

[54] SHOCK HARDENED TRANSDUCER 3,178,681 4/1965 Horsman et al. 340/10
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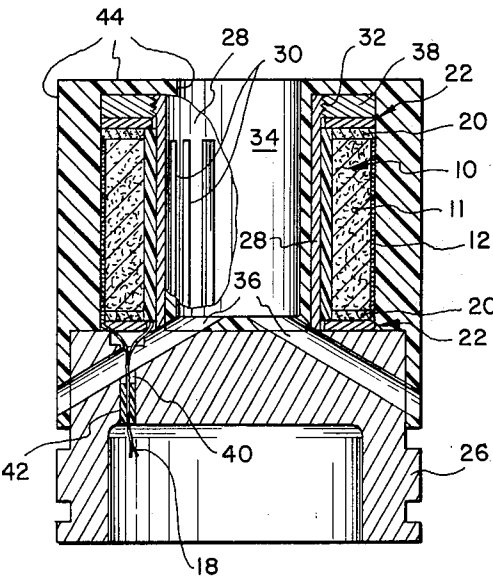
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[57] ABSTRACT
A transducer for use underwater and capable of sur-
viving high shock forces often sustained by ships, sub-
marines, and unretarded air delivery weapons. A ring-
shaped piezoelectric ceramic active element is tightly
wound with fiberglass and potted to obtain compres-
sive hoop stresses on the ceramic and mounted in
axial compression on a transducer base for attachment
to a vehicle.

7 Claims, 2 Drawing Figures



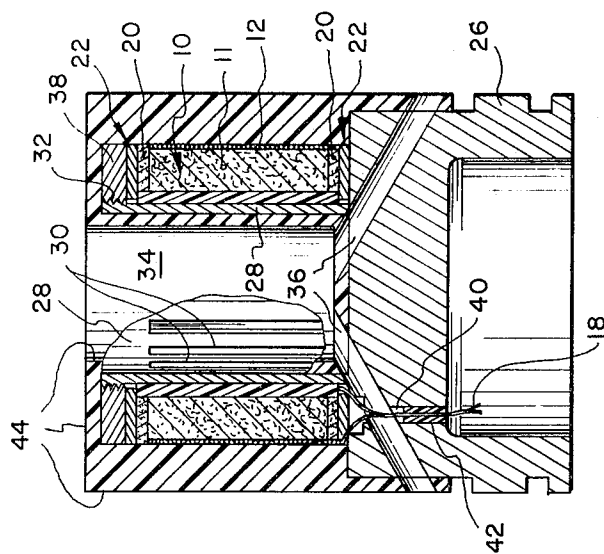
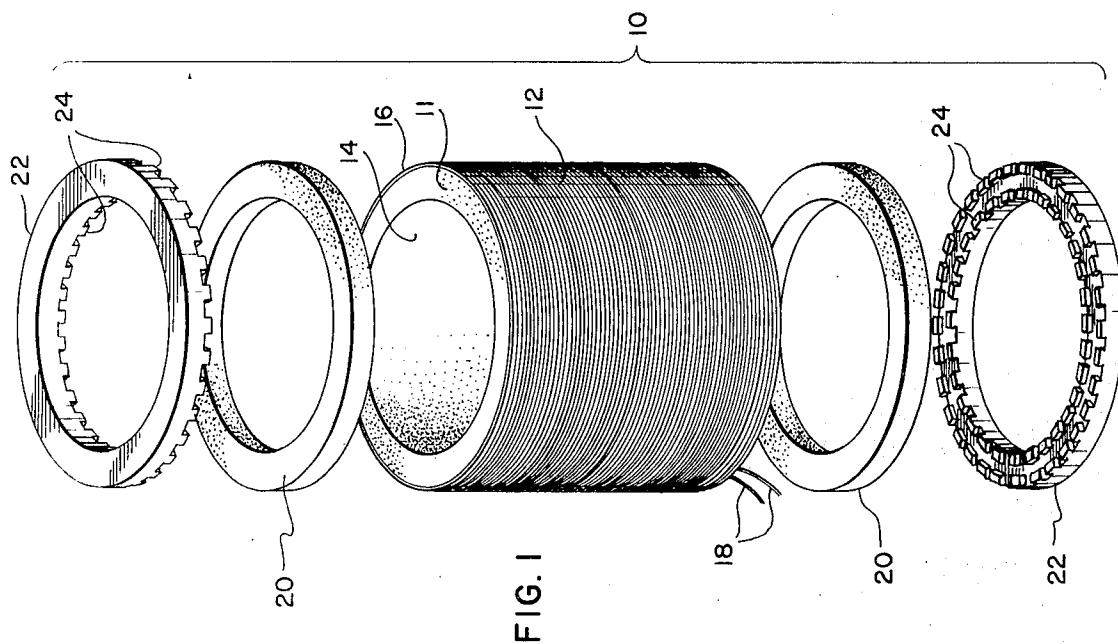


