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3,372,370

ELECTROACOUSTIC TRANSDUCER

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FIG. 1.

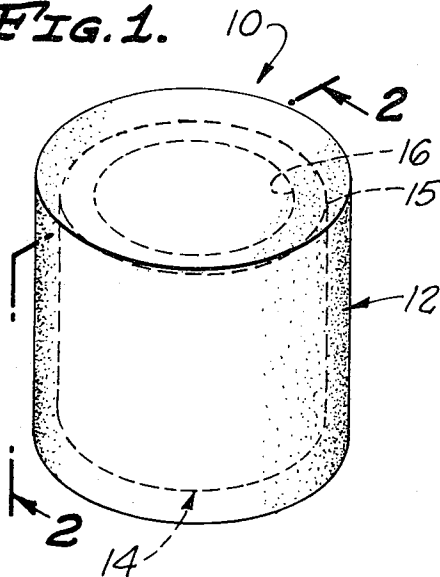


FIG. 3.

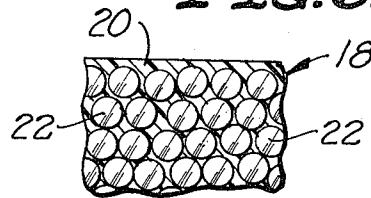


FIG. 2.

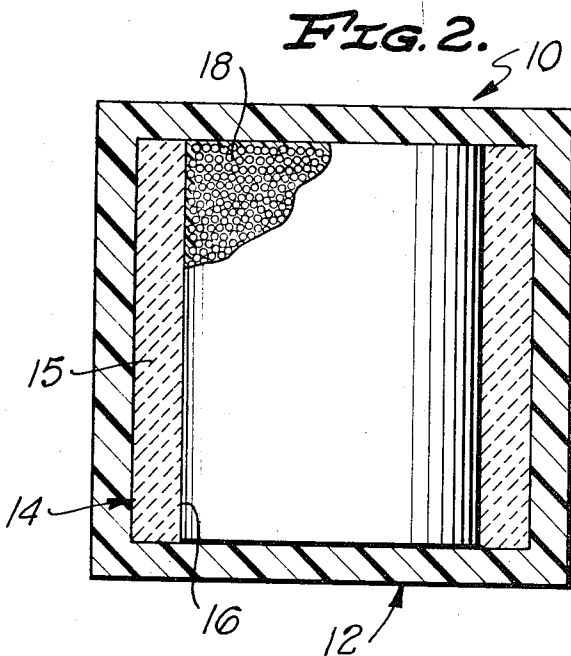
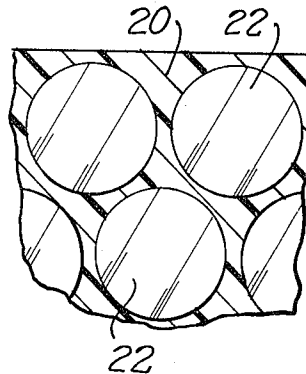


FIG. 4.



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ELECTROACOUSTIC TRANSDUCER

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This invention relates to an electroacoustic transducer of the piezoelectric type adapted to be utilized in deep underwater applications where extremely high pressures are encountered of an order so great as to prevent the accurate functioning of conventional prior art electroacoustic piezoelectric transducers.

It is well known to those skilled in the art that a piezoelectric transducer of any kind must be so mounted in association with its accompanying housing that it will perform throughout its frequency range without being damped in such a way by the rigidity of the mounting or the impression thereupon of ambient conditions as would prevent the proper functioning throughout its frequency range.

It has previously been known that piezoelectric acoustical transducers, when mounted in conventional packaging, have not functioned adequately at extreme subaqueous depths because the packaging of the transducers has been such as to permit the impression thereupon of the force created by the extreme pressures to which the transducers have been subjected, thus preventing them from functioning properly throughout their frequency range and militating against their use in deep undersea applications.

For instance, prior art piezoelectric transducers have made use of various types of foam material, such as polyurethane and foam rubber and the compressibility of such mounting materials, while satisfactory for ordinary applications, has not been sufficient to prevent the imposition of excessive forces generated by the extremely high pressures upon the piezoelectric transducing elements incorporated in said transducers.

It is, therefore, an object of my invention to provide a piezoelectric transducer peculiarly adapted for use in deep undersea applications which is packaged in conjunction with a pressure-accommodating mass which has been found particularly adaptable for sustaining high hydrostatic loading and, at the same time, serving as an acoustic energy absorbing material to protect certain surfaces of the piezoelectric transducing element, thus permitting the piezoelectric transducing element to function throughout its design range and to facilitate its use in deep undersea applications.

Another object of my invention is the provision of an electroacoustic transducer of the aforementioned character which includes a piezoelectric transducing element which has operatively associated therewith a pressure-accommodating mass which includes a supporting body, matrix or lattice of organic plastic material, such as epoxy-resin, and which incorporates a high percentage of nonorganic hollow spheroids, the combination of said piezoelectric transducing element and pressure-accommodating mass being encompassed in an appropriate housing.

