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ACCELERATION CANCELLING HYDROPHONE

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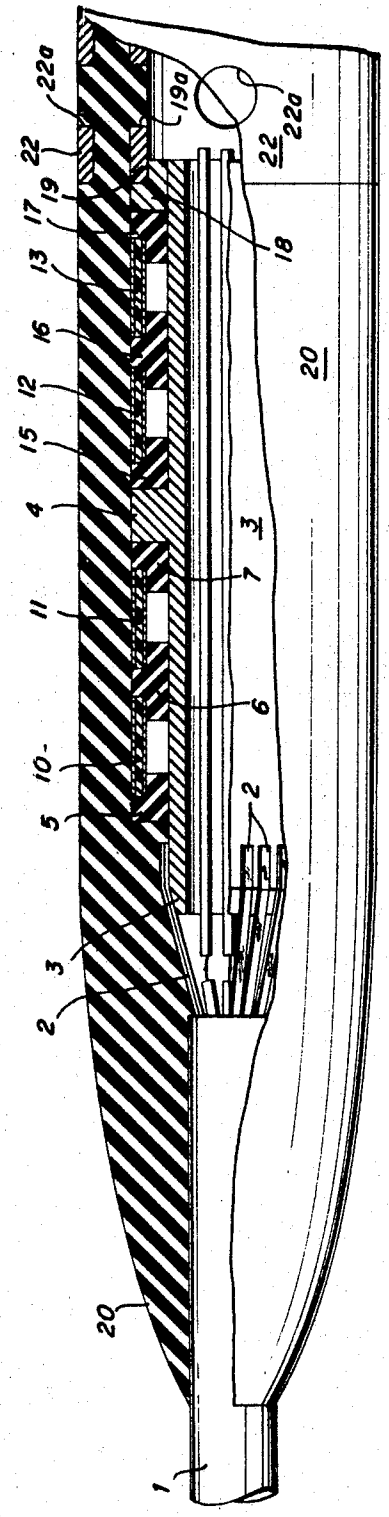


FIG. 1

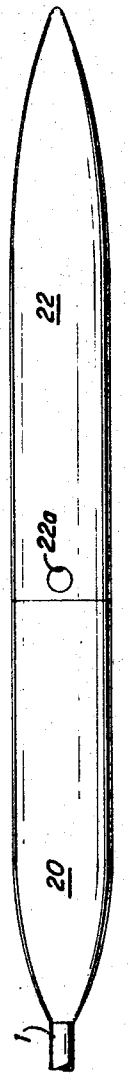


FIG. 2

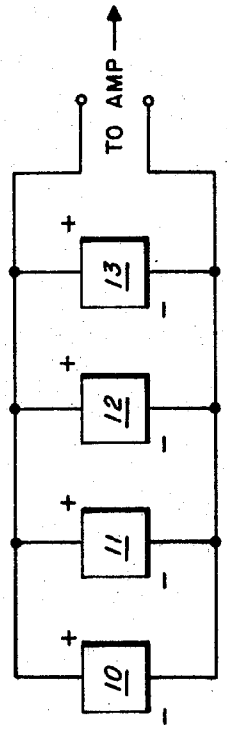


FIG. 3

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ACCELERATION CANCELLING HYDROPHONE

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U.S. Cl. 340—10 2 Claims

ABSTRACT OF THE DISCLOSURE

In a towed hydrophone, one piezoelectric element is compressed and another element is tensioned by acceleration in the direction of the towing cable. The voltages thus produced are out-of-phase and when added tend to cancel. Both elements, however, respond normally to the pressure waves producing in-phase voltages.

Statement of Government interest

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

Background

Underwater listening devices carried by a moving boat can be streamlined to minimize turbulence and local noise, but to remove the hydrophone from the machinery and propeller noises, long towing cables have been used to permit the hydrophone to travel astern. A second order effect now arises. A whipping motion appears in the cable and uncontrollable accelerations at the hydrophone occur. The resulting electrical noise can be many decibels above the level of the wanted signals.

The object of this invention is to provide an improved hydrophone.

A more specific object of this invention is to provide a hydrophone which is relatively insensitive to acceleration pressure in one direction while being quite sensitive to normal pressure waves of wanted signals.

Summary

The objects of this invention are obtained by so mounting two groups of piezoelectric elements that acceleration in one direction places one group in compression and the other group in tension. When the electrical terminals are all connected in parallel, the differential voltages tend to cancel while the normal pressure waves of wanted signals produce in-phase electrical signals.

Other objects and features of this invention will become apparent to those skilled in the art by referring to the preferred embodiment described in the following specification and shown in the accompanying drawing in which:

FIG. 1 is a elevational view of the hydrophone assembly embodying this invention,

FIG. 2 is a detailed, partly-sectioned view of the hydrophone of FIG. 1, and

FIG. 3 is a circuit diagram of the connections of the plural piezoelectric elements of FIG. 2.

The typical application of the hydrophone of this invention illustrated here is that where the hydrophone is mounted on the outer end of a long towing cable. In FIG. 2 the cable is shown at **1**, the end of which is terminated in the streamlined body **20** and **22**. Preferably, the sensitive piezoelectric elements are mounted in the forward compartment of the body at **20** whereas preamplifiers are mounted in the aft portion of the body **22**.

The towing cable **1** is preferably of the type comprising plural pairs of conductors enclosed in a woven steel

mesh or sheath. The whole being impregnated with rubber or rubber-like, water-tight coating.

The strands at the end of the steel portion of the sheath shown at **2** in FIG. 1 are unraveled and are joined by welding or brazing to the forward end of the metal spool **3**. The spool is machined from bronze or other non corrosive metal and is turned with an outwardly extending flange **4** intermediate the ends of the spool.

