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F. NESH

3,167,668

PIEZOELECTRIC TRANSDUCERS

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Fig. 1.

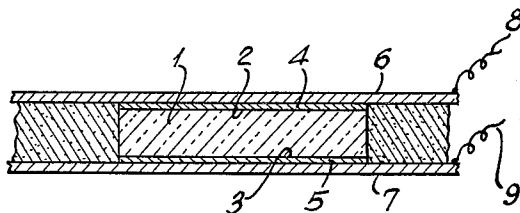


Fig. 2.

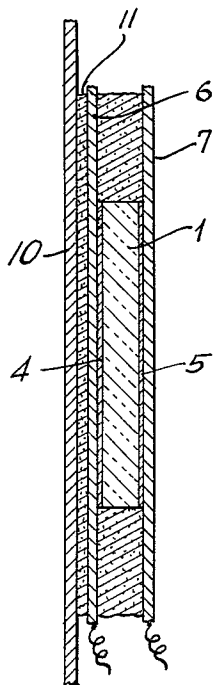
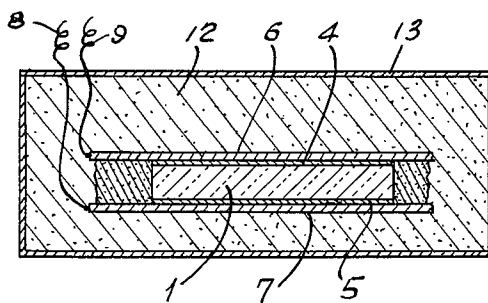


Fig. 3.



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PIEZOELECTRIC TRANSDUCERS

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11 Claims. (Cl. 310-9.7)

(Granted under Title 35, U.S. Code (1952), sec. 266)

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.

This invention relates to piezoelectric transducers, and particularly to those useful when submerged in or in contact with a liquid such as water.

In working with transducer mountings, where the conductor leads were soldered or cemented directly to the conductive coatings or electrodes, I discovered that the efficiency of transmission dropped very rapidly in use. Apparently, the coatings did not remain undisturbed and the contact broke or developed flaws. Use of a metal plate pressed directly against an uncoated piezoelectric crystal or body did not give a good contact with the crystal or body and transmission was poor. The use of an adhesive or cement between the piezoelectric crystal and the plates introduced a change in medium with new interfaces and also cut down on the efficiency of transmission.

Objects of this invention are to provide an improved piezoelectric transducer, in which the speed of transmission in use will remain approximately unchanged and be very efficient, which can be easily handled without disturbing the parts, even with rough usage, which can be put into or attached to any system, which is heat resistant and operative at higher temperatures than were usual heretofore, which stands up well under mechanical stress, which can be immersed and used in or in contact with most liquids, and which is relatively simple, compact and inexpensive in construction and easily made.

Another object is to provide an improved, simple, inexpensive, efficient, durable and practical device for converting vibrations of a wall into electric currents or vice versa for converting electric currents into vibrations of a wall, which will successfully withstand rough handling and exposure to most liquids.

Other objects and advantages will appear from the following description of several examples of the invention and the novel features will be particularly pointed out in connection with the appended claims.

In the accompanying drawing:

FIG. 1 is a sectional elevation of a piezoelectric transducer embodying the invention;

FIG. 2 is a sectional elevation of such a transducer as applied to a vibratile wall; and

FIG. 3 is a sectional elevational of such a transducer fully enclosed or encased.

