Aug. 9, 1938. A. L. W. WILLIAMS 2,126,438

PIEZOELECTRIC APPARATUS

Original Filed April 14, 1934

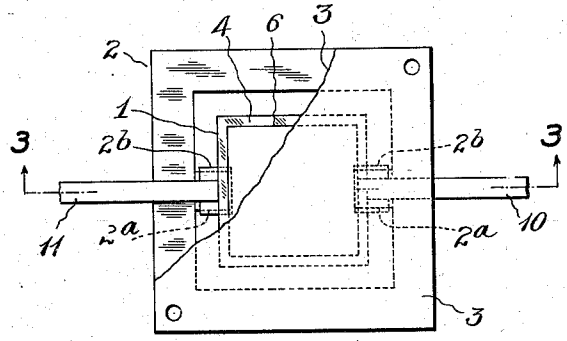


FIG. 1.

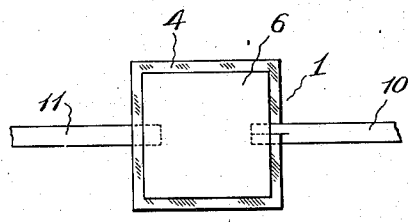


FIG. 4.

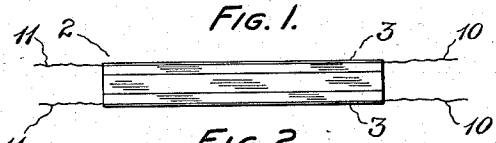


FIG. 2.

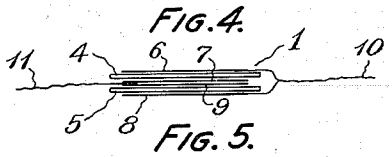


FIG. 5.

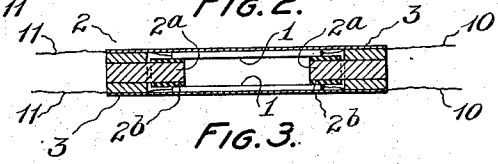


FIG. 3.

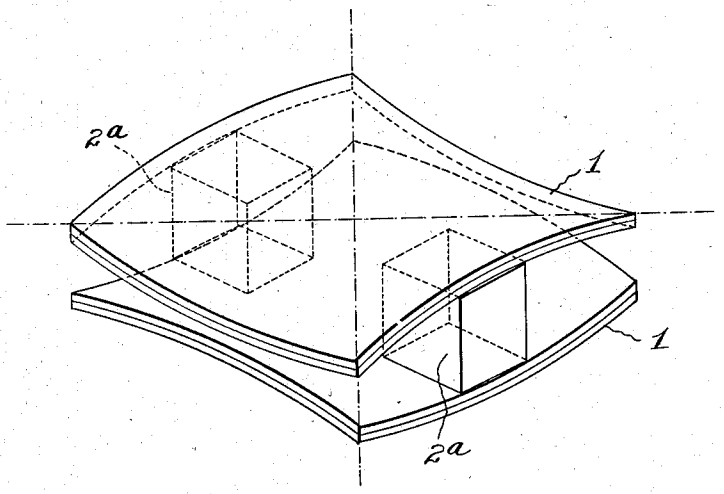


FIG. 6.

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PIEZOELECTRIC APPARATUS

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Original application April 14, 1934, Serial No. 720,593. Divided and this application August 9, 1937, Serial No. 158,044

7 Claims. (Cl. 171—327)

This invention relates to piezo-electric devices for conversion of mechanical into electrical energy or vice versa, and particularly to such devices employing crystal units of the flexing type, such, for example, as are disclosed in United States Letters Patent Reissue No. 20,680 and Reissue No. 20,213. The present application is a division of my copending application Serial No. 720,593, filed April 14, 1934.

One object of the invention is to provide an improved piezo-electric device of the type in which the flexible crystal unit acts as a diaphragm to coact with the surrounding medium and in which an improved type of support is provided for the crystal unit or units.

Another object of the invention is to provide an improved piezo-electric microphone having the advantages of faithful and non-directional response, insensitiveness to mechanical shock, relatively small size and light weight, and simple and rugged construction.

Other objects of the invention, more or less incidental or ancillary to the other objects stated, will appear from the following specification describing a preferred embodiment of the invention.

In the drawing,

Fig. 1 is an enlarged plan view of a microphone embodying my improvements.

