United States Patent

[11] **3,555,311**

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[21] Appl. No. **793,344**
[22] Filed **Jan. 23, 1969**
[45] Patented **Jan. 12, 1971**
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[54] **HIGH PRESSURE PIEZOELECTRIC TRANSDUCER**
20 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** **310/8.3,** 310/8.7; 340/10
[51] **Int. Cl.** **H01v 7/00**
[50] **Field of Search** 310/8.5, 8.6, 8.7, 9.1, 8.1, 8.2, 8.3; 340/10, 11, 12, 8

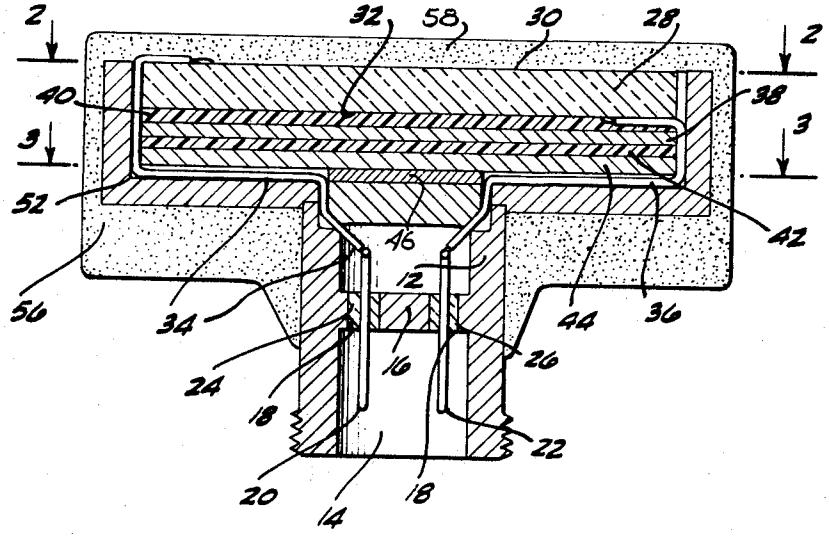
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ABSTRACT: An alternating voltage is applied to the electrodes of a piezoelectric crystal at the frequency of natural vibration of the crystal in the thickness mode which causes the crystal to vibrate in the thickness mode. This vibration is at one-half wavelength resonance. Vibrations from the front surface are transmitted through an epoxy window as an ultrasonic wave. Vibrations off the back surface are reflected from a reflector which is spaced one-quarter wavelength from the crystal. A filler material with negligible reflective qualities, such as neoprene, synthetic or natural rubbers, or the like, is sandwiched between the crystal and the reflective material. The filler also has the properties of compressions so that the crystal will not break or cave in when the transducer is subject to high pressures when submerged in very deep water.



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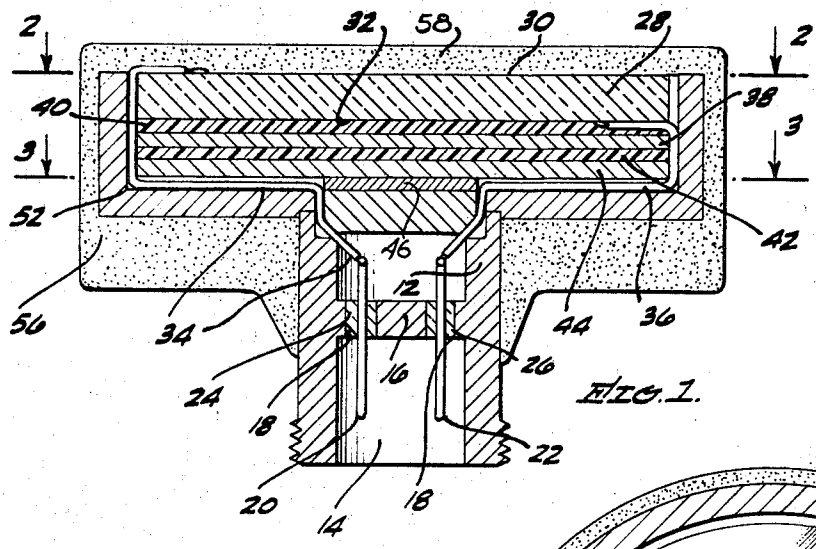


FIG. 1.

