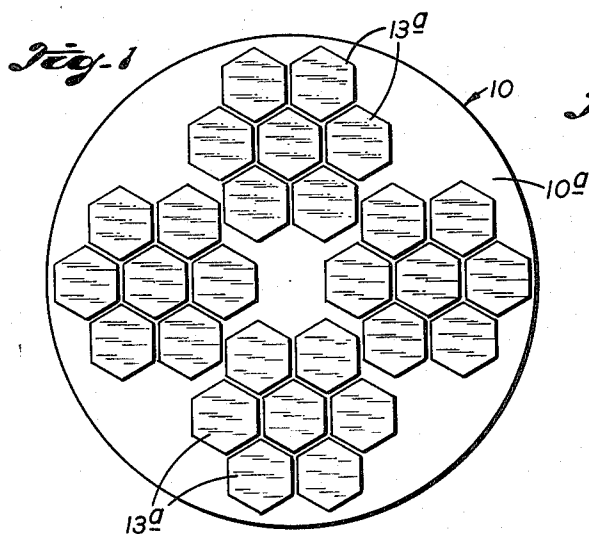
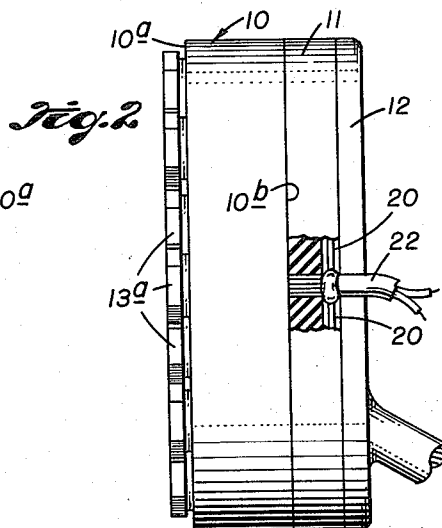
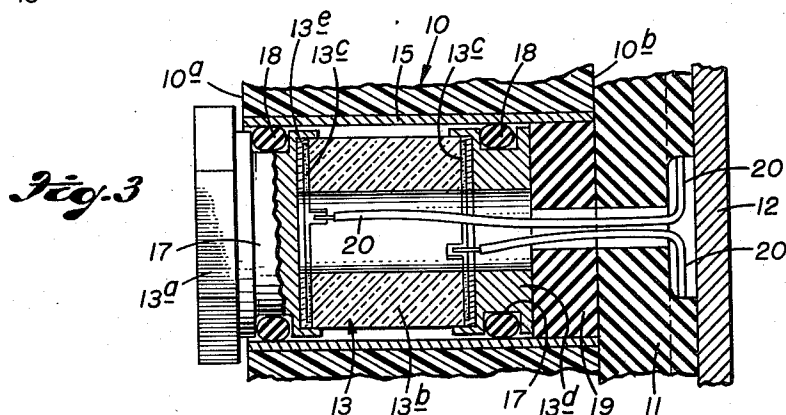
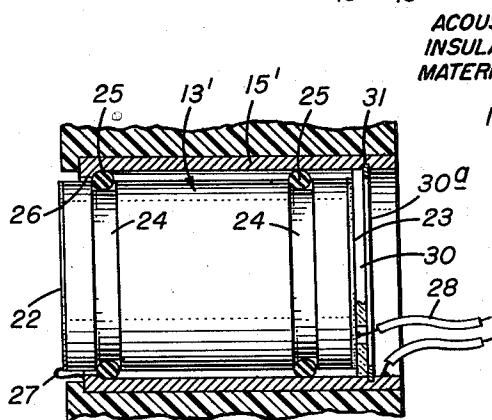
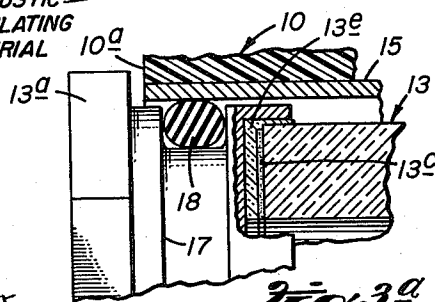


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UNDERWATER TRANSDUCER HAVING A LONGITUDINALLY
VIBRATILE ELEMENT
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UNDERWATER TRANSDUCER HAVING A LONGITUDINALLY VIBRATILE ELEMENT

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13 Claims. (Cl. 340—10)

This invention relates to underwater transducers for converting electrical oscillations into traveling pressure waves in liquids, and vice versa, and is particularly applicable to transducers utilizing as the active element or elements longitudinally vibratile electromechanically-responsive elements.

Underwater transducers usually consist of a watertight casing containing one or more vibratile elements so arranged as to have one face acoustically coupled to the surrounding water and the remaining surface acoustically insulated from the water (and from the other vibratile elements when there are more than one). Air or other gas is an excellent insulating medium, but it is most commonly utilized as a filling in the pores of porous yieldable material, such as cellular rubber, cork, etc., which materials provide some mechanical support and lock the air against displacement by liquid in which the vibratile elements may be immersed. To provide acoustic conduction between the working faces of the vibratile elements and the exterior water, it has also been common practice to provide a rubber sound window in the casing and fill the casing with a sound-conducting insulating liquid. When such transducers are submerged to substantial depths or otherwise exposed to high static pressure, the pressure is applied to the liquid filling the casing to compress the sound-insulating cellular material, thereby introducing severe problems of design.