Fig. 2 is an enlarged side or edge elevation of the microphone.

Fig. 3 is a section on the line 3—3 of Fig. 1.

Fig. 4 is an enlarged plan view of one of the crystal units of the microphone.

Fig. 5 is an enlarged side or edge elevation of the said unit with the parts separated enough to show more clearly the construction.

Fig. 6 is a diagram showing in enlarged perspective the crystal units of the microphone and illustrating the manner in which the units flex in operation.

Referring in detail to the construction illustrated in the drawing, a pair of crystal units 1, 1 are mounted in parallel spaced relation in a frame-like support designated in its entirety by 2. This support is preferably formed of a material such as Bakelite and is provided with two inwardly projecting lugs 2*a*, 2*a* for the support of the crystal units 1, 1. The frame can conveniently be formed in three parts, as shown in Fig. 3 by stamping the parts from sheet material, the middle part being formed with the lugs 2*a*, 2*a*. The two crystal units are secured in position on the lugs by elastic cement at 2*b* and by sheets 3, 3 of suitable material, such as thin paper, which are cemented to the faces of the crystal units and to the top and bottom faces of the supports 2.

As best shown in Figs. 4 and 5, each crystal unit consists of two plate-like elements 4 and 5, the plate 4 having metal foil electrodes 6 and 7 cemented on its outer and inner faces, respectively, and the plate 5 having electrodes 8 and 9 cemented on its outer and inner faces, respectively. The two plates thus formed are cemented together and leads 10 and 11 are brought out from the outer and inner electrodes, respectively. The crystal plates 4 and 5 are formed parallel to the plane of the *b* and *c* axes of the crystal with the sides or edges of the plates disposed at 45 degrees to said *b* and *c* axes. Thus it will be seen that the crystal units are supported by the microphone frame or support at two points at the opposite ends of an axis of expansion and contraction.

In the operation of the microphone sound waves or other mechanical impulses in the surrounding medium acting upon the sides of the microphone result in a flexing of the crystal units with resultant generation of electromotive forces at their electrodes and such electromotive forces may be conducted away to actuate loudspeakers or to perform other functions.

In practice it is convenient to connect leads 10, 10 together and leads 11, 11 together, each junction constituting one terminal of the unit. The units may, however, as will readily be understood, be connected in series. In either case the units 1, 1 must be so oriented that their electrical impulses reinforce each other when the units are simultaneously flexed toward or away from each other by fluid medium impulses.

The paper sheets 3, 3, together with frame 2, shield the inner faces of the crystal units, thus effectively preventing the mechanical impulses of the surrounding medium from acting on the inner faces.

With the crystal units 1, 1 locally supported by the lugs 2*a*, 2*a*, impulses or pressure variations of the fluid medium surrounding the microphone cause the crystal units to flex in a double curvature or what may be termed "saddle form." This double curvature is illustrated in exaggerated form in Fig. 6, which is an enlarged diagrammatic representation of the crystal units 1, 1, and the lugs 2*a*, 2*a*, the remainder of the frame 2 and the paper sheets 3, 3 omitted. The crystal units are shown as flexed toward each other to indicate the effect of an increase in fluid medium pressure. This double curvature of

the units, resulting from the application of distributed forces of the fluid medium on one face of each unit, sets up strains in the individual plates 4 and 5 of each unit in the proper direction for maximum piezo-electric response, i. e., expansion along one axis of expansion and contraction, and simultaneous contraction along the other axis of expansion and contraction. Conversely, if a potential is applied to the terminals of the microphone the units 1, 1 flex in double curvature or "saddle form" and all unsupported points of one unit are displaced in the same direction substantially perpendicular to the faces of the unit while all unsupported points of the other unit are similarly displaced in the opposite direction.

Thus it can be seen that by my invention I have provided a piezo-electric device for converting mechanical impulses of a fluid medium into electrical impulses, and vice versa, which takes maximum advantage of the piezo-electric action of flexing crystal units composed of Rochelle salt or similar crystalline material.

Due to the efficient use of the piezo-electric action of flexing plate units as above described it is possible to make microphone units of very small size thus reducing the effect of pressure doubling, phase shift, and diaphragm resonance usually encountered in other types of construction. For this reason and because the microphone is a pressure-sensitive device it has very faithful and substantially non-directional response over a wide range of frequencies. For example, a highly satisfactory microphone may be constructed as shown in Figs. 1, 2 and 3 by making the crystal units 1, 1 approximately 3/8" square by 0.030" thick and the remainder of the parts in proportion. A microphone so constructed has substantially uniform response, on open circuit, for frequencies from below audibility to approximately 10,000 cycles with somewhat increased response at higher frequencies reaching a peak at the mechanical resonance of the crystal unit in the neighborhood of 17,000 cycles. Obviously by changing the length, width and thickness of the crystal units the response characteristics can be altered to suit a variety of conditions.

