Sept. 29, 1959 L. W. CAMP 2,906,991

TRANSDUCER CONSTRUCTION EMPLOYING ANNULAR VIBRATORS

Filed June 27, 1955

Fig. 1

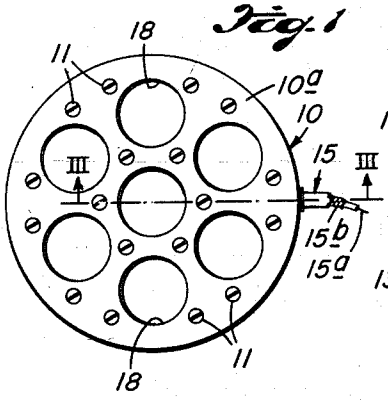


Fig. 2

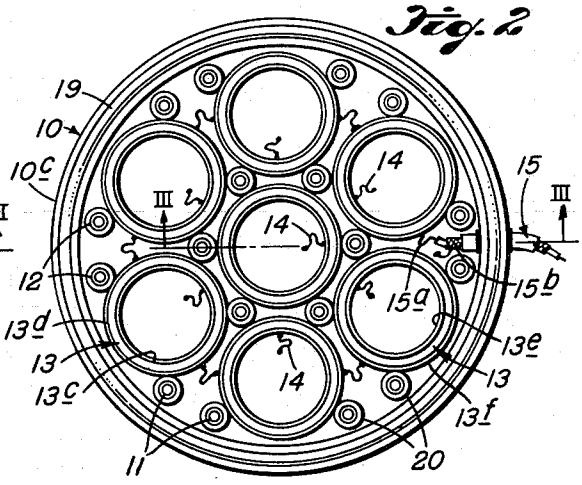
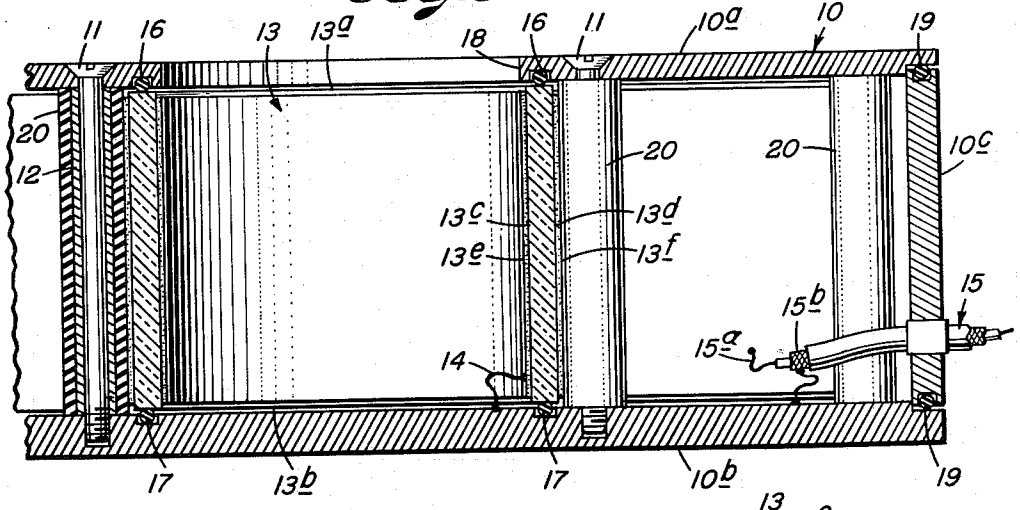


Fig. 3



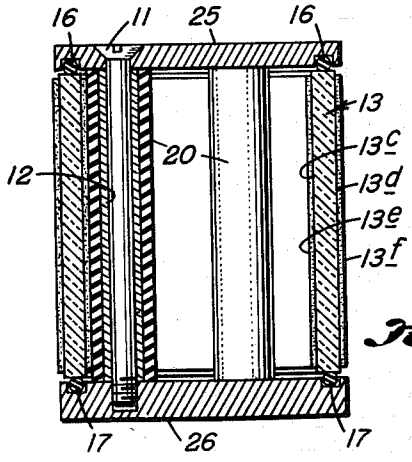


Fig. 5

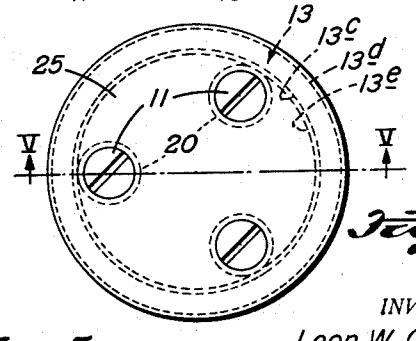


Fig. 4

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TRANSDUCER CONSTRUCTION EMPLOYING ANNULAR VIBRATORS

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7 Claims. (Cl. 340—8)

This invention relates to underwater transducers of the type employing one or more radially vibratile annular vibrators, the inner faces of which are in acoustic conductive relation with the water and the outer faces of which are acoustically insulated from the water. Certain features of the invention are also applicable to transducers in which the outer face of an annular vibrator is in contact with the water and the inner face is acoustically insulated from the water.