In the embodiment of the invention illustrated in FIG. 1, a body 1 of piezoelectric material of any desired lateral shape has, on two of its opposite faces 2 and 3, electroded or electrically conducting coatings or layers 4 and 5 respectively which are preferably coextensive in surface areas with the two faces 2 and 3. An individual, thin, metal plate 6 or 7 is disposed face to face against each such electroded face, coating or layer 4 or 5 and extending beyond all of the marginal edges of the piezoelectric body, so as to overhang the edges of such body. The space between the overhanging margins of the plates, i.e., the portions of the plates which extend outwardly away from the marginal edge of the piezoelectric body, is filled with a non-conducting adhesive or cement, preferably an epoxy resin type of cement, which bonds together the marginal areas of the plates to prevent their separation, and also bonds such marginal areas of the plates to the circumfer-

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ence of the piezoelectric body which is between the plates. This resin and the metal plates provide a moisture impervious seal enclosing the piezoelectric body and the plates are confined firmly against the conducting layers on the faces of the piezoelectric body. Individual conductor leads 8 and 9 are connected to the plates 6 and 7 and extend away from the plates for inclusion in a utilization circuit.

The conducting layers, coatings or electrodes on the opposite faces of the piezoelectric body are applied in any suitable manner, including the manner commonly used in piezoelectric transducers. Since the particular manner in which the electrode layers or films are applied to the piezoelectric body are old in the art and is not material to the present invention, no particular description of such film or layer applying procedure is given. The piezoelectric material may be any of the materials that have piezoelectric properties, examples of which are quartz, tourmaline, barium titanate ceramics which can be molded to the desired shape and size and hardened, lead zirconate titanate, and mixtures containing barium titanate and lead zirconate ceramics. The piezoelectric ceramics containing lead zirconate operate successfully at temperatures much higher than those at which barium titanate bodies can operate successfully and also at much higher efficiency (such as 90%) than transducers using barium titanate alone where the efficiency is about 70%. The lead zirconate type of piezoelectric material provides a transducer which has flat tuning characteristics, which reduce the necessity for close frequency control of the generator, and which also has the ability to accept and convert high electrical input power to mechanical energy.

In the embodiment of the invention illustrated in FIG. 2, the transducer, as illustrated in FIG. 1 and described above, has one of the outside or exposed faces of one of the plates 6 or 7 disposed face to face against a vibratile wall 10 and secured firmly thereto such as by an interposed layer 11 of cement, preferably an epoxy type of cement. The transducer when affixed to wall 10 is useful to convert vibrations of wall 10 into electric currents, or vice versa to convert electric currents into vibrations of the wall 10.

In the embodiment of the invention illustrated in FIG. 3, the transducer, as illustrated in FIG. 1 and described above, is embedded in the interior of a body 12 of an epoxy type resin such as is used to fill the space between the overhanging margins of the plates 6 and 7, and the body 12 containing the transducer enclosed in a container 13, or enclosure of any suitable material such as plastic, metal, rubber and the like, with the conductor leads 8 and 9 extending out of the container for connection to a utilization circuit, not shown.

Use of a metal plate directly on a metal coating according to this invention keeps the speed of transmission approximately the same, and the sealing effect of the resin between the plates outside of the piezoelectric body or crystal keeps the plates tightly clamped on the electroded faces or coatings on the piezoelectric body or crystal, and permits nothing extraneous, such as air, water, oil, dust, etc., to seep in between the surfaces of the body or crystal and the coatings and plates. This type of mounting has proved to give a very efficient transmission. It is simple, cheap and easy to make, but care is required in pouring the epoxy resin cement to avoid inclusion therein of air bubbles or cells. Once the transducer has been completed, it is permanent, can be easily handled without the parts thereof, and included in or attached to any system for use. It is heat resistant, stands up well under mechanical stress, and can be used in contact with or immersed in most liquids. If one desires to remove the piezoelectric body or crystal for another purpose, the epoxy resin can be dissolved out with a suitable solvent, available on the market, such as for example by a RCM

resin solvent made by Resin Consultants and Manufacturing Company of New York City.

In this transducer as with others, the piezoelectric body is polarized in the manner common in the art before use.

It will be understood that various changes in the details, materials, and arrangements of parts, which have been herein described and illustrated in order to explain the nature of the invention, may be made by those skilled in the art within the principle and scope of the invention as expressed in the appended claims.

