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2,589,135

SUBMARINE SIGNALING DEVICE

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FIG. 1

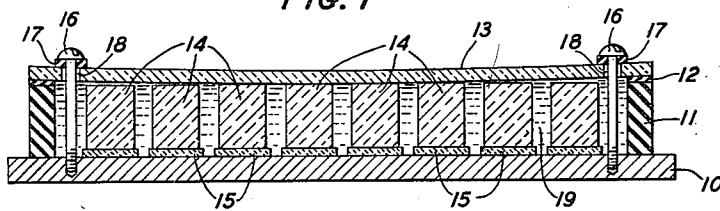


FIG. 2

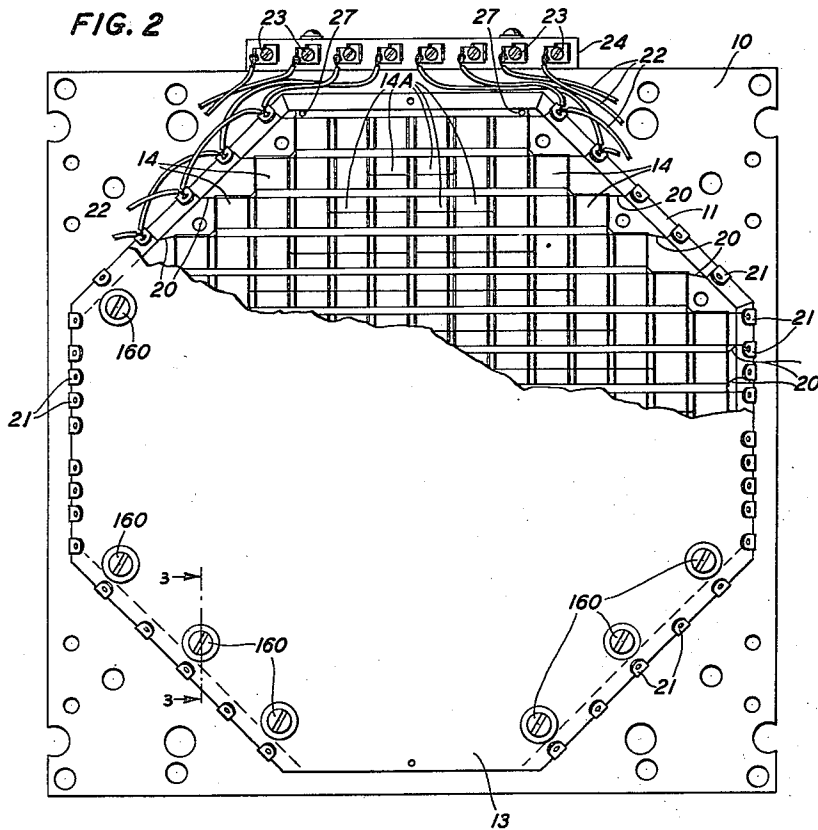
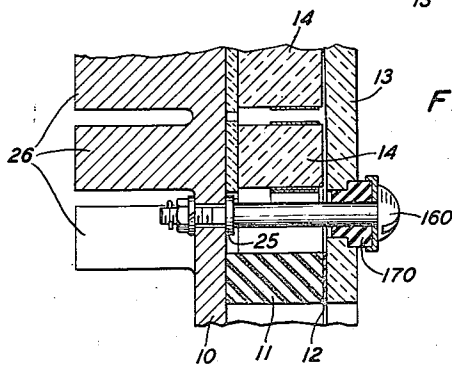


FIG. 3



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SUBMARINE SIGNALING DEVICE

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6 Claims. (Cl. 177—386)

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This invention relates to piezoelectric signal translating devices and more particularly to supersonic underwater signal transducers of the piezoelectric crystal type.

In one type of transducer utilized for the propagation and reception of supersonic underwater signals, a plurality of piezoelectric crystals are mounted between a support and a fixedly supported diaphragm and secured thereto, the space between the support and the diaphragm being filled with a medium having substantially the same characteristics as sea water for the transmission of supersonic compressional wave energy. In use such a transducer is subject to substantial variations in temperature.

It has been found that in such transducers, because of the temperature variations and particularly because of differences in the temperature coefficients of the diaphragm, crystals and the support, the crystals are subjected to sheer stresses frequently of sufficient magnitude to cause fracture of the crystals and, hence, to render the transducer inoperative.

One object of this invention is to substantially eliminate stresses due to temperature variations in piezoelectric transducers of the type comprising crystals mounted between a diaphragm and a support.