An important object of the invention is the provision of a pressure-accommodating mass which is an acoustical energy absorber and is sufficiently compressible to allow response to a weak alternating sound field while still providing the required pressure release or accommodation internally of a cylindrical transducer.

An additional object of my invention is the provision of an electroacoustic transducer of the aforementioned type in which the hollow spheroids are fabricated from glass, ceramic, or similar nonorganic materials and are of dimensions of several microns in diameter. These

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spheroids are known to the art, when manufactured out of such materials as polyurethane and the like, as microballoons, and will hereinafter be referred to by that term.

Other objects and advantages of the invention will be apparent from the following specification and the accompanying drawing, which is for the purpose of illustration only, and in which:

FIG. 1 is an isometric view illustrating a transducer manufactured in accordance with the teachings of this invention in its simplest form;

FIG. 2 is a vertical, sectional view taken on the broken line 2-2 of FIG. 1;

FIG. 3 is an enlarged, fragmentary, sectional view showing the mechanical arrangement of the constituents of the pressure-accommodating mass; and

FIG. 4 is an enlarged, fragmentary, sectional view showing the manner in which the organic, synthetic plastic lattice or body of the pressure-accommodating mass encompasses the microballoons and serves to support them in operative relationship with one another.

Referring to the drawing, and particularly to FIGS. 1-2 thereof, I show an electroacoustic transducer 10 constructed in accordance with the principles of my invention and including a housing 12 which may be placed about the piezoelectric transducing element 14 and may be selected from any one of a large variety of suitable encapsulating materials, such as polyurethane, neoprene, and the like.

The piezoelectric transducing element 14 is illustrated as being constituted by a substantially cylindrical body 15. For instance, a lead zirconate-lead titanate ceramic cylinder has been utilized whose over-all diameter is one inch, whose height is one inch, and whose wall thickness is .125 inch. The ceramic body 15 incorporates a centrally located bore 16, and the bore has a pressure-accommodating mass 18 deposited therein, in a manner to be described in greater detail below.

While the pressure-accommodating mass 18 has been disclosed as deposited in the bore 16 of the piezoelectric element 14, it is also possible and feasible to completely encompass the piezoelectric element 14 in the pressure-accommodating mass. This is particularly the case when a piezoelectric element having a configuration, such as a disk configuration, is utilized in substitution for the cylindrical type of element 14 disclosed herein. The pressure-accommodating mass 18 will perform two functions. It will serve as an encapsulating as well as a pressure release medium.

In addition, the mass 18 can be applied directly to the exterior or vibrating surface of a ceramic transducer of a given geometric shape and thickness to produce a shaded operational pattern. This pattern will be fixed regardless of depth.

Moreover, the pressure-accommodating mass may be used in conjunction with line transducers as a gasket material between the ceramic components thereof to decouple said components from one another.

The pressure-accommodating mass 18 includes a supporting body 20 which may be fabricated from an epoxy-resin or a similar synthetic organic plastic material and has deposited therein a plurality of microballoons 22 which are hollow spheroids of a few microns in diameter, which are fabricated from glass, ceramic, or other nonorganic materials. The microballoons 22 are disposed in close juxtaposition to one another, and are supported by a relatively thin lattice work constituted by the supporting body 20 of plastic material.

The pressure-accommodating mass may be fabricated by utilizing 100 parts of epoxy-resin, 10 parts of an appropriate catalyst, and a high percentage of microballoons mixed in the fluid resin before it has catalyzed. By weight,

I have found that 4 to 8 grams of microballoons mixed with 8 to 15 grams of epoxy-resin provides a suitable mixture for the pressure-accommodating mass.

The pressure-accommodating mass is poured into the bore of the piezoelectric element 14 and is permitted to catalyze therein under ambient temperatures. Subsequently, the exterior of the piezoelectric element 14 and the associated pressure-accommodating mass are potted in a suitable potting material, such as polyurethane, epoxy-resin, or the like, in accordance with the procedures well known to those skilled in the art. If desired, a preformed boot can be substituted for the potting materials previously mentioned.

When conventional pressure-accommodating masses are utilized in conjunction with piezoelectric transducing elements at great depths, the neoprene or polyurethane sponges constituting such masses eventually become compressed to such an extent as to prevent the response of said elements to incident acoustic energy throughout their frequency range.

When microballoons fabricated from organic plastics, such as polyurethane, or the like, are utilized in conjunction with conventional neoprene sponges or polyurethane sponges, they will not permit the defective functioning of the piezoelectric elements below a depth of 10,000 feet.

However, I have found that the combination of non-organic microballoons with the epoxy-resin body to form a pressure-accommodating mass serves effectively as a pressure-accommodating or pressure-release medium which will withstand pressures up to 20,000 p.s.i.

The relevant frequency response and electrical resistance of the electroacoustical transducer incorporating the teachings of the invention are essentially the same as where a piezoelectric transducing element is constructed using foam or closed cell neoprene as a pressure release material. Furthermore, the air transmission of an underwater phone incorporating the transducer of this invention appears identical with the standard elements conventionally utilized.

