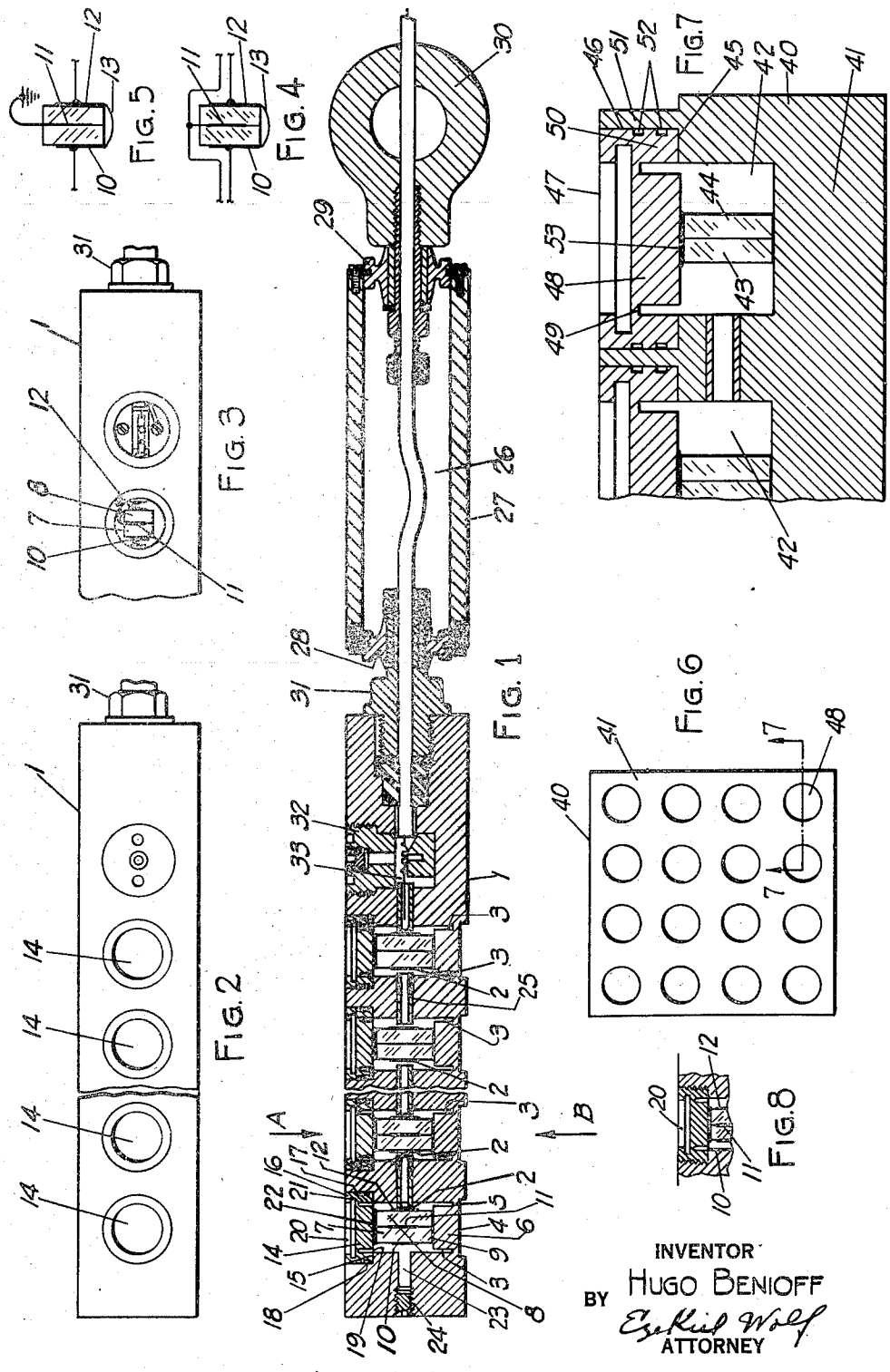
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PIEZOELECTRIC TRANSDUCER

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PIEZOELECTRIC TRANSDUCER

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The present invention relates to acoustic transmitting and listening apparatus and more particularly to apparatus for transmitting and receiving sound waves below and above audible frequencies over a very broad range in a water, liquid or other sound propagating medium.