FIG. 2

SHOCK HARDENED TRANSDUCER

BACKGROUND OF THE INVENTION

The instant invention relates generally to underwater transducers and more particularly to a ceramic transducer having the capability of surviving high shock loading.

Transducers used for sonar underwater sound transmission and listening, as location beacons, and other underwater communications equipment are often subjected to high g shock stress loading from nearby underwater explosions and from the water impact of unretarded, free-flight air-delivered weapons. A problem with state-of-the art ceramic elements is that they will often fail due to cracking from the tension forces sustained. Magnetostrictive element type transducers have therefore generally been used for applications requiring durability in such shock environments. But these elements are not a complete solution to the problem because of their low efficiency and acoustic response, lack of flat response, and the need for a transformer for impedance matching.

Another problem associated with the use of piezoelectric ceramic elements is in obtaining efficiency of operation with the mounting techniques used and the configuration of the element. In order to eliminate shattering of a ceramic element due to high shock forces, it must be structurally supported in compression, but this leads to very reduced efficiencies unless care is taken to allow vibration in at least one plane or mode.

SUMMARY OF THE INVENTION

Accordingly, an object of the present invention is to provide a new and improved underwater transducer.

Another object of the instant invention is to provide an underwater transducer that is durable and acoustically efficient in operation.

Still another object of the present invention is to provide a ceramic piezoelectric transducer capable of surviving high shock stresses without loss of acoustic performance.

Briefly these and other objects of the present invention are attained by the use of piezoelectric ceramic element in the form of a short tube or ring that is prestressed in compression axially and circumferentially. The ceramic element is tightly wound with an outer layer of fiberglass to produce high compression hoop stresses and then prepotted. The element is mounted in a transducer base and prestressed in axial compression. The assembly is potted to exclude sea water. The element is acoustically operative in both cavity and ring radial modes.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the invention and many of the attendant advantages thereof will be readily appreciated as the same become better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIG. 1 is an exploded isometric view of the wrapped piezoelectric ceramic element; and

FIG. 2 is a cross-sectional view of the element mounted in a transducer base.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings wherein like reference numerals designate corresponding parts throughout the several views, there is shown generally in FIG. 1 a transducer 10 having a ceramic element 11 made of barium titanate, lead-zirconate-titanate, commonly referred to as PZT-4, or the like, in the form of a short tube or ring. Circumferentially around the element 11 is wound a fiber glass wrap 12 which produces a high compressive hoop prestress in the ceramic. The ceramic element to be wound is spindled and rotated while a filamentary strand of fiberglass dipped in an epoxy adhesive is wound on under tension to produce a few layers. Prior to being wound, an inner electrode 14, and an outer electrode 16, for making electrical connections by conductors 18, are deposited on the inner and outer cylindrical surfaces of the short tubular element. These electrodes 14 and 16 are preferably plated on and are composed of a noble metal.

On each end of the ceramic element 11 is placed a ceramic insulation ring 20. Outside the insulator rings 20 are placed compliant rings 22 having extending teeth 24 formed around the inner and outer edge of the inner face and axially projecting therefrom. These teeth 24 contact the face of the insulator rings adjacent the inner and outer cylindrical surfaces.

