

July 4, 1944.

H. B. SHAPIRO

2,353,089

TRANSDUCER

Filed March 26, 1942

2 Sheets-Sheet 1

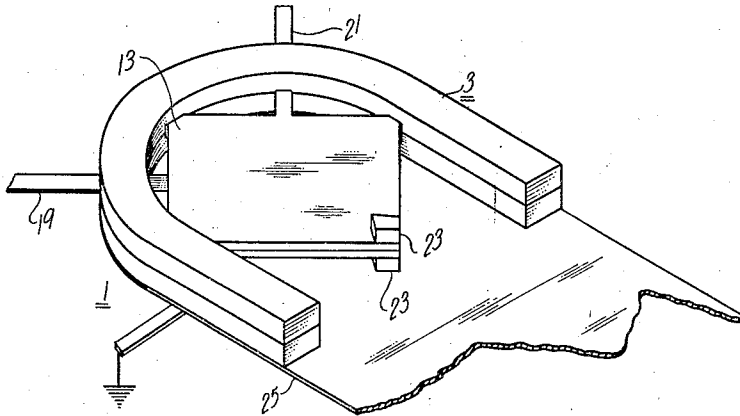


FIG. 1

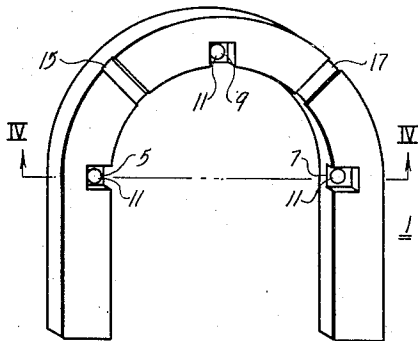


FIG. 2

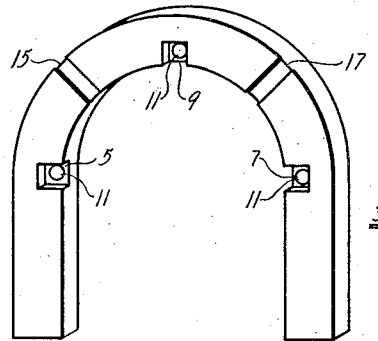


FIG. 3

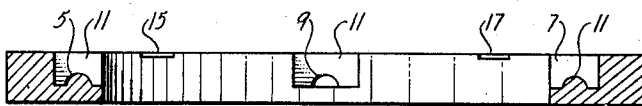


FIG. 4

INVENTOR.
HARRY B. SHAPIRO

BY
J. R. Goldborough

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H. B. SHAPIRO

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2 Sheets-Sheet 2.

