

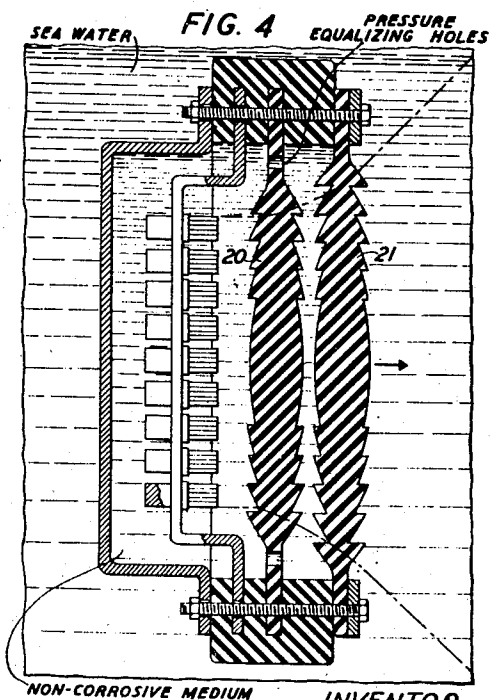
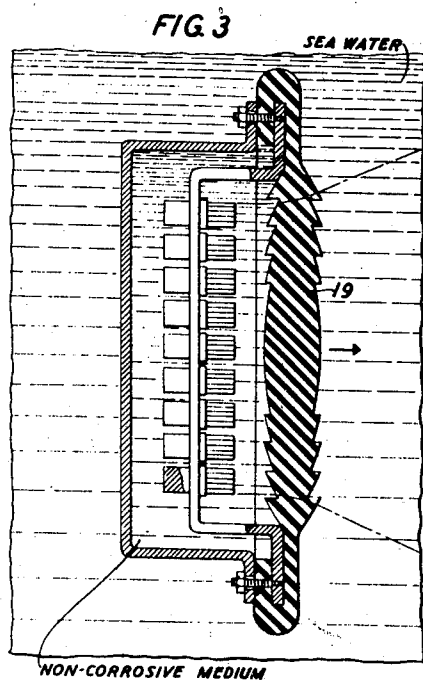
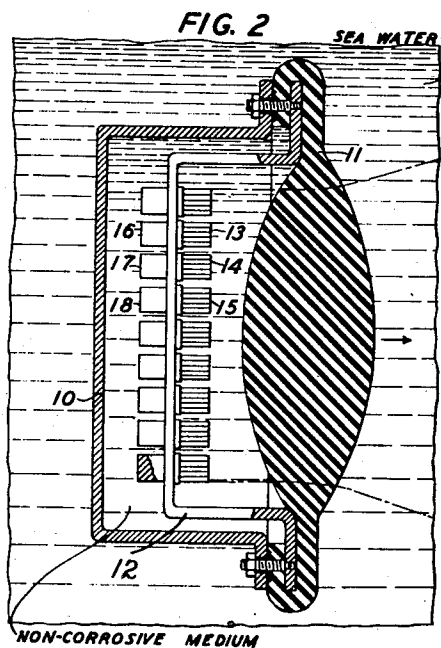
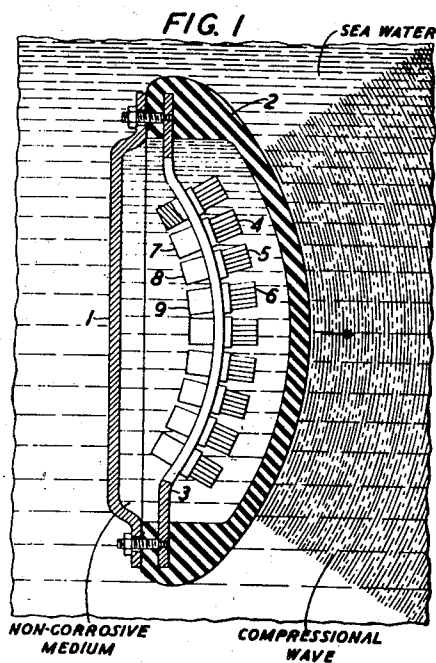
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ELECTROMECHANICAL TRANSDUCER

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ELECTROMECHANICAL TRANSDUCER

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1 Claim. (Cl. 177-386)

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This invention relates to compressional wave transmission in the ultrasonic range and has for its object the provision of means to transmit signals of high power over a wide range.

In submarine detection work it is often desirable to get a large amount of power into a wide beam at relatively high frequencies. If a conventional flat plate radiator is employed these requirements are mutually exclusive, for great power requires a large area and at high frequencies this inherently gives a very sharp pattern of power distribution.

In accordance with the present invention means are employed to equalize the intensity of the compressional waves over a wide angle so as to change the characteristic sharp lobe pattern into a very broad lobe pattern. In general this may be accomplished by making the shape of the face of the radiator convex in shape, approximating a spherical section.

In accordance with one form of the invention a crystal array is mounted on a curved plate so that each crystal face is approximately in a spherical surface.

In accordance with another and a preferred form of the invention an array of crystals is mounted on a flat plate and a lens shaped body having a high index of refraction to ultrasonic compressional waves is interposed between the crystal array and the sea water.

A feature of the invention is a plurality of transducers arranged to transmit compressional waves from a surface approximately spherical in contour.

Another feature of the invention is an array of transducer faces forming an approximately spherical surface.

Another feature of the invention is a radiator formed of a plurality of transducers having their faces approximately in a plane surface and a lens-like diaphragm interposed between said surface and the outer surface of said radiator.

Other features will appear hereinafter.