The present invention is more specifically an improvement on my previously filed and copending United States application Serial No. 387,633, filed April 9, 1941. In this prior application the casing is made of two parts, one of which is a cover which forms the diaphragm with which the piezoelectric crystals come in contact at one end. In a slightly different construction the cover forms a closing member at the side of the casing in which the crystals are placed and secured in their proper position. The use of the cover at the side of the casing where it does not come in contact with any part of the piezoelectric crystal has certain advantages perhaps in replacement and assembly. However, this construction does not provide a symmetrical device and the joint of the cover with the diaphragm member may bring into play certain undesirable vibratory conditions. The use of a separate cover element is apt to weaken the structure of the casing at least to the extent of permitting a slight pressure release and undesirable vibrations of the unsupported side edge of the cover member or casing, particularly in such structures where the unit is very long as in the present case. On the other hand, using an elongated diaphragm as the cover of the unit also has certain constructional disadvantages which at times increases the cost of the apparatus. Longitudinal vibrations of the diaphragm may be present and similar union for all crystals with the diaphragm may be difficult to obtain.

The applicant in the present case is particularly interested in making a piezoelectric vibrator of the general type set forth in the above-described copending application which could be simply and easily made, quickly assembled and which even under production methods would provide improved apparatus in comparison to the prior types of construction.

In the present invention there is used preferably an elongated bar or block of the desired size to provide the main structural element for the device. This elongated block or bar is drilled with a number of cavities to provide chambers for the piezoelectric crystal members. A single bore longitudinally of the bar passes through each chamber and provides the means for making electrical connections to the crystal elements

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in each cavity. The cavities formed in the bar are covered by block members which either are threaded into the walls of the cavities or which otherwise fit snugly and seal the openings in the bar. On their inner surfaces the block members are cemented to the crystal ends in order to conduct the acoustic pressure from the water to the piezoelectric crystals. The use of individual plug members in solid bars, each small and acting independently on its own crystal element, provides an important advantage in having a minimum pressure release. These means, together with other features embodied in the present construction, furnish the principal advantages of the present invention over constructions of the prior art.

The invention will be more fully understood when taken in connection with the drawing describing an embodiment of the same in which Fig. 1 shows a transverse broken section through the unit longitudinally, as the unit may be very long, for instance, five or six feet long or even more; Fig. 2 shows a plan view of the device shown in Fig. 1; Fig. 3 shows a detail view of Fig. 2 with the end-cover plug removed; Figs. 4 and 5 show details of electrical connections; Fig. 6 shows a modified form of the invention indicated in Figs. 1 and 2; Fig. 7 shows a section substantially on the line 7—7 of Fig. 6; and Fig. 8 shows a modification of a detail of Fig. 1.

In Fig. 1, 1 represents an elongated bar having the height dimension as shown by the section width in Fig. 1 and width dimension as shown by the width in Fig. 2. It will be noted that this bar, which has a substantially square cross section, has formed therein a plurality of substantially cylindrical cavities 2, 2, 2, 2 uniformly positioned and spaced apart from each other distances substantially less than the wave length corresponding to the lower end of the band of frequencies desired to be received. These cylindrical cavities have annular recesses 3 formed at their bases and extending substantially to the back surface of the bar which is undercut forming a shallow cylindrical recess, as indicated at 4, for protection of the crystal against fracture. The thin web 5 provides a compliance such that the rigid member 6 formed by this construction conducts the pressure of the waves in either direction to or from the medium.

Piezoelectric crystals 7 and 8 are cemented to the surface 9 of this base member 6. These crystals are so cut that for compressional waves producing changes in length a corresponding potential is produced between the electrodes on the