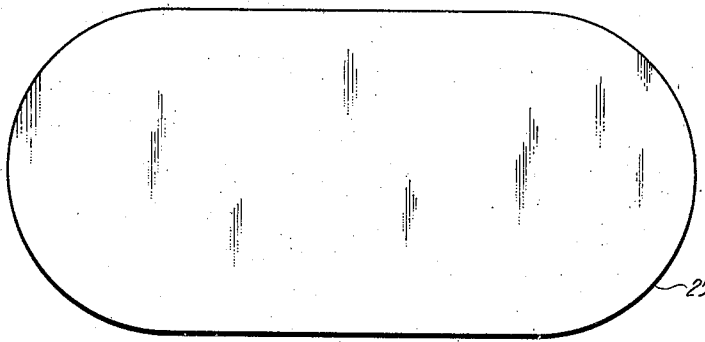


FIG. 5

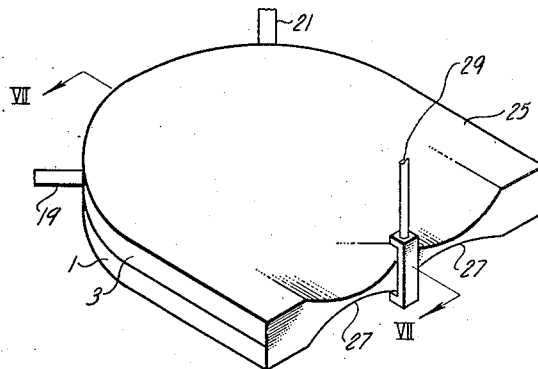


FIG. 6

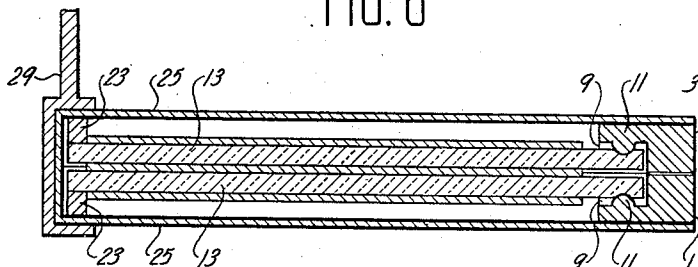


FIG. 7

INVENTOR.
HARRY B. SHAPIRO

BY
J. R. Goldborough

UNITED STATES PATENT OFFICE

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TRANSDUCER

Harry B. Shapiro, Willoughby, Ohio, assignor to
The Brush Development Company, Cleveland,
Ohio, a corporation of Ohio

Application March 26, 1942, Serial No. 436,230

18 Claims. (Cl. 171—327)

This invention relates to transducers and, more particularly to transducers of the type wherein a piezo-electric element is utilized for converting electrical energy into mechanical movements or mechanical stresses into electrical potentials.

Transducers of the general type to which this invention pertains are exemplified by the Sawyer Reissue Patent 20,680 and by the Williams Patent 2,222,056.

It is an object of the invention to provide housing means, for piezoelectric units, that shall be waterproof, sturdy and capable of resisting rough handling in use.

Another object of this invention is to provide piezoelectric crystal unit housing means that shall require the minimum number of separate parts.

Another object of the invention is to provide housing means, of the type described, that shall be substantially unaffected by changes in barometric pressure.

Another object of the invention is to provide hermetically sealed housing means, of the type described, such that mechanical movement may be transmitted to or from a crystal element contained therein without the necessity of resorting to sealing means for the drive rod such as are disclosed in the Williams patent.

Another object of the invention is to provide a sealed piezoelectric unit cartridge that may be utilized as a replacement part in apparatus such as phonograph pickups, loud speakers, microphones, oscillographs and the like.

Another object of the invention is to provide electrostatically shielded housing means of the type described.

Another object of the invention is to provide housing means, of the type described, capable of accommodating piezoelectric "Bimorphs" that vary slightly in thickness.

A still further object of the invention is to provide housing means, of the type described, that shall firmly hold a piezoelectric "Bimorph" in fixed position yet shall impose minimum restraint upon vibratory movement thereof.

In a preferred embodiment of the invention, the housing takes the form of a U-shaped, rigid frame, hermetically sealed by a cover-sheet of metal foil that is folded around the open end of the frame and cemented to its opposite faces. A rectangular piezoelectric "Bimorph" is mounted within the frame with its faces parallel to the foil cover-sheet, three corners of the crystal element being clamped to the inner walls of the frame and the free corner extending toward the spaced-apart arms thereof.

The phrase "U-shaped" has been chosen merely for purposes of convenience in describing the frame. It is to be understood that such phrase is intended to embrace all three-sided and/or open ended frames, irrespective of their contour, and whether or not the arms thereof converge, diverge or are parallel.

For the purpose of transmitting movement to or from the free corner of the "Bimorph," small driving pads of semi-resilient or non-resilient material, such as hard rubber, "Bakelite" or the like, are affixed, respectively, to the opposite surfaces of the said corner, which pads contact the inner surface of the cover-sheet. The free corner, therefore, may be clamped, through the covering, to an appropriate motion-transmitting mechanism, such as a rod or a stylus holder, without disturbing the continuity of the cover-sheet or breaking the hermetic seal afforded thereby.