It is my belief that the explanation of the effective functioning of the electroacoustic transducer of the present invention, as discussed and shown in FIGS. 1 and 2, can be attributed to the circumferential excitation of the piezoelectric element by the incident sound field. Stated in another way, the mean diameter and the mean circumference of the ceramic element contract and expand in accordance with the forces characterizing the sound field. The pressure-accommodating mass 18 attenuates or absorbs the sound in the bore of the transducing element 14 while at the same time being sufficiently compressible to allow the incident sound field on the external surface to cause circumferential excitation. If the condition exists where the sound field is incident upon both internal and external surfaces, zero circumferential strain develops and no transducing action is observed for the circumferential mode.

Of course, this aspect of the performance of the transducing element in conjunction with the pressure-accommodating mass becomes even more critical when the housing 12 in which the pressure-transducing element 14 is encompassed is subjected to the extremely high pressures characteristic of the deep undersea depths in which such transducers may be utilized. Adequate pressure release is required at all pressures and, at extreme depths where pressures are high, the epoxy-microballoon material is vastly superior to currently used materials for the reasons of low compressibility, the maintenance of sound-absorbing properties, good structural properties, and ease of fabrication.

I thus provide by my invention an electroacoustic transducer whose performance at great depths is facilitated by the incorporation, in conjunction with a piezoelectric transducing element, of a pressure-accommodating mass characterized by the utilization of an organic synthetic plastic body in conjunction with a plurality of microballoons formed from such materials as glass and ceramic.

It has also been discovered that a mass of nonreactant lubricant, such as silicone oil, transformer oil, or castor oil, which is basically noncompressible can be substituted for the pressure-accommodating mass 18 and the microballoons 22 immersed in said oil in proportions substantially equal to those mentioned hereinabove in discussing the use of an organic plastic pressure-accommodating mass.

I claim:

1. In an electroacoustic transducer adapted for underwater applications, the combination of: a piezoelectric transducing element; means including a pressure-accommodating mass of acoustic energy absorbing material disposed in operative relationship with said transducing element for supporting said element against destructive deformation from the pressure of surrounding water while permitting the vibratory functioning of said element, said mass consisting of a plurality of inorganic microballoons supported in closely juxtaposed operative relationship with each other by a suspensory body with the assembly thereof disposed in operative supporting relationship with said piezoelectric transducing element; and a housing encompassing said transducing element and said pressure-accommodating mass.

2. In a piezoelectric transducer adapted for subaqueous applications, the combination of: a cylindrical piezoelectric transducing element having openings in its opposite extremities communicating with an internal cavity in said element; means including a pressure-accommodating mass of acoustic energy absorbing material located in said cavity for supporting said element against destructive deformation from the pressure of surrounding water while permitting the vibratory functioning of said element, said pressure-accommodating mass including a plurality of closely juxtaposed, inorganic, hollow microspheroids and a supporting body of organic synthetic resin encompassing said microspheroids with the assembly thereof supporting said element; and a housing disposed in encompassing relationship with said element and said mass.

3. In a piezoelectric transducer for use in underwater applications, the combination of: a cylindrical piezoelectric transducing element incorporating an axial bore; means including a pressure-accommodating mass of acoustic energy absorbing material disposed in said bore for supporting said element against destructive deformation from the pressure of surrounding water while permitting the vibratory functioning of said element, said mass including a plurality of closely juxtaposed, inorganic, hollow microspheroids, said microspheroids being supported in an organic lattice with the assembly thereof supporting said element; and a housing encompassing said element and said mass.

4. In an underwater transducer, the combination of: an elongated cylindrical transducing element having an axially located bore therein extending therethrough; means including a pressure-accommodating mass of acoustic energy absorbing material mounted in said bore in contact with the wall thereof for supporting said element against destructive deformation from the pressure of surrounding water while permitting the vibratory functioning of said element, said pressure-accommodating mass including a plurality of closely juxtaposed microspheroids which are hollow and fabricated from glass and a lattice formed from organic plastic material encompassing said microspheroids with the assembly thereof supporting said element; and an enclosure encompassing said transducing element and said mass.

5. In a piezoelectric transducer adapted for underwater use at high pressures, the combination of: a piezoelectric element; means including a pressure-accommodating mass of acoustic energy absorbing material disposed in operative relationship with said element for supporting said element against destructive deformation from the pressure of surrounding water and for preventing the pressure to

which said element is subjected from being effective to render said element inoperative, said mass including a latticed body of organic synthetic resin encompassing a plurality of closely juxtaposed, inorganic, hollow microspheroids, said mass permitting vibratory functioning of said element during said support; and an enclosure potted about said element and said mass to isolate said element and said mass from aqueous infiltration.

6. In an underwater transducer, the combination of: a piezoelectric transducing element; means including a pressure-accommodating mass of acoustic energy absorbing material mounted in operative relationship with said element for supporting said element against destructive deformation from the pressure of surrounding water while permitting the vibratory functioning of said element, said mass including a supporting lattice of organic synthetic plastic and a plurality of ceramic, hollow spheroids distributed closely juxtaposed throughout and supported by said lattice with the assembly thereof supporting said element; and an enclosure encompassing said pressure-accommodating mass and element.

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