In accordance with one feature of this invention, in a transducer of the type above noted, the crystals, support therefor and diaphragm are cooperatively associated so that efficient transfer of energy between the diaphragm and crystals is assured and expansion and contraction of the diaphragm with temperature changes causes no deleterious stresses in the crystals.

More specifically, in accordance with one feature of the invention, the diaphragm is mounted in such manner that its abuts certain of the crystals and can expand and contract in the directions of its major dimensions without exerting substantial forces upon the crystals.

The invention and the above noted and other features thereof will be understood more clearly and fully from the following detailed description with reference to the accompanying drawing, in which:

Fig. 1 is a simplified sectional view of an underwater signal transducer illustrative of one embodiment of this invention;

Fig. 2 is a detailed face view of a transducer constructed in accordance with this invention, a portion of the diaphragm being broken away to show a number of the crystals; and

Fig. 3 is a fragmentary detail view in section along line 3—3 of Fig. 2.

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Referring now to the drawing, the transducer illustrated in Fig. 1 comprises a support or plate 10, for example of metal, such as steel, upon which a frame 11, for example of insulating material such as laminated phenolic is seated. Positioned upon the frame 11 is a thin, resilient, e. g. soft rubber, shim or washer 12. Seated upon the washer 12 is a diaphragm 13 which advantageously is of a polymerized methyl methacrylate, such as the plastics known commercially as "Lucite" and "Plexiglas," highly transparent to supersonic compressional wave energy.

A plurality of rectangular, longitudinally vibratile, piezoelectric crystal blocks 14, for example of 45-degree Y-cut ammonium dihydrogen phosphate, are mounted between the diaphragm 13 and support 10 and secured to the latter. Specifically, the crystal blocks 14 are cemented to ceramic wafers 15 which are cemented in turn to the support or plate 10.

A plurality of screws 16 having resilient, e. g. soft rubber, bushings or sealing washers 17 thereon extend through oversize apertures 18 in the diaphragm and are threaded into the support 10. The chamber in which the crystal blocks are enclosed is vented for filling and draining by small holes 27, and is filled with a medium, indicated at 19, such as deaerated castor oil, having substantially the same characteristics as sea water for the transmission of supersonic compressional wave energy.

In the assembly of the device, the frame 11 and the crystal blocks 14 are secured to the support or plate 10 and the free ends, i. e. the upper ends in Fig. 1, of the frame and blocks are lapped simultaneously so that they are accurately coplanar. Then the diaphragm 13 and washer 12 are mounted in position and the screws 16 are tightened. Inasmuch as the screws apply force to the diaphragm intermediate the center and periphery of the latter, the diaphragm bows, as indicated in Fig. 1, so that it engages the central crystal blocks. The washer 12 is made very thin of a preassigned thickness, e. g. of the order of 0.008 inch, so that when the screws 16 have been tightened, the maximum separation between the outermost crystals and the diaphragm is so small, e. g. of the order of 0.008 inch or less, that substantially no loss occurs in transmission of energy from these crystals to the diaphragm or vice versa. The high viscosity of the fluid 19 assures a stiff coupling between the diaphragm and the crystal surfaces in juxtaposition thereto.

Because of the resiliency of the washer 12

and the bushings 17, the diaphragm 13 may expand and contract with very little restraint, in all directions normal to its thickness. When it expands and contracts thus, free sliding of the diaphragm over the crystals with which it is in contact occurs. Consequently, expansion and contraction of the diaphragm with temperature variations causes no deleterious stresses in the crystals.

As indicated hereinabove, Fig. 1 of the drawing has been simplified, for ease of disclosure and illustration of the more essential principles and features of the invention. Figs. 2 and 3 show in some detail, a supersonic underwater signal transducer illustrative of one embodiment of this invention.

In the construction illustrated in Figs. 2 and 3, the crystal blocks 14 are arranged in horizontal and vertical parallel rows to constitute an octagonal array or blanket within an octagonal frame 11. The crystals may be graded as to power capacity, in ways known in the art, to assure a highly directional propagation and reception pattern for the array. For example, the inner crystals, some of which are designated as 14A in Fig. 2, may be composed of two similar slabs electrically in parallel and the outer crystals may be formed as single blocks. All of the crystals may be connected electrically in parallel by way of suitable leads 20 connected to terminals 21 mounted on the frame 11 and connected in turn, by conductors 22, to lugs 23 on a terminal block 24.

The diaphragm 13, in the form of an octagonal plate, is clamped in place by a plurality of bolts 160, which, as shown in Fig. 3, extend through the support or plate 10 and are provided with integral collars 25 which limit the extent to which the bolts can be tightened. The resilient bushings 170 are stepped and fitted in apertures in the diaphragm.