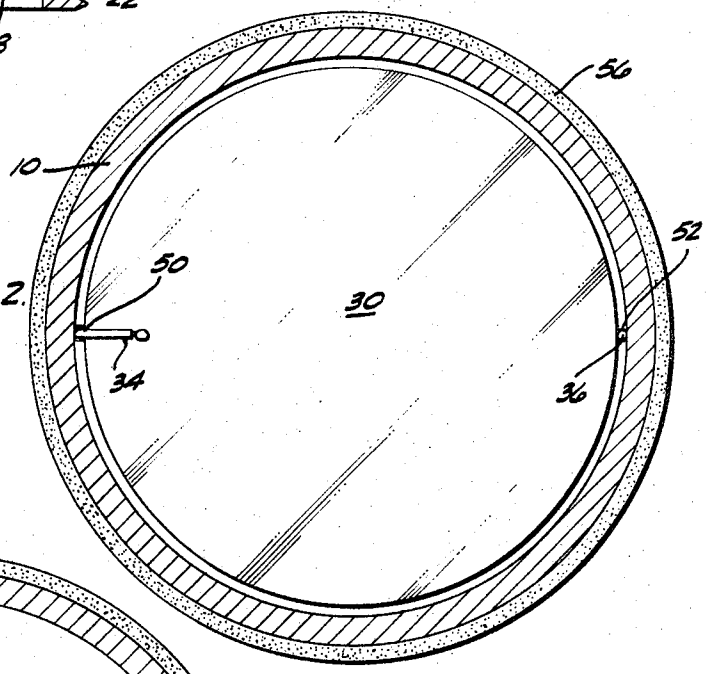
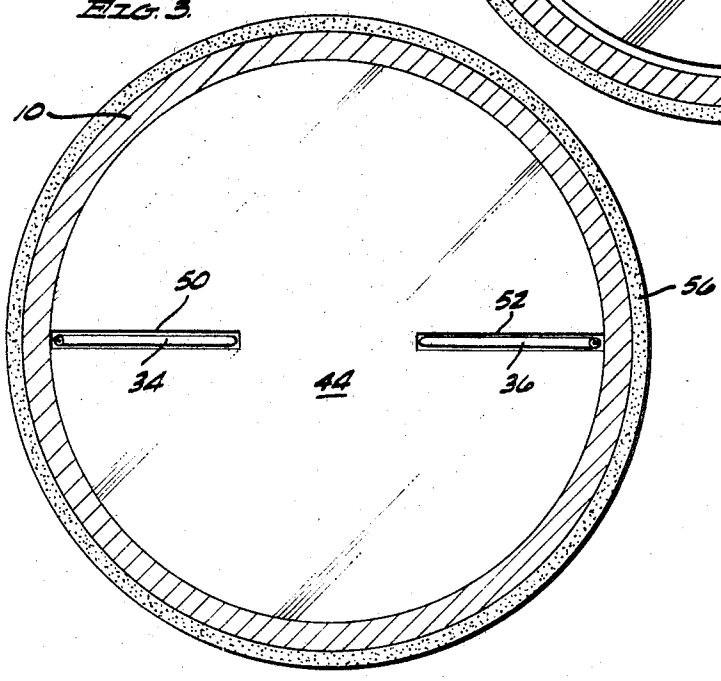


FIG. 2.

FIG. 3.



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HIGH PRESSURE PIEZOELECTRIC TRANSDUCER

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to underwater transducers and more particularly to novel and improved underwater transducers which have the qualities of reflecting the back energy to increase the initial output of the transducers without significant losses thereto.

2. Description of the Prior Art

Transducers of the prior art are generally comprised of a crystal oscillator formed of piezolectric material. Those crystals vibrate in the thickness mode, sending out an acoustic vibration when an electrical energy is applied to the electrodes thereof. These vibrations are generally caused by the contractions and expansions of the crystal.

These transducers are generally used as sonic transmitters and receivers and are used to send acoustic energy either down or through the water and received back by transducers similar to the transmitting transducers.

Problems occur with transducers which are placed many fathoms under the water. When subjected to these depths, extreme pressures are exhibited to the transducers. Approximately one-half p.s.i. for every foot of water in depth. The normal use of some transducers are in 20,000 feet of water. When down this deep, they are subjected to approximately 10,000 p.s.i.

In the prior art, transducers were filled with oil to transmit and equalize the pressure and prevent the crystals from caving in. However, the prior art oil filled transducers had many problems. First, they are susceptible to spillage and leakage during assembly. Further, it is not desirable to work with transducers which are filled with oil because they require many mechanical joints which may leak.

It is found that the back energy from the crystal is normally lost because the only energy which is desired to be used is that which is projected in a forward direction. Because the crystal oscillates in the thickness mode, the ultrasonic vibrations thereof are transmitted in its forward and back direction, whereas only the forward direction is of any use and the back direction of the ultrasonic wave is virtually lost.

Thus, it would be desirable to provide a transducer which can utilize the back ultrasonic waves as well as the forward ultrasonic waves. This is accomplished in the present invention by a unique technique of reflecting the ultrasonic waves that are emitted from the back of the transducer crystal to add to the ultrasonic energy transmitted from the forward end of the transducer, and thereby increasing the efficiency of this transducer.