An object of the invention is to simplify the construction and improve the efficiency of transducers of the type mentioned.

A more specific object is to improve the acoustic insulation of the non-working surface of the annular vibrator.

Another specific object is to provide a transducer construction permitting the use of free air or other gas as the acoustic insulating medium in contact with the inactive or non-working surface of an annular vibratile element.

Other more specific objects and features of the invention will appear from the description to follow.

In transducers employing annular vibratile elements, as usually constructed, one end of each vibrator is closed by a wall of radically different impedance from water to reflect sound, and the other end is open so that the inner annular surface is communicated with the water. Since radially vibratile rings also radiate from their peripheral faces, the latter must be acoustically insulated from the water. Furthermore, when the rings are of ceramic materials having electrodes on their inner and outer walls, the walls must be electrically insulated from each other. Acoustic and electrical insulation has been accomplished in the past by providing a sound-conductive liquid barrier (sound window) as the front wall of the transducer, filling the transducer with an electrically insulating liquid having substantially the same acoustic properties as water, and surrounding the outer faces or walls of the annular vibrators with an acoustic insulating material, such as air cell rubber, Corprene, etc.

The present invention eliminates the use of both the sound window and the solid insulating material by sealing between the ends of the annular vibrators and the casing so that the inner surfaces of the vibrators are exposed directly to the water, whereas the outer surfaces are separated from each other and from the casing by air space. The seal must be of such a nature as to permit the radial vibration of the vibrators, and this condition is satisfied by employing a rubber O-ring positioned between each end of each vibrator and the adjacent end wall of the transducer casing.

A full understanding of the invention may be had from the following detailed descripion with reference to the drawing, in which:

Fig. 1 is a front end elevational view of a complete transducer in accordance with the invention employing seven annular vibratile elements.

Fig. 2 is a front end elevational view with the front wall removed.

Fig. 3 is an enlarged detail longitudinal section taken in the plane III—III of Fig. 1.

Fig. 4 is an end view, showing a single annular transducer in accordance with the invention adapted to receive or transmit at its external cylindrical face.

Fig. 5 is a longitudinal section in the plane V—V of Fig. 4.

Referring to Figs. 1, 2 and 3, the transducer therein disclosed comprises a front wall **10***a*, a rear wall **10***b*, and a cylindrical lateral wall **10***c*, together defining a casing **10**. The front wall **10***a* and the rear wall **10***b* are rigidly secured in fixed spaced relations parallel to each other by a plurality of screws **11** which extend through apertures provided therefor in the front wall **10** and are threaded into the rear wall **10***b*. Each screw **11** is surrounded by a rigid metal sleeve **12** which determines the spacing between the walls **10***a* and **10***b* when the screws are drawn up tight. The peripheral wall **10***c* is so dimensioned as to be clamped tightly between the front and rear walls at the edges thereof. A rubber seal **19** may be provided between the ends of the peripheral wall **10***c* and the front and rear walls **10***a* and **10***b* respectively.

The casing **10** contains an array of seven annular vibratile elements **13**, each having flat parallel end walls **13***a* and **13***b*, respectively, a cylindrical inner wall **13***c*, and a cylindrical outer wall **13***d*. Each element **13** has an inner electrode **13***e* on its inner cylindrical face **13***c* and an outer electrode **13***f* on its outer cylindrical face **13***d*. Connection to the inner electrodes **13***e* may be made by connecting each electrode to the casing as by a pigtail **14**. The outer electrodes **13***f* can be connected by leads to each other and to the central conductor **15***a* of a coaxial lead-in-cable **15**, the outer conductor **15***b* of which is grounded to the casing **10**.

Each element may be of an electromechanically sensitive material, such as barium titanate, which is capable of vibrating radially in response to electrical potential applied between the inner and outer electrodes **13***e* and **13***f*, or, vice versa, is capable of generating a potential between said electrodes when vibration is induced mechanically. However, the present invention does not relate to any particular electromechanically-sensitive material, but rather to an assembly incorporating radially vibratile rings, regardless of the exact nature of the elements themselves.

The upper end **13***a* of each element **13** is sealed with respect to the front wall **10***a* by an O-ring **16** of rubber or other suitable elastomer mounted in an annular groove, either in the casing end wall **10***a* or the upper end wall **13***a* of the element. It is usually easier to form the groove in the casing wall **10***a*, and such an arrangement is shown in Fig. 3. The lower end **13***b* of the vibratile element is similarly sealed with respect to the casing wall **10***b* by an O-ring **17**.