The ceramic rings 20 and compliant rings 22 are assembled to the ends of the ceramic element 11 by any conventional means such as adhesive means, and the complete transducer assembly 10 is then potted using as, for example, a polyurethane or epoxy potting compound.

Referring now to FIG. 2, the transducer base comprises a cylindrical body 26 adapted to be secured to a ship, or a weapon when used as a locator beacon. Extending away from the base is a thin tubular collar 28 having axial slots 30 therethrough along its length and external threads 32 at the distal end and thus forming a chamber 34. A plurality of flooding ports 36 are formed angularly in the transducer base 26 and terminate inside the tubular collar 28 to insure complete flooding of chamber 34 when immersed.

The complete transducer assembly 10 surrounds the tubular collar 28 and rests on the top of the transducer base 26. An internally threaded ring or stress nut 38 engages the external threads 32, whereby the ceramic element 11 may be placed in axial compression. The conductors 18, connected to the element 11, are fed through a bore 40, closed with a sealing compound 42, for subsequent electrical connection appropriate for use as a signaling or detecting hydrophone, or the like. The entire assembly of the transducer assembly with the body 26 is coated with a potting compound 44 having resiliency and which precludes the ingress of water at high pressure depths.

In operation, the shock hardened transducer will be described in a signaling mode. In view of the piezoelectric characteristic of some ceramics, namely barium titanate and lead-zirconate-titanate, a varying voltage, a.c. or pulsating d.c. in the order of 3,000 volts, when applied to electrodes 14 and 16 through conductors 18, will cause the ceramic element 11 to expand and contract or vibrate. (Conversely, when vibrated from an outside source the piezoelectric ceramic will produce electrical current). Although the ceramic ele-

ment 11 is prestressed by being tightly wound with a layer of fiberglass 12 to produce a compressive hoop stress and prestressed axially by the compression of stress nut 38, it will vibrate in both the cavity and ring radial modes. The axial and hoop prestress is just enough to prevent the ceramic from shattering due to tension forces set up within the ceramic when subjected to a high shock environment. The compliant rings 22 having teeth 24 permit compliance of the ceramic in expanding and contracting. Further, the thin collar 28, having slots 30 permits vibration of the ceramic element and readily transmits this vibration in to the chamber 34, which acts as an open-tube resonant cavity to further enhance the accoustic transmission. The potting compound 44 is resilient to readily vibrate and couple the ceramic vibration to the surrounding environment.

Obviously, many modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A shock hardened transducer for use as an underwater hydrophone comprising:

a tubular piezoelectric ceramic element;
an electrode deposited over each of the inner and outer cylindrical surfaces of said ceramic element;

wrap means tightly encompassing the outer cylindrical surface of said ceramic element for producing a compressive hoop prestress;

mounting means contacting the ends of said ceramic element for producing a compressive axial prestress, including

a base having a tubular collar with an externally

threaded end, and
a stress-nut engaging said threaded end;
compliant rings interposed between said mounting means and each end of said ceramic element; and

potting compound completely surrounding said ceramic element.

2. The shock hardened transducer of claim 1 wherein said wrap means comprises

a fiberglass filamentary thread coated with an adhesive, wound under tension on said ceramic element.

3. The shock hardened transducer of claim 2, wherein said compliant rings are further defined as a washer-shaped ring having a plurality of teeth projecting from one face thereof, said teeth contacting the ends of said ceramic element adjacent the inner and outer cylindrical surfaces.

4. The shock hardened transducer of claim 3 wherein

said compliant rings are composed of metal and an insulator ring is interposed between said compliant rings and the ends of said ceramic element.

5. The shock hardened transducer of claim 4 wherein

said piezoelectric ceramic element is composed of leadzirconate-titanate.

6. The shock hardened transducer of claim 4 wherein

said electrodes are a noble metal coated on the inner and outer cylindrical surfaces.

7. The shock hardened transducer of claim 4 further comprising

a resonant cavity formed within said tubular piezoelectric ceramic element.

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