In accordance with the present invention, the necessity of a sound window is eliminated, and an unobstructed air space is substituted for at least a part of the usual cellular insulating material. This is accomplished by exposing the working faces of the vibratile elements directly to the water and sealing the sides of the elements to the casing against ingress of water with rubber O-rings, which have long been used as sealing rings on pistons and the like in hydraulic apparatus. The O-rings not only seal the air spaces about the elements under high hydrostatic pressure, but yieldably support the elements for vibration with respect to the casing.

An object of the invention is to provide an effective and practical construction for transducers subject to high static pressures such as exist at substantial depths in water.

Another object is to provide a transducer unit that is well insulated acoustically at the sides and is adapted for use in combination with other similar units in a large array to obtain desired directive patterns.

Other more specific objects and features of the invention and the advantages of the invention will be apparent from the following detailed description with reference to the drawing, in which:

Fig. 1 is a front end view of a multi-unit transducer incorporating the invention.

Fig. 2 is a side elevation of the same transducer.

Fig. 3 is a longitudinal section showing details of one of the units of the transducer of Figs. 1 and 2.

Fig. 3a is an enlarged portion of Fig. 3.

Fig. 4 is a longitudinal section similar to Fig. 3, but showing an alternative construction.

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Referring to Figs. 1 and 2, the transducer therein depicted has a body 10, a rear closure member 11, a mounting bracket 12, and, projecting from the front face 10a of the body, an array of active heads 13a arranged in any desired pattern for directional effects.

The body 10 has parallel front and rear faces 10a and 10b between which there extend a plurality of cylindrical passages containing separate vibratile elements 13 (Fig. 3) associated with the respective heads 13a. The body 10 may be of a rigid material, but it is conveniently cast or molded from a stiff plastic material, such as Epoxy-elastomer mixture, with sleeves 15 of more rigid material, such as metal, defining the cylindrical passages.

Referring to Fig. 3, each vibratile element 13 comprises one of the heads 13a, a hollow cylindrical body 13b of electromechanically sensitive material, such as barium titanate, having electrodes 13c bonded to its ends, and a rear head 13d. The heads 13a and 13d are preferably of metal, the front head being of a metal that is relatively resistant to corrosion by water. Titanium has been found to be an excellent metal for this purpose. The heads are firmly bonded to the opposite ends of the vibratile body 13b with an insulating bonding material 13e. Glass has been found to be excellent for this purpose. In manufacture, a disk of glass is placed between each end of the body 13b and the adjacent heads 13a and 13d, and the assembly is placed in a furnace and heated to a temperature sufficient to fuse the glass. The electrodes 13c are the conventional silver coatings which themselves are very tightly bonded to the body 13. In turn, the glass 13e forms a tight bond between the electrodes and the heads 13a and 13d, respectively. It is desirable to form the body 13b of slightly smaller diameter than the heads 13a and 13d and recess the heads to receive the body, as shown in Fig. 3. The glass may flow into the narrow clearance space between the sides of the recesses in the heads and the sides of the body 13b, as shown in Fig. 3a (in which the clearance space is exaggerated).

Each of the heads 13a and 13d is provided with a peripheral groove 17 containing a rubber O-ring 18.

The expression "O-ring," as used in this specification, including the claims, has a specific meaning that it has acquired in the hydraulic art. It means a ring of rubber or other elastomer mounted in a groove in one of two cylindrical surfaces to be sealed with respect to each other, and of such dimensions that it does not completely fill the groove but bears lightly against the opposed cylindrical surface in the absence of fluid pressure. Fluid pressure on either side of the ring presses it axially against the opposite side of the groove and expands it radially to seal against the bottom of the groove and the opposed cylindrical surface with a force proportional to the fluid pressure. An essential characteristic of "O-rings" that distinguishes them from conventional mechanically compressed rubber gaskets is that they are only lightly distorted and offer little friction in the absence of pressure, but are increasingly distorted in proportion to applied pressure only to the extent necessary to maintain the fluid seal.

The two O-rings form a resilient support that maintains the vibratile element 13 out of contact with the wall of the sleeve 15 but offers little impedance to longitudinal vibration of the element 13. In addition, the front ring 18 forms a fluid-tight seal to prevent the entry of water through the front end into the space between the element 13 and the liner 15. Therefore, this space remains filled with air, which offers excellent acoustic insulation against the transmission of sound to and from the sides of the vibratile element 13.

As shown in Fig. 3, the vibratile element 13 is shorter than the liner 15, and the rear end of the latter is filled with a cylindrical block 19 of acoustic insulating material

that is relatively dense, so that it does not compress excessively in response to large forces imparted thereto by the element 13 in response to high hydrostatic pressures acting on the front head 13a.