The fold of the cover-sheet, between the drive pads and the adjacent ends of the U-shaped frame, may be crimped flat to reduce its stiffness.

The novel features characteristic of the invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and its method of operation, together with additional objects and advantages thereof, will be understood best from the following description of a specific embodiment, when read in connection with the accompanying drawings, in which:

Figure 1 is a view in perspective of a piezoelectric cartridge constructed according to the invention, the metal foil covering having been removed from one face thereof;

Figures 2 and 3 are views in perspective of the complementary U-shaped constituents of the housing frame;

Figure 4 is a vertical cross-sectional view of a frame element taken along a line corresponding to the line IV—IV in Figure 2;

Figure 5 is a plan view of a metal foil cover-sheet;

Figure 6 is a view in perspective of a piezoelectric cartridge, constructed according to the invention, exemplifying the mode of applying mechanical force to, or deriving mechanical movement from the crystal unit, and

Figure 7 is a vertical cross-sectional view of the device, taken along a line corresponding to the line VII—VII in Figure 6.

In all figures of the drawings, identical elements are similarly designated.

Referring now to Figures 1, 2, and 3 of the drawings a preferred embodiment of the inven-

tion comprises a U-shaped housing constituted by two U-shaped elements designated generally by the numerals 1 and 3 disposed in matching contact throughout their extent, the contacting faces of the said elements, respectively, being provided with three complementary half-notches 5, 7 and 9. The half-notches 5 and 7 are formed in the inner walls of the arms of the U-shaped elements and the half-notch 9 is formed in the closed end thereof. Projecting upward from the base of each half-notch is a small hemispherical protuberance 11. These protuberances will be referred to hereinafter and their function explained in more detail.

The half-notches, when mated, are adapted to provide gripping sockets for the salient corners of a rectangular piezoelectric unit 13 which, in Figure 1, is disclosed as being a "Bimorph" of the twister type such as is described in the Sawyer Relssue Patent 20,680. As is well-known to those skilled in the art, if three corners of a twister "Bimorph" are held firmly by a mounting device, such as is shown in Figure 1, and potentials are applied to the central and outer electrodes affixed to the faces thereof, the free corner of the "Bimorph" will flex, the direction of the bending being determined by the polarity of the applied potential.

Referring specifically to Figures 2 and 3, each of the U-shaped elements is provided with a pair of complementary channels 15 and 17 which, when the elements are mated, provide passageways for the leads 19 and 21 extending from the "Bimorph" electrodes.

In the process of assembly of the improved piezoelectric unit cartridge three of the corners of a "Bimorph" are inserted, respectively, into the half-notches of one of the U-shaped elements and the leads therefrom are placed in the transverse channels 15 and 17. Thereafter, a coating of water-proof cement is applied to the face of the U-shaped element and the mating element is superimposed thereon and pressed firmly into contact therewith. A jig or the like may be employed to hold the elements in engagement until the cement has firmly set.

Because of pressure exerted by the jig during the assembly process, the small protuberances 11 rising from the floors, respectively, of the several half-notches are forced to a greater or less extent below the surfaces of the corner of the "Bimorph" in contact therewith. Should the "Bimorph" vary slightly in thickness from a predetermined standard such variation will be compensated by greater or less penetration of the protuberances into the faces of the corners. The framework, therefore, is capable of accommodating crystals having slight variation in their thickness while, at the same time, the three corners of the crystal are gripped firmly in the sockets constituted by the mating half-notches.

At this stage of the assembly or prior thereto, if desirable, a small block 23 of material such as "Bakelite," hard rubber, Celluloid or the like is affixed to each face of the free corner of the "Bimorph" the planes of the free ends of the blocks, respectively, lying approximately in the planes of the outer faces of the assembled frame. As will hereinafter be explained, these blocks form links in a chain of mechanism whereby motion may be transmitted to the free corner of the "Bimorph" or from the free corner thereof to the exterior of the cartridge.