I claim:

1. A piezoelectric transducer which comprises a polarized piezoelectric body having metal electroded opposite faces, a separate metal plate abutting in direct face to face contact with each said electroded face and extending beyond the margins of said body between said plates, a non-conducting adhesive interposed between and filling the space between said plates along the margins of said plates, entirely around and in contact with said body, bonding said plates together and to said body, with the adhesive completely covering and protecting the surface of that part of said body between said plates, and an individual conductor lead connected directly to each of said plates.

2. A piezoelectric transducer which comprises a body of piezoelectric material having electroded conducting layers on opposite faces thereof, an individual metal plate disposed face to face directly against each said layer and overhanging the entire margins of said layers and said body, a non-conducting adhesive resinous material interposed between and filling the space between said overhanging margins of said plates, and bonding together said plates, and with the plates completely enclosing and sealing said body, and an individual conductor lead connected directly to each of said plates.

3. The transducer according to claim 2, wherein said resinous material is an epoxy type of cement.

4. A piezoelectric transducer which comprises a body of piezoelectric material containing lead zirconate titanate having electroded conducting layers on two opposite faces thereof, an individual thin, impervious metal plate disposed face to face against each said layer in substantially full contact therewith, a non-conducting resinous material bonded to and joining the marginal areas of said plates and covering the edge surfaces of said body between said plates, to provide a water impervious seal for said edge surfaces of said body, and an individual conductor lead connected directly to each of said plates.

5. A piezoelectric transducer which comprises a body of piezoelectric material having electroded conducting layers on two opposite faces thereof, an individual metal plate disposed face to face against each said layer in substantially full contact therewith, a non-conducting resinous material bonded to and joining the marginal areas of said plates and covering the edge surfaces of said body between said plates, to provide a water impervious seal for said edge surfaces of said body, and an individual conductor lead connected directly to each of said plates.

6. A piezoelectric transducer which comprises a body of piezoelectric material having electroded conducting layers on two opposite faces thereof, an individual metal plate disposed face to face against each said layer in substantially full contact therewith, an epoxy resinous ce-

ment bonded to and joining the marginal areas of said plates and covering the edge surfaces of said body between said plates, to provide a water impervious seal for said edge surfaces of said body, and an individual conductor lead connected directly to each of said plates.

7. The transducer according to claim 6 wherein said cement is substantially free of air bubbles.

8. A piezoelectric transducer which comprises a body of piezoelectric material having on two opposite faces thereof electroded conducting layers which are approximately coextensive with such faces, an individual metal plate disposed face to face against the outside face surface of each such layer in substantially full contact therewith, each such plate extending in all directions beyond the borders of said layers, an epoxy type of cement filling the space between the marginal areas of said plates, covering the circumferential edge surfaces of said body which are between said plates, and bonded to said plates to provide, with said plates, a water impervious enclosure for said body, and an individual conducting lead connected directly to each of said plates and extending outwardly therefrom.

9. A device for selectively converting vibrations of a wall into electric currents or electric currents into vibrations of a wall, which comprises said wall, a piezoelectric transducer having a body of piezoelectric material with electrically conducting layers on two of its opposite faces thereof, an individual metal plate disposed face to face against the outside face surface of each such layer in substantially full contact therewith, an epoxy type resinous cement bonded to and joining the marginal edge portions of said plates on the plate faces towards one another and encircling and engaging the periphery of said body in the portion between said plates, one of said plates being bonded face to face to said wall by an adhesive cement interposed between them, and an individual conductor lead connected directly to each of said plates.

10. The device according to claim 9, wherein said adhesive cement is an epoxy type cement.

11. A piezoelectric transducer comprising a body of piezoelectric material having on each of two of its opposite faces an individual, electrically conducting layer, an individual metal plate extending beyond all of the marginal edges of said body disposed face to face against the outside surface of each such layer in substantially full contact therewith, an enclosure in which said body with said plates is placed, an epoxy resin type of cement filling the balance of said enclosure, bonding said plates together, and encircling the circumferential edge surface of said body in the portion between said plates, and with said plates sealing said body from moisture, and an individual conductor lead connected directly to each of said plates and extending out of said enclosure.

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