In a particularly advantageous construction, the crystal blocks 14 are made of height, i. e. the dimension normal to the support 10, equal to one-quarter wavelength in sea water of the intended operating frequency of the transducer, or of the mid-frequency in the intended operating frequency band. The support 10 has affixed thereto or integral therewith, resonator blocks 26, one in axial alignment with each crystal, also of length equal to one-quarter wavelength of the intended operating frequency or of the mid-frequency in the case of band frequency operation. Consequently, each crystal and associated resonator constitute a half wavelength longitudinal vibratile system having a vibrational antinode at the support 10 whereby maximum translating efficiency is realized.

The entire transducer may be mounted within a housing, such as disclosed in the application Serial No. 493,177, filed July 2, 1943, of Arthur C. Keller, now Patent 2,417,830, granted March 25, 1947, supported from a ship and having an extended window highly transparent to compressional wave energy, opposite the diaphragm 13.

Although a specific embodiment of the invention has been shown and described, it will be understood that it is but illustrative and that various modifications may be made therein without departing from the scope and spirit of this invention as defined in the appended claims.

What is claimed is:

1. A signal translating device comprising a support, a plurality of piezoelectric crystals each having one end secured to said support and vibratile normal to said support, the opposite ends

of said crystals being substantially coplanar, support means having a surface substantially coplanar with said opposite ends, resilient spacing means upon said surface, a diaphragm rigid in the direction parallel to said opposite ends, in juxtaposition to said opposite ends and having its peripheral portion seated upon said spacing means, resilient members engaging said diaphragm adjacent and inwardly of its periphery, and securing means engaging said resilient members and holding said diaphragm against said spacing means and in engagement with said opposite ends of certain of said crystals.

2. A signal translating device comprising a support, a plurality of piezoelectric crystal blocks each secured at one end to said support and vibratile normal thereto, a frame disposed about said blocks and having a seating surface, the other ends of said blocks being substantially coplanar with said seating surface, a thin resilient washer seated upon said surface, a diaphragm of stiff material seated upon said washer, and means holding said diaphragm against said washer and bowing it to engage said other ends of certain of said crystal blocks, said holding means having resilient connection to said diaphragm whereby said diaphragm may slide over said certain crystal blocks as it expands and contracts with temperature variations.

3. A signal translating device comprising a support, a plurality of piezoelectric crystal blocks seated upon said support, the ends of said blocks remote from said support being substantially coplanar, support means laterally beyond and disposed about said blocks, a diaphragm of material rigid in the direction parallel to said ends, seated upon said support means and in juxtaposition to said ends of said blocks, and means exerting force upon said diaphragm at regions inside of said support means to hold it against said support means and in engagement with said other ends of certain of said blocks, said force exerting means including resilient portions such that said diaphragm may slide over said certain blocks as it expands and contracts with temperature variations.

4. A signal translating device comprising a support, a plurality of piezoelectric blocks each seated at one end upon said support, the other ends of said blocks being substantially coplanar, support means disposed about said blocks and having a seating surface in a plane slightly beyond said other ends of said crystals, a stiff diaphragm seated upon said surface, resilient members engaging said diaphragm at regions inside of said support means, and means acting upon said diaphragm through said resilient members for bowing said diaphragm toward said blocks and into engagement with said other ends of certain of said blocks.

5. A signal translating device comprising a support, a frame on said support and having a seating surface, a thin resilient washer on said surface, a stiff diaphragm having the peripheral portion of one face seated upon said washer, resilient members engaging the opposite face of said diaphragm at regions inside of said frame, clamping means bearing against said resilient members for bowing said diaphragm toward said support, and a plurality of longitudinally vibratile crystal blocks within said frame and each having one end seated upon said support and its other end substantially coplanar with said seating surface.

6. A signal translating device comprising a support, a frame on said support and having a

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seating surface, a blanket of piezoelectric crystal blocks within said frame and vibratile normal to said support, each of said blocks having one end secured to said support and its opposite end substantially coplanar with said seating surface, 5 a thin resilient washer seated upon said surface, a plastic diaphragm seated upon said washer and defining a chamber with said frame and support, a fluid filling in said chamber, said diaphragm having a plurality of apertures therein 10 inside of said frame, resilient bushings seated in said apertures, and a plurality of screws extending through said bushings and coupled to said support, said screws holding said diaphragm upon said washer and bowing said diaphragm into engagement with certain of said blocks.

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