One end of a sheet 25 of metal foil, such as is shown in Figure 5 of the drawings, is next ce-

mented tautly to one face of the composite frame, is bent around the open end thereof and is cemented to the opposite face of the frame. The thickness of the foil may be of the order of .0005 of an inch. The open ends of the frame as well as the arms of the U-shaped frame has been crimped. Such crimping, indicated by the numerals 27, 27, is for the purpose of increasing the flexibility of the end-fold in the covering which otherwise would be relatively stiff.

The appearance of the completed cartridge is exemplified by Figure 6 of the drawings from which it will be noted that the fold of the metal foil between the free end of the "Bimorph" and the arms of the U-shaped frame has been crimped. Such crimping, indicated by the numerals 27, 27, is for the purpose of increasing the flexibility of the end-fold in the covering which otherwise would be relatively stiff.

A drive link 29 or the like may be clamped around the end of the cartridge to compress the cover-sheet 25 against the blocks 23 affixed to the free corner of the "Bimorph" and to grip the free corner therebetween whereby motion may be transmitted to and from the said free corner without interrupting the continuity of the covering or breaking the hermetic seal afforded thereby. The manner in which the drive rod is clamped, effectively, to the free corner of the crystal may be discerned from Figure 7 of the drawings.

It will be noted from Figure 7 that the small protuberances 11 in a corner receiving socket slightly indent the corner of the "Bimorph" inserted therein. Attention is also called to the fact that the flexible cover sheet 25 is spaced away from the surfaces of the "Bimorph." The surface electrodes of the unit, therefore, need not be insulated nor need the "Bimorph" unit itself be waterproofed unless such water-proofing is desired as additional protection. Furthermore, the metallic covering may be grounded to provide an electrostatic shield for the "Bimorph" or it may, if desired, be electrically connected to either the inner or outer electrode thereof externally or internally of the cartridge. In either event, substantially complete electrostatic shielding of the crystal unit is provided, which is a desirable feature in certain apparatus.

The U-shaped elements of the frame are made from insulating material, preferably hard rubber, "Bakelite" or the like or they may be composed of ceramic material that has a high dielectric constant.

The covering material may be of any suitable metal such, for example, as copper or aluminum, provided it be flexible in the neighborhood of the free end of the crystal and that it have reasonably high tensile strength.

The finished cartridge, either with or without the drive link 29 affixed thereto, may be utilized as a replacement part in apparatus such as microphones, loud-speakers, vibration pickups, oscillographs and the like.

A cartridge constructed according to the invention is water-proof and is quite resistant to rough handling in use. Furthermore, by reason of its flexibility, the covering is free to give to some extent in response to barometric changes and thus to preclude the possibility of rupture. This feature is very desirable because it enables maintenance of the hermetic sealing despite sudden changes in barometric pressure such as are encountered when piezoelectric apparatus is utilized on aircraft.

Also because of the fact that the hermetic seal is maintained despite changes in barometric pressure, the expensive moisture-proofing of the crystal unit itself is not a necessity. This is a very important advantage of the invention.

In addition, the rigidity of the U-shaped frame permits the entire cartridge to be held in place by screws, bolts or the like, in a device such as a microphone or loud-speaker, without imposing the slightest additional strain upon the crystal unit.

The outside foil cover may, if desired, constitute one of the connection terminals of the device. This is an advantage not attained with piezoelectric housing means such as were known previous to the invention.

Although a single specific embodiment of the invention has been shown and described it is not to be inferred that it is limited to housings for piezoelectric "Bimorphs" of the so-called twister type because, while still retaining the advantages secured by the invention, the housing may be suitably modified, without invention, to accommodate crystal sections of other types such as "benders."

It is also believed obvious that numerous other modifications will be apparent to those skilled in the art. The invention, therefore, is not to be limited except insofar as is necessitated by the prior art and by the spirit of the appended claims.