SUMMARY OF THE INVENTION

Briefly described, the present invention includes a crystal vibrator which vibrates in its thickness mode. The vibrations from the front surface of the crystal are used for ultrasonic transmission. Means are disposed behind the crystal to reflect the ultrasonic waves to reinforce the ultrasonic waves to reinforce the ultrasonic waves emitted in the downward direction. A further filler is positioned between the crystal and the reflecting means to maintain a distance therebetween which is one-quarter wavelength distance. The filler material is composed of a substance which is compressible and doesn't require air in its compression process, whereby the volume of the material is completely filled, such as neoprene, cork, rubber, either natural or synthetic. A number of these reflective stages may be used to further increase the efficiency of the transducer reflection in its forward direction. The entire transducer may then be encapsulated in epoxy.

It, therefore, becomes one object of this invention to provide a novel and improved high pressure transducer.

Another object of this invention is to provide a novel and improved high pressure transducer which reflects back sonic waves to aid in the overall output of the transducer system.

Another object of this invention is to provide a novel and improved transducer which is capable of being submerged in very deep water without damage thereto.

Another object of this invention is to provide a novel and improved transducer which has characteristics safeguarding the crystal material used therein from being crushed due to the deep water pressures.

These and other objects, features and advantages will become more apparent to those skilled in the art when taken into consideration with the following detailed description, wherein like reference numerals indicate like and corresponding parts throughout the several views, and wherein:

FIG. 1 is a section view of the transducer of this invention showing the internal apparatus;

FIG. 2 is a section view taken along the lines 2–2 of FIG. 1; and

FIG. 3 is a section view taken along the lines 3–3 of FIG. 3.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Turning now to a more detailed description of this embodiment, there is shown a housing 10 which may be composed of a metallic material, such as stainless steel. The end 12 of the housing 10 may be, for example, tubular in shape and having a bore 14 therein, and a bulkhead 16 which is used to seal the internal apparatus of this invention from water. A pair of holes 18 are provided in the bulkhead 16 of the end 12 for a pair of electrodes 20 and 22 to extend therethrough. The electrodes 20 and 22 are insulated from the end 12 of housing 10 by the insulators 24 and 26, respectively. These insulators are tightly placed within the bulkhead 16 to assure that no leakage of water enters the internal mechanisms of the invention.

A crystal 28 is placed within the housing 10 and is shaped in the form of a disc. The top surface 30 and the bottom surface 32 are silvered and electrical lead 34 is coupled to the electrode 20 and to the top surface 30 of the crystal 28. A lead 36 is coupled to the electrode 22 and to the bottom surface 32 of the crystal 28. These leads may be electrically insulated wires to prevent the short circuit to the housing 10 and other internal mechanisms of the invention.

A reflective device 38, which is also shaped in the form of a disc, is placed within the housing 10 and spaced below the bottom surface 32 of the crystal 28. This reflective device 38 may be formed of brass because of its reflectivity qualities.

A filler 40 is spaced between the crystal 28 and the reflector 38 at a predetermined distance. The filler material 40 may be comprised of a suitable compressible material, such as neoprene, pliable plastics elastomers, isoprene butylene, cork, natural rubber, synthetic rubber, and compressed sponge, and the like, as an example.

The thickness of the crystal 28 is selected so that when it vibrates in its thickness mode by having an alternating voltage applied to the electrodes 20 and 22, the material changes dimensions in the thickness mode. It has been found, by way of example, that if the material is 0.336 inches thick it will vibrate at one-half wavelength in terms of velocity propagation through the crystal for a frequency of 300 kHz. This thickness will vary depending upon the bulk velocity of the material and the frequency required, but it is selected to have the one-half wavelength resonance. Thus, when the voltage is applied to the crystal 28, the total cubic inches of the crystal changes from the voltages applied thereto.

If the reflector is positioned one-quarter wavelength from the crystal 28, its return will be a full one-half wavelength, thus reinforcing or adding to the energy emitted from the front surface and no loss of energy is realized, but rather a reinforcement of the front energy. The material brass can be selected because it has good sonic reflectivity, although it should be understood that many other materials may be used and the limitation of brass is shown only by way of example.

The filler 40, which faces the reflector 38, from the crystal 28 at the aforesaid distance, should be selected from a material which is compressible so that as the thickness of the crystal

28 changes, the filler will compress and prevent the crystal from being damaged by cracking or caving in, or the like. The substance for the filler 40 should be selected from a material which is compressible, but does not require air in the process of compressing and wherein the volume of the material may be neoprene, cork, rubber, either natural or synthetic, or the like. Neoprene has been selected for the preferred embodiment in that the molecular chain breaks and reforms during compression without filling with another substance, such as air.

FIG. 1 illustrates that a second filler 42 and a second reflective device 44 is positioned behind the first reflective device 38 and the filler 40. The second stage is added because no material is a perfect reflector. Thus, the energy is reflected for a second time at a similar operation as the first stage. Also the energy is reflected a third time from the metal housing 52.