side surfaces of the crystals. Thus, for waves approaching in the direction of the arrows A and B, as indicated in Fig. 1, electrical potentials are developed transversely between the electrodes 10 and 11, and 11 and 12. As indicated in Figs. 4 and 5, the electrode 11 is a common electrode for both crystals 7 and 8, whereas the electrodes 10 and 12 are connected together by means of the conductors 13. The two crystals, therefore, are connected in parallel, although they may be connected in series or series parallel. The crystals are first cemented to the base member 6, and then the plug member 14 is inserted in the end of the cavity 2 with a clearance between crystal and plug of .015 inch, which clearance is filled with cement bonding the crystal ends to the inner surface of the plug. The open end of the cavity 2 is enlarged by the shoulder 15 so that the plug 14 which is provided with a heavy flange 16 and two undercut rings 17 and 18 may be securely cemented to the side walls of the cavity in the shoulder portion. Cement placed between the outer surface of the heavy ring 16 and the inside wall of the shoulder of the cavity 2 fills up the grooves 17 and 18 and cements the plugs firmly in place. As indicated in Fig. 8, however, the plug 14 may be screwed in the opening, in which case the threads are filled with cement which seals the plug to the wall of the cavity. The plug 14 has a shape similar to that of the corresponding member at the closed end of the chamber or cavity, namely, it comprises a central rigid member having an edge compliance in the form of an annular web formed by the annular groove 19 between the center mass and the ring 15. The outer end of the plug member has formed in its surface a shallow cylindrical cavity 20 with an inwardly extending groove 21 at its base by means of which with a proper tool the plug may be raised after it has once been cemented in place. On the inner face of the plug 14 there is provided a heavy layer of cement 22 which may be of the order of eight to ten thousandths of an inch thick, and as the plug is put down in position, this cement makes contact with the upper ends of the crystals and provides a secure bond between the surface of the plug and the ends of the crystals.

The electrical connections are made through the bore 23 which may be plugged at one end by the plug 24. This bore may, if desired, be lined with an insulating member 25 throughout its whole length. Connections are made as indicated in Figs. 4 and 5 either by grounding the central electrode and using a single wire cable looping from one external electrode to the other around the crystals, as indicated in Fig. 5, or the system may be constructed as a two-wire system, as indicated in Fig. 4, in which both conductors are drawn through the entire unit.

A simple method of wiring the device which has been used is to provide the electrodes of the crystals with long connecting members. The connecting wire of one electrode is then threaded through the channel and twisted together with the connecting wire from the electrode of the crystal in that recess. These leads may then be soldered together, cut off and then pushed down into the recess at the sides of the crystals. This is done before the plug to which the crystal is ultimately cemented is put in place so that the mechanic will have sufficient opportunity to see that the job is done properly before the recess is finally closed.

A special cable connecting member 26, as indicated to the right of Fig. 1, is provided for the

structure. This comprises a casing 27 which is hollow inside and which at each end has two watertight end plugs 28 and 29. At one end of the cable connecting member 26 there may be provided a supporting eyelet 30 where the supporting cable is attached for supporting the whole unit, while at the other end there is a connecting member 31 effecting a watertight coupling between the cable member and the receiving unit itself.

In the operation of the receiver the whole unit may be immersed in water with both the front and back faces exposed for receiving sound through the water medium. If vertically suspended, the unit will be directive substantially in a horizontal plane, and if horizontally supported, the unit will be directive in a vertical plane normal to the direction of the unit itself. The unit, as shown in the drawing, is particularly adaptable for the transmission and reception of sonic and also of supersonic vibrations. Connecting terminals may be changed or effected at the connecting plug 32 which closes the well 33, housing the terminal connections for the cable.

In the arrangement shown in Figs. 1 to 5, the main portion of the casing, the cylindrical depression in the plugs and the corresponding depression on the opposite surface of the casing serve to protect the diaphragms and the crystals within the casing in event that the unit may be dropped upon the deck of a vessel or upon the ground against direct contact and pressure.

In the arrangement shown in Figs. 6 and 7, the casing 40 is composed of a heavy back member 41 in which recesses 42, 42 are bored to receive the piezoelectric crystal units 43 and 44. The well 42 is provided with an annular shoulder 45 forming an enlarged cylindrical chamber 46 in which the top plug 47 is placed. This plug is formed similarly to the plug described in connection with Fig. 1 and comprises a comparatively central large mass member 48 which is substantially rigid and which is surrounded by a thin flange 49 joining the member 48 to the heavy rim 50 which is cemented in the shoulder 45 and the cylindrical wall 46 to the casing 51. The heavy rim 50 is provided with cut grooves 52, similarly as in Fig. 1, which are filled with cement and which furnish added sealing strength of the plug to the walls of the casing. On the inside surface of the heavy member 48 there is a thick layer of cement 53 which unites the top edge of the crystal with the surface of the central section 48. The plate 41 which may have the shape shown in Fig. 6 may contain a great number of recesses each constructed and filled as described in connection with Fig. 7. The spacing apart of each unit from the other should be less than a wave length corresponding to the high frequency end of the band desired to be received.