Since the crystal units 1, 1 are so oriented that their electrical impulses combine in additive relation when they are flexed toward or away from each other (under the influence of pressure impulses in the surrounding medium), impulses applied to the units as the result of mechanical vibrations of the frame 2 cause the unit to flex practically simultaneously in the same direction with resultant subtraction of their individual impulses. Thus it will be evident that by my invention I have provided a microphone that is relatively insensitive to mechanical vibrations of the frame such as might be imparted by mechanical shock.

It will be understood that my invention is not limited to the specific form of construction herein illustrated and described and that various features of the invention may take various other forms within the scope of the appended claims.

What I claim is:

1. A piezo-electric device having a flexing type piezo-electric unit, supports for said unit disposed substantially at the ends of an axis of expansion and contraction of said unit and adapted to prevent motion of adjacent portions of said unit normal to the faces of said unit, and means connected to the edges of said unit adapted to shield one of its faces from the surrounding fluid medium and adapted to permit vibratory motion of the unsupported portions of said unit substantially normal to its faces.

2. A piezo-electric device having a cell-like structure comprising a crystal unit which has a plurality of parallel plates of crystalline material with two mutually intersecting major axes of expansion and contraction, the faces of the plates being substantially parallel to the said axes and said unit being adapted to flex under the influence of electrostatic fields; supporting means for the unit disposed to engage it at the two ends of one of the two said major axes to prevent substantial movement of the adjacent parts of the unit normal to its faces while permitting such movement of other parts of the unit; and means serving, in conjunction with the said unit, substantially to enclose a space adjacent the inner face of the crystal unit.

3. A piezo-electric device having a cell-like structure comprising a plurality of crystal units, each of which has a plurality of plates of crystalline material with two mutually intersecting major axes of expansion and contraction, the faces of the plates being substantially parallel to the said axes and said units being adapted to flex under the influence of electrostatic fields; supporting means for each of the units disposed to engage it at the two ends of one of the two said major axes to prevent substantial movement of the adjacent parts of the unit normal to its faces while permitting such movement of other parts of the unit; and means serving, in conjunction with the crystal units, to enclose a space adjacent the inner faces of said units.

4. A piezo-electric device as in claim 3 in which there are two of the crystal units and said units are disposed in substantially parallel spaced relation to each other.

5. A piezo-electric device having a cell-like structure comprising a pair of crystal units each of which has a plurality of plates of crystalline material with two mutually intersecting major axes of expansion and contraction, the faces of the plates being substantially parallel to the said axes and said units being adapted to flex under the influence of electrostatic fields; means engaging the units at the two ends of one of the two said major axes of each unit to space said units apart in parallel relation to each other; and means, including a rigid frame structure, which, in conjunction with the said units, encloses the space between the inner faces thereof.

6. A piezo-electric device comprising a crystal unit which has a plurality of parallel plates of crystalline material with two mutually intersecting major axes of expansion and contraction, the faces of the plates being substantially parallel to the said axes and said unit being adapted to flex under the influence of electrostatic fields; a rigid frame; supporting means for the crystal unit carried by the frame and disposed to engage the unit substantially at the two ends of one of the two said major axes to prevent substantial movement of the adjacent parts of the unit normal to its faces while permitting such movement of other parts of the unit; and flexible means joining the edges of the crystal unit to the frame and serving to prevent passage of the surrounding medium between the edges of the unit and the frame.

7. A piezo-electric device having a cell-like structure comprising a pair of crystal units each of which has a plurality of plates of crystalline

material with two mutually intersecting major axes of expansion and contraction, the faces of the plates being substantially parallel to the said axes and said units being adapted to flex under the influence of electrostatic fields; means engaging the units at the two ends of one of the two said major axes of each unit to space said units apart in parallel relation to each other; and means serving in conjunction with the said units to enclose the space between the inner faces thereof, said means comprising a rigid frame structure and flexible means joining the edges of the crystal units to the frame structure and serving to prevent passage of the surrounding medium between the edges of the units and the frame.

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