With reference to FIGS. 2 and 3, there is shown, for example, in FIG. 2 a slot 50 which is provided in the fillers and reflective brass material to allow the lead 34 from the electrode 20 to pass therethrough and to become affixed to the silvered top surface 30 of the crystal 28. A slot is cut in the filler 46 to accommodate the lead 36 from electrode 22. A similar slot (not shown) is provided in the filler 40 so that the lead 36 may be connected to the silvered portion of the bottom surface 32 of crystal 28. This lead comes up through the slot 52 in the reflectors 38 and 44 and their respective fillers 40 and 42.

The entire transducer is encapsulated in an epoxy coating 56 which provides that at the area 58 the epoxy window is used to transmit the ultrasonic vibration waves. The epoxy is used because it has nearly the same velocity as the velocity of sound in sea water.

I claim:

1. A transducer for emitting ultrasonic vibrations comprising:
- a housing;
- means for emitting ultrasonic energy in a first direction and a second direction, said means being disposed within said housing;
- means disposed within said housing and being juxtaposed with said means for emitting ultrasonic energy for reflecting the ultrasonic energy transmitted in a second direction to the first direction; and
- a compressible filler means disposed within said housing for spacing said ultrasonic energy emitting means from said reflecting means a quarter wave length therefrom.

2. The apparatus as defined in claim 1 wherein said transducer being encapsulated in an epoxy material.

3. The transducer as defined in claim 1 and further comprising a pair of electrode means protruding from said housing and wherein one of said electrodes is coupled to the top surface of said ultrasonic energy emitting means and the other electrode is coupled to the bottom surface of said ultrasonic energy emitting means.

4. The apparatus as defined in claim 1 wherein said filler means being neoprene.

5. The transducer as defined in claim 1 wherein said filler means being a pliable plastic.

6. The transducer as defined in claim 1 wherein said filler being an elastomer.

7. The transducer as defined in claim 1 wherein said filler being an isoprene butylene.

8. The transducer as defined in claim 1 wherein said means for emitting a frequency vibration wave being a piezoelectric crystal.

9. The transducer as defined in claim 1 wherein said reflective means being comprised of brass.

10. The transducer as defined in claim 1 wherein:
- said means for emitting frequency vibrations being a piezoelectric crystal;
- said reflective means being brass; and
- said filler means being neoprene.

11. A transducer comprising:
- a piezoelectric crystal having a front surface and a back surface and including electrodes coupled to the back surface and front surface of said crystal for causing said crystal to vibrate in the thickness mode when energized with an electric energy, said crystal being of a thickness and characteristics to resonate at one-half wavelength;
- a means disposed adjacent the back surface of said crystal and being spaced therefrom by one-fourth wavelength of the vibrations of said crystal for reflecting vibrations of said crystal back to said crystal for transmission from only the front surface thereof; and
- a filler means disposed between said crystal and said reflecting means, said filler means being comprised of an acoustic and pressure absorbing material.

12. The transducer as defined in claim 11 wherein said filler is composed of a material which being a solid compressible material.

13. The transducer as defined in claim 12 wherein said filler is selected from the group consisting of neoprene, natural rubber, synthetic rubber, cork, plastic, compressed sponge, and isoprene butylene.

14. The transducer as defined in claim 11 wherein said reflective means being a metallic substance with an acoustic reflectivity.

15. The transducer as defined in claim 11 wherein said reflective means being brass.

16. The transducer as defined in claim 11 wherein said transducer being encapsulated in epoxy.

17. A transducer comprising:
- a metallic housing;
- a piezoelectric crystal being capable of vibrating in the thickness mode for emitting ultrasonic vibrations on the front surface and back surface thereof, said crystal being of a predetermined thickness and characteristic to resonate at one-half wavelength;
- a pair of electrodes protruding from said housing and being coupled to the back surface and the front surface of said crystal for causing said crystal to vibrate in the thickness mode thereof when energized with electric energy;
- a first means disposed adjacent the back surface of said crystal and being spaced therefrom by one-fourth wavelength for reflecting vibrations of said crystal back to said crystal for transmission from only the front surface thereof;
- a first filler means disposed between said crystal and said reflecting means, said first filler means being comprised of a pressure absorbing material;
- a second means disposed adjacent the back surface of said first means and being spaced from said first means by one-fourth wavelength of reflecting vibrations passed by said first means back to said crystal for transmission from only the front surface thereof; and
- a second filler disposed between said crystal and said reflecting means, said second filler means being comprised of a pressure absorbing material.

18 The transducer as defined in claim 17, wherein said filler being comprised of neoprene.

19. The transducer as defined in claim 17, wherein said first means and second means being comprised of a metallic reflective material.

20. The transducer as defined in claim 19, wherein said reflective material being comprised of brass.