In the unit shown in Fig. 1, sound waves will act upon both the back and the front side of the unit since the width of the unit is presumed to be less than a wave length of the sound wave to be received. In the apparatus shown in Figs. 6 and 7, however, the area of the unit has linear dimensions which may be large as compared to the wave length of the sound to be received so that the pressure on the back of the casing will for the most part be different from that on the front of the casing. In order to take advantage of the reception at one side and eliminate the out-of-phase component at the back of the casing, the back of the casing is made heavy so that it will furnish a pressure surface against which the

crystal and the vibrating front diaphragm can act.

Having now described my invention, I claim:

1. A piezoelectric wave transducer comprising a substantially rigid casing member having an open recess formed therein, a piezoelectric crystal having opposing end surfaces on which pressure variations are adapted to act for producing electrical potentials between electrodes positioned on surfaces on the sides of the crystal, and vice versa, one of said end surfaces being cemented to the bottom wall of said recess, a plug member formed with a central rigid section, a thin annular compliance web and a heavy rim, said rim element fitting the open end of said recess and being cemented therein, the under surface of said rigid section being joined to the other compressional end of said crystal by a layer of cement.

2. A piezoelectric wave transducer comprising a substantially rigid casing member having an open recess formed therein, a piezoelectric crystal having opposing end surfaces on which pressure variations are adapted to act for producing electrical potentials between electrodes positioned on surfaces on the sides of the crystal, and vice versa, one of said end surfaces being cemented to the bottom wall of said recess, a plug member formed with a central rigid section, a thin annular compliance web and a heavy rim, said rim element fitting the open end of said recess and being cemented therein, the under surface of said rigid section being joined to the other compressional end of said crystal by a layer of cement, said plug member in its outer ring being provided with annular grooves adapted to be filled with cement in cementing said plug in the open end of said recess.

3. A piezoelectric wave transducer comprising a substantially rigid casing member having an open recess formed therein, the bottom of said recess being provided with a heavy central section surrounded by a thin annular compliance web providing a substantially rigid compressional wave receiving surface, a piezoelectric crystal having opposing end surfaces on which pressure variations are adapted to act for producing electrical potentials between electrodes positioned on surfaces on the sides of the crystal, and vice versa, said crystal being mounted with one of said ends resting on said central section and cemented thereto, a plug member having a similar central section with a rim section fitting into the open end of said recess and cemented therein and acoustic coupling means joining the inner central surface of said plug member to the other of said compressional end surfaces of said crystals.

4. A piezoelectric wave transducer comprising a substantially rigid casing member having an open recess formed therein, the bottom of said recess being provided with a heavy central section surrounded by a thin annular compliance web providing a substantially rigid compressional wave receiving surface, a piezoelectric crystal having opposing end surfaces on which pressure variations are adapted to act for producing electrical potentials between electrodes positioned on surfaces on the sides of the crystal, and vice versa, said crystal being mounted with one of said ends resting on said central section and cemented thereto, a plug member having a similar central section with a rim section fitting into the open end of said recess and cemented therein and acoustic coupling means joining the inner central surface of said plug member to the other of said compressional end surfaces of said crystal, comprising a layer of cement positioned between the inner surface of said plug and the compressional end surface of said crystal.

5. A piezoelectric wave transducer comprising an elongated solid bar member having a great number of recesses formed therein closely spaced from each other, substantially along the whole length of said bar with a continuous channel extending from each recess to the next for providing electrical connection, piezoelectric crystal elements positioned in each of said recesses having electrical connecting elements extending through said channel to adjoining recesses and individual plug members sealing the open ends of said recesses and being joined on their inner surfaces by a layer of cement to the ends of said crystals.

6. A piezoelectric wave transducer comprising an elongated solid bar member having a great number of recesses formed therein closely spaced from each other, substantially along the whole length of said bar with a continuous channel extending from each recess to the next for providing electrical connection, piezoelectric crystal elements positioned in each of said recesses having electrical connecting elements extending through said channel to adjoining recesses, individual plug members sealing the open end of said recesses and being joined on their inner surfaces by a layer of cement to the ends of said crystals, said plug members comprising a central heavy section having the inner surface covered with the layer of cement by which the crystal is connected, an annular thin compliance ring, and a heavy joining annular flange with a sealing means sealing the plug in the bar.

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