The drawings consist of a single sheet having four figures, as follows:

Fig. 1 is a vertical section of an electromechanical transducer in which the crystal array is mounted on a plate having a generally spherical contour;

Fig. 2 is a similar figure showing the crystal array secured to a flat mounting plate and the rubber diaphragm in the form of a lens of generally spherical contour;

Fig. 3 is a similar figure showing the use of a diaphragm formed like a Newtonian lens; and

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Fig. 4 is a similar figure showing the use of a plurality of lens-like diaphragms to give greater spread to the transmitted compressional waves.

In the drawings various forms of electromechanical transducers are shown as being immersed in water. In Fig. 1 the transducer consists of a rigid housing 1 and a sound transparent plastic diaphragm 2, which may be clamped together to provide a watertight casing. Within such casing there is secured a mounting plate 3 having a generally spherical shape. Secured to this mounting plate there are a plurality of crystal mosaics 4, 5 and 6, each having its resonator 7, 8 and 9 respectively. The casing is filled with a liquid such as castor oil or a mixture of dimethyl phthalate and xylene hexafluoride which like the rubber of which the diaphragm is generally constructed has substantially the same mechanical impedance as the sea water in which the transducer is immersed.

Since the compressional waves produced by a crystal mosaic travel in a line normal to the end faces thereof or along the longitudinal axis of the combination of the crystal mosaic and its backing resonator the effect of mounting them on a spherical surface is to produce an aggregate wave spread out as indicated by the curved lines to the right of the device.

A single crystal mosaic will of course produce a compressional wave having a wide spread but where a plurality of crystals must be used in order to produce a wave of sufficient intensity to be useful, the effect is usually highly directional and this effect increases with the frequency. Therefore to produce a wide wave front a construction such as shown in Fig. 1 must be employed.

An alternative method of spreading the wave front from a transducer constructed from a plurality of crystal mosaics is to mount them on a flat plate so that their faces are in one plane and then to interpose a lens-shaped diaphragm in the path of the transmission therefrom. In Fig. 2, the element 10 represents a steel casing to which a plastic lens-shaped diaphragm 11 is secured. In the assembly of these two elements there is a mounting plate 12 to which are secured a plurality of crystal mosaics 13, 14 and 15 and their respective backing resonators 16, 17 and 18.

The lens-like diaphragm 11 is constructed of a material having a transmission velocity greater than the transmission velocity of water, whereby an acoustic lens with a negative focal length is produced. By way of example, there is commer-

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cially available an oil resisting type of synthetic rubber which has a density

$$\rho=1.14$$

and a transmission velocity

$$v=2.04 \times 10^5$$

Through these figures the quantity corresponding to the index of refraction in a lens is

$$n = \frac{v_w}{v_r} = \frac{1.50 \times 10^5}{2.04 \times 10^5} = .735$$

where v_w is the transmission velocity of water and v_r is the transmission velocity of this synthetic rubber. From standard lens formulae, the focal lengths of the lens formed from two segments of a sphere is

$$\frac{1}{f} = \frac{2(n-1)t}{a^2}$$

where t is the thickness of the lens and $2a$ is the width. If, for example, we wish to spread out a beam over a 45-degree angle, with

$$n=.735,$$

the focal length f must be given by

$$\frac{a}{f} = \tan 22.5^\circ = .4141 \text{ or } f = 2.42a.$$

Then the thickness t is

$$t = .782a$$

and the thickness is nearly half the width.

To cut down the total weight of rubber and to cut down the loss due to the acoustic path length through the rubber, a lens of the Newtonian type shown as element 19 in Fig. 3 can be constructed. The curvature of any part is the same as that of element 11 in Fig. 2 but the thickness is much less. It appears that with the type of synthetic rubber mentioned above, any spread up to 45 degrees should be obtainable. To get a larger angle, say 90 degrees, would be impossible with a single lens on account of the thickness dimensions, but this should be possible by arranging two 45-degree lenses as indicated in Fig. 4. The first lens 20 would have a virtual focus at the same point as the element 19 of Fig. 3, but when the diverging beam is sent through the second lens 21 a further divergence is obtained by the relation

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f_2}$$

where u is the distance of the focal point from the second lens 21, f_2 its focal length and v the position of the virtual center of the second lens 21. If u is set near f_2 , which can be done if the two lenses are close together, then

$$\frac{1}{v} = \frac{1}{u} + \frac{1}{f_2} = \frac{2}{f_2}$$

and the position of the second virtual center is at half the focal length of the second lens.

In each of Figures 2, 3 and 4, the spread of the beam is indicated by dot-and-dash lines.

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It will be apparent that other arrangements may be made in accordance with the properties of available plastic materials, due consideration being had with regard to other properties necessary in the use of these devices.

What is claimed is:

- 10 In ultrasonic compressional wave transmitting means the combination of a plurality of transducers mounted in closely adjacent relationship and having an aggregate comparatively great area of transmitting surface, the individual surfaces of said transducers being substantially in a common surface whereby a wave conforming in shape to said surface is transmitted
- 15 therefrom, a housing for said transducers, a plurality of lens shaped diaphragms for closing the open end of said housing and directly in the path of a beam transmitted from the surfaces of said transducers for retaining within said
- 20 housing a liquid transmission medium and for excluding therefrom the sea water in which said device will be immersed, said diaphragms being formed of elastic material having a high index of refraction to ultrasonic compressional waves
- 25 whereby the waves transmitted therethrough are dispersed in a beam widened successively by each said lens shaped diaphragm, said elastic material having transmission characteristics closely approaching the transmission characteristics of
- 30 sea water, a liquid transmission medium filling said housing and the space between said diaphragms for transmitting waves from the faces of said transducers to and through said diaphragms, said liquid medium having transmission
- 35 characteristics closely approaching the transmission characteristics of sea water and apertures in a diaphragm both of whose faces are in contact with said liquid medium for equalizing the pressure in said different bodies of said liquid medium.

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