Two groups of piezoelectric elements are mounted on the spool. The first group comprising rings or cylinders **10** and **11** of polarized ceramics, such as barium titanate or lead zirconate, which are quite sensitive to pressure and produce voltages across metal electrodes deposited on the inner and outer surfaces of the rings. Piezoelectric elements **10** and **11** are larger in diameter than the spool **3** and are insulated and spaced therefrom by rubber rings **5**, **6**, and **7**. Each ring is fashioned with a shoulder to hold the rings **10** and **11** in concentric spaced relation. Fine wires, not shown, contact the electrodes deposited on the inner and outer electrodes and are conducted through the spool and hence, into the cable **1** at one end or if desired into an amplifier in the casing **22** at the other end.

The second group of piezoelectric elements **12** and **13** are in all respects like elements **10** and **11** and are also ring shaped and are supported on the right hand side or aft side of flange **4**. The rings **12** and **13** are spaced concentrically about the spool by insulating spacer rings **15**, **16** and **17**. Elements **12** and **13** likewise have deposited metal electrodes on the inner and outer surfaces and are connected by lead wires to the interior of the spool **3**.

As stated, the object of this invention is to cancel the voltages caused by lengthwise accelerations of the hydrophone, and to this end the two groups of piezo elements are, respectively, simultaneously compressed and tensioned to produce equal and opposite voltages. The magnitude of either voltage is a function of the distortion of piezoelectric elements which in turn is a function of the magnitude of acceleration and the magnitude of the mass opposing the acceleration. Assuming that positive-going and negative-going voltage changes at the element terminals are linear functions of compressional forces and tensional forces, then the mass forward of one element group should be approximately equal to the mass aft of the other group. These simple relationships will of course change when friction and mechanical impedances in the system are added. Without lessening the generality of this invention, it will be assumed that the principal force, because of acceleration, is applied at the forward and aft surfaces of flange **4**. The flange **4**, in FIG. 1, will push piezoelectric elements **10** and **11** and will pull elements **12** and **13**. In such an arrangement, the end-to-end elements **12** and **13** must be joined together and to the aft surface of flange **4**. Conveniently, elements **12** and **13** and spaces **15**, **16** and **17** may be bonded with a strong adhesive and the left spacer, **15**, glued to the flange.

Ring **18** is slipped onto the spool at the right hand end and is cemented to the collar **19** which in turn is attached to the casing **22** containing the amplifier.

In the specific embodiment shown, the spacers **5**, **6**, **7**, **15**, **16**, and **17** as well as collars **18** and **19** are preferably loosely or slip-fitted over the spool **3**. The entire assembly must be protected from sea water. To this end the assembly forward of the amplifier case **22**, is encased in a semi-soft jacket **20** of rubber-like material, such as neoprene which may be either precast or molded in place. The rear end of jacket **20** is cast around ring **19** and into openings **19***a* and **22***a* in the ring and casing **22**, to positively interlock the aft end of the jacket with the ring assembly **19**, and with the amplifier case **22**. Attachment between to case **22** and jacket **20** may be screw threads or adhesives. Now, the lengthwise distortions of the piezo-

electric elements, microscopic as they are, are restrained by the yieldability of material of the jacket **20** surrounding the assembly. Positive and negative pressure attributable to accelerations of mid-spool flange **4** are transmitted to greater or lesser degree depending on the hardness of the jacket.

In operation, a sudden acceleration from right to left of the assembly of FIGS. 1 and 2, produced by erratic whipping and yanks on cable **1**, pulls the flange **4** to the left with the same acceleration. Such acceleration presses flange **4** against the end of spacer **7** and tends to compress the piezoelectric rings **10** and **11**. The same movement of flange **4** pulls on spacer **15**, and tends to stretch the attached rings **12** and **13**. If compression of rings **10** and **11** produce an increased voltage across the electrodes, the tension of rings **12** and **13** produce a decreased voltage across the electrodes. With corresponding terminals of the electrodes connected in parallel as suggested in FIG. 3 the positive-going and negative-going voltages tend to cancel and the input to the amplifier receives little or no voltage caused by the acceleration.

Pressure waves orthogonal to the tow axis impinging upon the hydrophone **20**, however, produces the same distortions in all of the piezoelectric elements **10**, **11**, **12**, and **13**. Hence wanted signal voltages of all elements are added, thus, materially increasing the signal-to-noise ratio at the terminals of the hydrophone.

What is claimed is:

1. A hydrophone assembly comprising;

two groups of piezoelectric elements, each element having electrodes which produce a signal voltage when the body of the element is subjected to pressure from either of two orthogonal directions,

a spool, means connected to said spool to axially accelerate said spool in one of said orthogonal directions, a circumferential flange affixed to said spool intermediate the ends of said spool,

said elements comprising rings of piezoelectric material, said rings comprising said two groups, being slidably telescoped over opposite ends of said spool so that acceleration of said flange compresses the rings of one group while tensioning the rings of the other group,

the electrodes of said elements of both groups being connected to additively combine the signal voltages of all elements,

said two groups of elements being so disposed as to be similarly distorted by a pressure wave from the other of said orthogonal directions for producing wanted in-phase voltages, and to be differentially distorted by the acceleration pressure from the other of said directions for producing cancelling out-of-phase voltages.

2. The hydrophone assembly defined in claim **1** further comprising

spacers of insulating material attached to and yieldably supporting said rings concentrically about said spool so that compressing and tensioning pressures from said flange are transmitted, respectively, to said two groups.

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