordance with the preceding claims, further characterized in that it is made of metal that is homogeneous and regular in structure, devoid of pores, with good elastic properties, low internal friction losses, and a high tolerance to fatigue.

5) A sonic or ultrasonic radiator in accordance with the preceding claims, further characterized in that the structure of the material of which it is made is such that the direction of the fibre coincides with that of the stresses caused by the deformations.

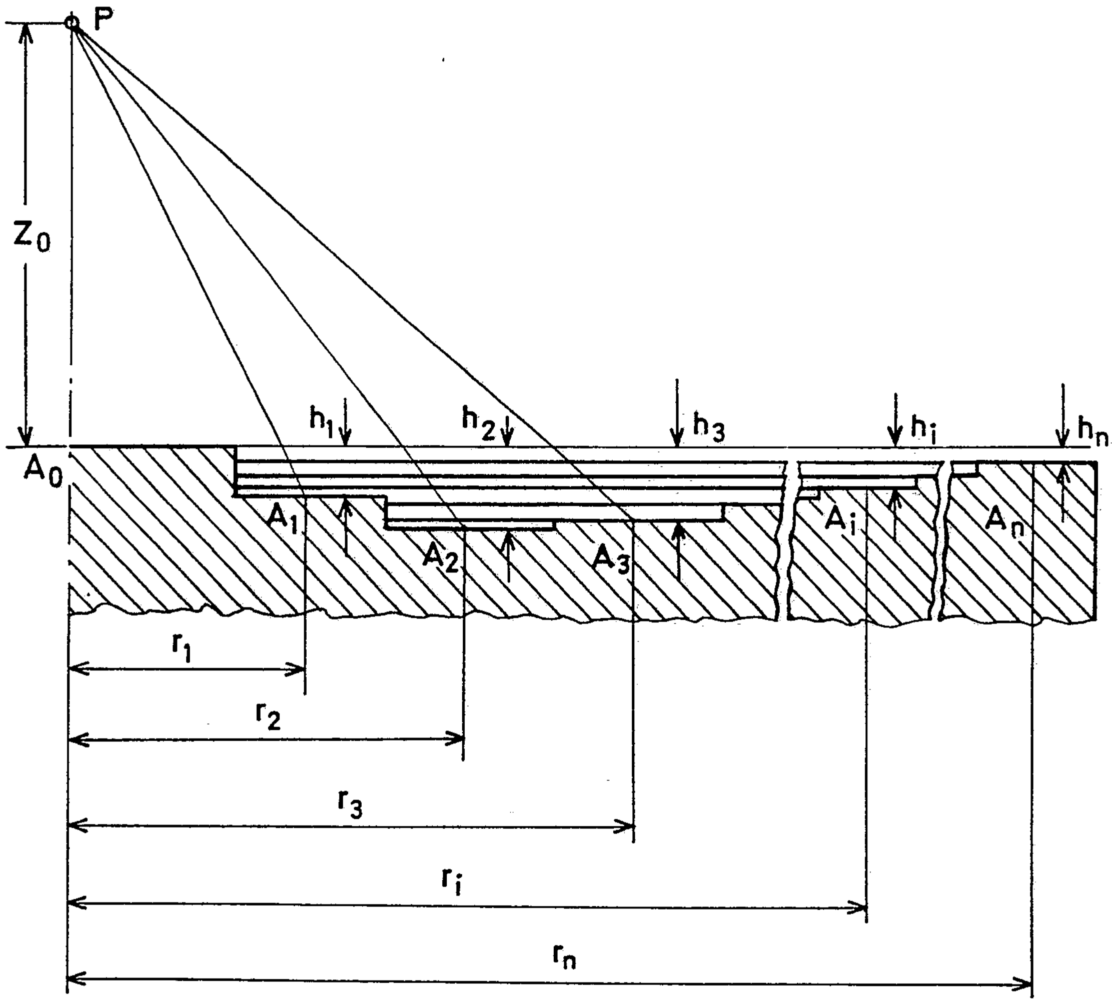


Fig.1

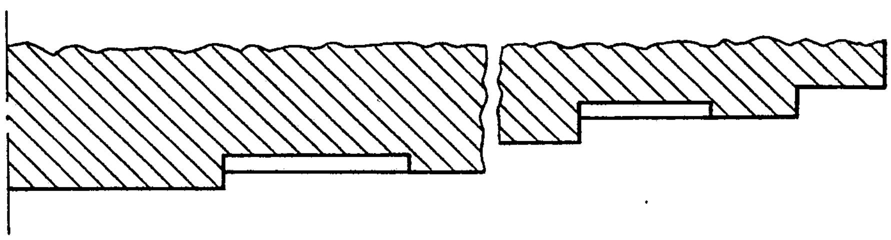


Fig.2

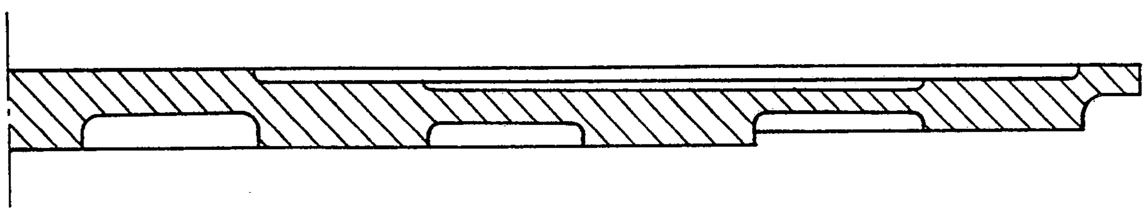


Fig.3

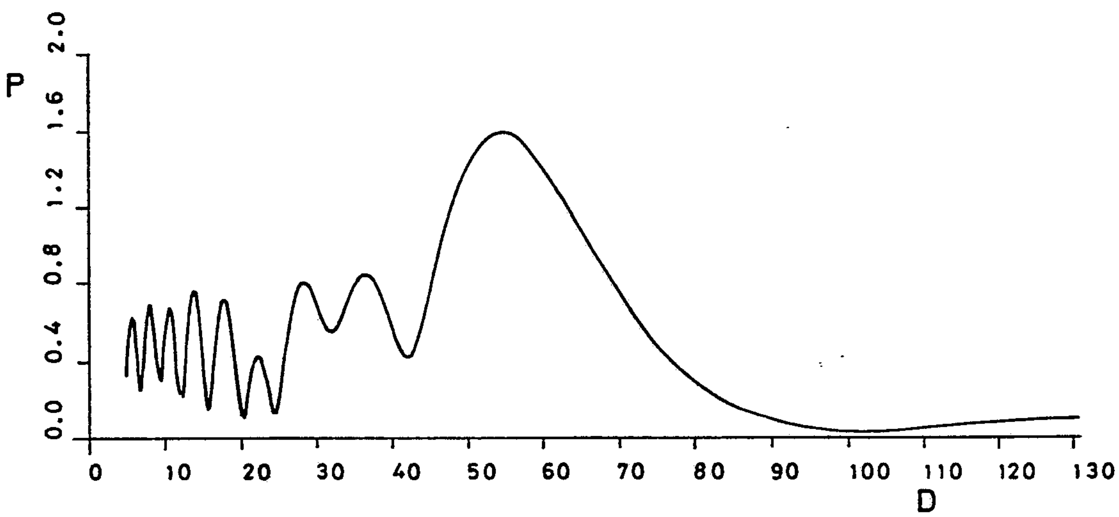
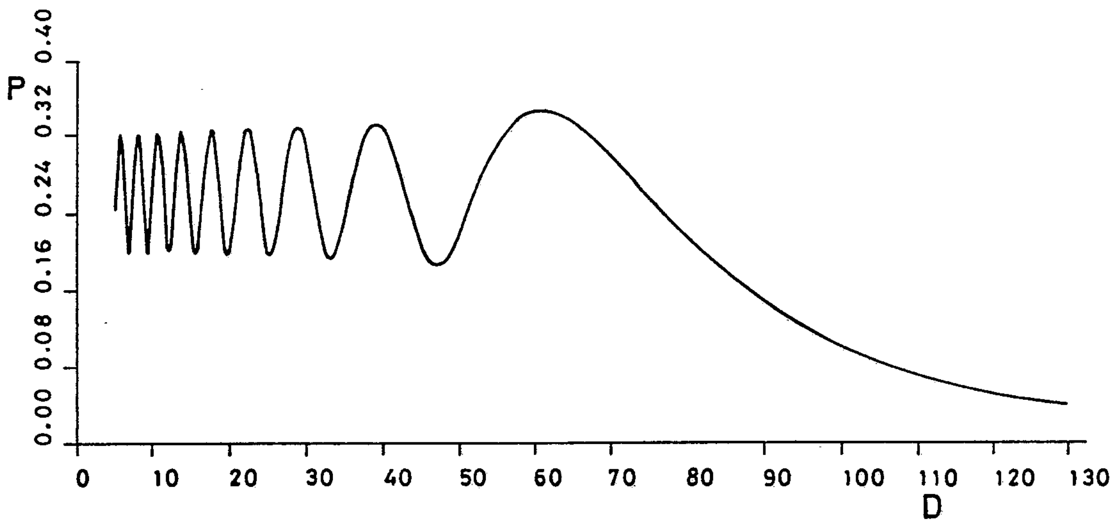


Fig.4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0.24
0.32
0.40
0
10
20
30
40
50
60
70
80
90
100
110
120
130
D

Fig.5