What is claimed is:

1. A housing for a piezoelectric crystal unit, constituted by an open end frame having relieved portions wherein portions of said piezoelectric crystal unit are held, and a covering affixed to both of the opposite faces thereof and extending entirely around the open end to define a closed container.

2. The invention set forth in claim 1, characterized in this, that the covering is flexible in the vicinity of the open end of the frame.

3. The invention set forth in claim 1, characterized in this, that the frame is U-shaped.

4. The invention set forth in claim 1, characterized in this, that the covering is impervious to moisture and that it is sealed to the frame at all points of contact therewith.

5. The invention set forth in claim 1, characterized in this, that the covering is metallic foil.

6. The invention set forth in claim 1, characterized in this, that the frame is made from electrically insulating material.

7. A housing for a piezoelectric unit, comprising a pair of substantially U-shaped elements disposed in matching contact throughout their extent to provide a U-shaped frame, the contacting faces of the elements being provided with a plurality of complementary half-notches, the said half-notches, when mated, being adapted to provide gripping sockets for salient corners of a rectangular piezoelectric unit, and a rectangular piezoelectric unit disposed within the frame, at least two salient corners of said unit being held, respectively, within said sockets.

8. The invention set forth in claim 7, characterized in this, that the faces of the piezoelectric unit, respectively, are disposed below and substantially parallel to the planes defined by the opposite faces of the U-shaped frame, and additionally characterized in this, that a flexible

impervious covering is hermetically sealed to the faces of the frame and across the open end thereof to provide a closed container.

9. The invention set forth in claim 7, characterized in this, that the U-shaped elements are made from electrically insulating material.

10. In combination, a planar piezoelectric unit having a portion adapted to flex upon the application of electrical potential between the faces thereof or adapted to generate electrical potential in response to mechanical flexing thereof, a hermetically sealed container wherein said unit is mounted, the said container having at least two flexible walls spaced away from said unit, and means for conveying mechanical movement through both of said flexible walls of the container to or from the flexible portion of the unit.

11. The invention set forth in claim 7, characterized in this, that the faces of the piezoelectric unit, respectively, are disposed below and substantially parallel to the planes defined by the opposite faces of the U-shaped frame, and additionally characterized in this, that a flexible metallic foil covering is hermetically sealed to the faces of the frame and across the open end thereof to provide a closed container.

12. In combination, a U-shaped frame, a piezoelectric crystal unit mounted within and enclosed by said frame, a free portion of said unit lying intermediate the arms of the frame adjacent the ends thereof, a moistureproof covering affixed to the faces of the frame and extending around the otherwise open end thereof to constitute a closed container, and means, including a part of the covering contiguous to the free portion of the piezoelectric unit, for transmitting mechanical forces between said free portion and exterior of the container.

13. The invention as set forth in claim 1, characterized in this, that the covering is metallic foil and is at all points spaced from said piezoelectric crystal unit.

14. The invention as set forth in claim 1, characterized in this, that said frame includes passageway means for accommodating leads for the crystal unit.

15. The invention as set forth in claim 7, characterized in this, that the flexible impervious covering is metallic foil and is at all points spaced from the said piezoelectric unit.

16. The invention as set forth in claim 12, characterized in this that a portion of the moistureproof covering lying between the frame and the free portion of the piezoelectric unit is crimped to increase the flexibility of the said covering.

17. The invention as set forth in claim 1, characterized in this, that the covering is metallic foil and is grounded to establish the covering as an electrostatic shield for said crystal unit.

18. The invention as set forth in claim 10, characterized in this, that the hermetically sealed container includes electrical insulating portions in contact with said piezoelectric unit and electrical conducting portions insulated from said piezoelectric unit, and that said electrical conducting portions are grounded to establish those portions of the container as an electrostatic shield for said piezoelectric unit.

HARRY B. SHAPIRO.