The front end wall **10***a* of the casing **10** is provided with seven apertures **18**, each aligned with and substantially coextensive with the inner wall **13***c* of its associated vibratile element. Hence, the interior surface or wall **13***e* of each vibratile element is in direct communication with water exterior of the casing, whereas the outside walls **13***d* of all the vibratile elements are acoustically isolated from each other and from the casing by a dead air space defined by the vibratile element and the casing. This dead air space provides about the best possible acoustic insulation to acoustically insulate the outer surfaces of the vibratile elements.

Although the O-rings **16** and **17** provide sufficient freedom of movement to substantially unappreciably impede the acoustic vibration in radial mode of the vibrators **13**, they offer substantial frictional resistance to large displacements of the elements from their desired

positions in alignment with the openings 18. However, as additional precaution to prevent such displacement of the annular elements, the posts 11 are positioned adjacent the outer surfaces 13*d* of the elements 13 and are surrounded with tubes of yieldable material 20 of such thickness as to lightly contact the outer surfaces 13*d* of the vibratile elements and thereby prevent any appreciable movement thereof away from their predetermined positions.

A transducer having an array of vibratile elements, as shown in Figs. 1, 2 and 3, is particularly useful where it is desired to have directional properties; i.e., to transmit or receive sound most efficiently in a certain direction. However, there are occasions where it is desirable to transmit or receive sound simultaneously in all horizontal directions. A desirable form of transducer for this purpose is a single radially vibratile annular element having its outer cylindrical wall in acoustic conductive relation with the water and its inner wall acoustically insulated.

Such an arrangement in accordance wtih the present invention is shown in Figs. 4 and 5. It will be observed that the construction is essentially the same as that in Figs. 1, 2 and 3, except that there is only one radially vibratile annular element, and both of its ends are closed by casing plates 25 and 26 of substantially the same diameter as the external diameter of the annular element 13, the end plates having grooves therein and O-rings 16 and 17 corresponding to the O-ring seals in Fig. 3. However, the two end plates 25 and 26 are solid, so that they define with the element 13 a closed cylindrical air space which acoustically insulates the inner wall 13*c*. Bolts 11, spacer sleeves 12, and locating sleeves 20 identical with those shown in Fig. 3 are employed in Fig. 4, but they are positioned within the annular element 13 so that they extend through the dead air space therein.

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 for use in liquids comprising: a radially vibratile annular element of electromechanically-sensitive material having flat parallel opposite end walls and inner and outer cylindrical walls; means associated with said element for electrically coupling it to an electric circuit; casing means defining with said annular element a closed air space acoustically isolating the outer cylindrical wall of said element and including a pair of casing end walls juxtaposed to but spaced from the respective end walls of said element, and an elastomer sealing ring compressed between each end wall of said annular element and the adjacent casing end wall for effecting a fluid seal therebetween while permitting radial vibration of the element relative to said casing means.

2. A transducer according to claim 1 in which one of said end walls has an opening therethrough aligned with said element for acoustically communicating the inner surface thereof with the exterior of said casing.

3. A transducer according to claim 1 in which said casing means includes a plurality of rigid post members extending between said end walls of said casing through said closed air space for rigidly supporting said casing end walls spaced apart a distance slightly exceeding the length of said annular element.

4. A transducer according to claim 3 in which one of said juxtaposed end walls at each end of said element has an annular groove therein and said sealing ring is an O-ring positioned partly in and partly projecting from said groove.

5. A transducer according to claim 3 in which said post members are positioned adjacent said outer wall of said element and yieldable means supported by said posts and contacting relatively small areas of said outer wall for supporting said annular element against lateral displacement.

6. Liquid-vibrating apparatus comprising: a radially vibratile annular element of electromechanically-sensitive material having flat parallel opposite end faces and inner and outer generally cylindrical faces; means associated with said element for electrically coupling it to an electric circuit; casing means for supporting said element for radial vibration and forming a liquid barrier between the said inner and outer cylindrical faces thereof, said casing means comprising a pair of casing end walls juxtaposed to the respective end faces of said element, each said end wall having an annular groove therein opposite and of less radial width than the associated end face of said element; an elastomer sealing ring in each said groove of such thickness as to project from the groove against the associated flat end face of said element; means rigidly supporting said end walls with respect to each other and in spaced relation to said element such as to slightly compress each said ring between the bottom of its groove and the associated end face of said element, said rings constituting the sole means axially supporting said element with respect to said casing means; and means other than said elastomer rings for limiting transverse movement of said element wtih respect to said casing end walls.

7. Apparatus according to claim 6 in which said elastomer rings are O-rings, and said spacing between said end walls is such as to slightly flatten said O-rings whereby they effect a fluid seal between said end walls and said end faces of said element while offering only slight resistance to radial vibration of said element with respect to said end walls.

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