The rear closure member 11 is bonded to the body 10 in fluid-tight relation so that it effectively prevents any entry of water into the rear ends of the sleeves 15. The closure member 11 in turn is bonded to the bracket 12 which may have a face of corresponding size against which the rear face of the closure member 11 fits.

To make electrical connections to the electrodes 13c, the silvered surfaces constituting said electrodes are extended slightly over the inner edge of the annular body 13b and soldered to wires 20 which extend through an aperture provided therefor in the member 13d and in the member 19. The rear closure member 11 has apertures extending from the front face thereof to the rear face thereof opposite each of the elements 13 and may have grooves in its rear face for bringing the wires to common connector leads 22 which are extended through an aperture provided for that purpose in the bracket 12.

As the apparatus is lowered to substantial depth in water, the hydrostatic force acting on the heads 13a slides the elements 13 rearwardly in the liners 15, compressing the supporting blocks 19 in so doing. However, as the blocks 19 compress, their resistance to further compression increases until an equilibrium is reached. These blocks 19 are sufficiently elastic that they do not seriously dampen the longitudinal vibratory motion of the element 13.

Fig. 4 shows a simpler version of the invention in which the vibratile element 13' consists of a single solid cylinder of electromechanically sensitive material, such as barium titanate, having the usual silvered electrodes 22 and 23 on its opposite ends. In this instance, the grooves 24 for the O-rings 25 are formed directly in the element 13'. At its front end, the liner 15' may have a re-entrant lip 26 for limiting forward movement of the element 13 with respect to the liner 15'. To make electrical connection to the front electrode 22, it is connected by a flexible lead 27 to the adjacent end of the liner 15'. The rear electrode 23 is insulated from the liner 15' and is connected to an ungrounded lead 28.

To support the element 13' against movement in response to hydrostatic pressure on its face, it is supported by a glass disk 30 which rests against the rear electrode 23 of the element 13' and engages at its edge a split ring 30a which is held in an annular groove 31 in the inner surface of the liner 15'. This leaves an air space between the major portion of the rear end of the vibratile element 13' and the rear closure member 11.

Although for the purpose of explaining the invention a particular embodiment thereof has been shown and described, obvious modifications will occur to a person skilled in the art, and I do not desire to be limited to the exact details shown and described.

I claim:

1. A transducer comprising: a body member having a front end and a rear end and a passage having a cylindrical wall extending therethrough from one end to the other; a longitudinally vibratory electromechanically-sensitive piston element having a cylindrical wall loosely fitting in the passage and one of said walls having annular grooves adjacent each end; an elastomer O-ring in each annular groove radially compressed against the juxtaposed wall for resiliently supporting said piston element out of contact with the wall of said passage for longitudinal vibration and effecting a liquid seal between said piston element and said passage wall; said piston element having an exposed rigid working face adjacent the front end of said body, and a rear face; and means bearing

against said rear face of said piston element supporting said piston element against static fluid pressure forces on the face thereof.

2. A transducer according to claim 1 in which said rear face of said piston element is positioned within said passage, and said last-mentioned means comprises: a cylindrical body of acoustic insulating material extending from said rear face of said piston to the rear end of said body member, and a rear wall member overlying the rear end of the body member and said body of insulating material.

3. A transducer according to claim 2 in which said rear wall member is of semi-rigid acoustic insulating material bonded to said body member.

4. Apparatus according to claim 1 in which said body member comprises a body of semi-rigid insulating material and a rigid cylindrical shell imbedded therein defining said cylindrical passage.

5. Apparatus according to claim 1 including a plurality of passages in said body and a plurality of piston elements corresponding to and arranged side by side with respect to each other and said mentioned passage and piston element.

6. A transducer according to claim 1 in which said vibratory piston element comprises a cylindrical body of electromechanically-sensitive material vibratile in longitudinal mode in response to alternating potential applied to its ends, electrodes bonded to said ends of said cylindrical body and means for making electrical connections to said electrodes.

7. Apparatus according to claim 6 in which said vibratory piston element includes front and rear heads mechanically bonded to said electrode and constituting with said body of electromechanically-sensitive material and electrodes an integral unit vibratile longitudinally by expansion and contraction.

8. Apparatus according to claim 7 in which at least one of said heads is of electrically conductive material and is bonded to its adjacent electrode with an electrical insulating material.

9. Apparatus according to claim 8 in which said annular grooves are in said heads.

10. Apparatus according to claim 8 in which said cylindrical body and rear head are hollow, and electrical connection means extending therethrough to said front electrode.

11. In an underwater transducer: an electromechanically-responsive hollow cylindrical element having flat parallel rear and front ends; rear and front heads bonded to the respective ends of said element and constituting with said element an integral unit vibratile longitudinally by expansion and contraction, said front head being solid; housing means enclosing at least the side and rear portions of said integral unit for preventing ingress of water thereto; and a body of acoustic insulating material between said rear head and said housing supporting said unit against rearward displacement relative to the housing.

12. Apparatus according to claim 11 in which said rear head is a hollow cylinder.

13. Apparatus according to claim 12 in which said rear head and said hollow cylindrical element have flush internal cylindrical surfaces.

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