Oct. 23, 1928.

A. L. R. ELLIS

1,688,694

PIEZO ELECTRIC DEVICE

Filed July 14, 1925

Fig.1.

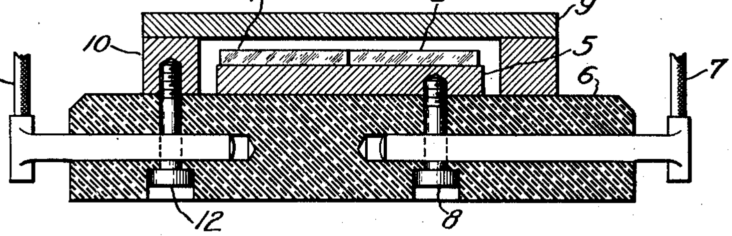


Fig.2.

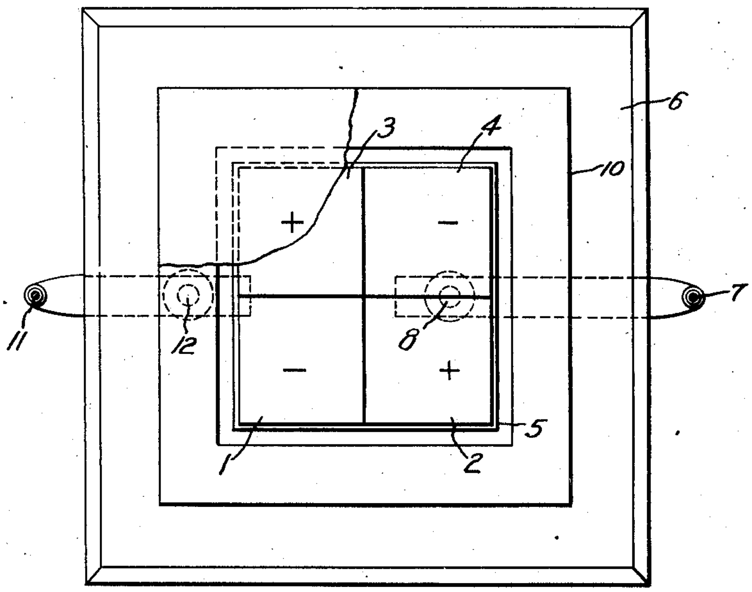


Fig.3.

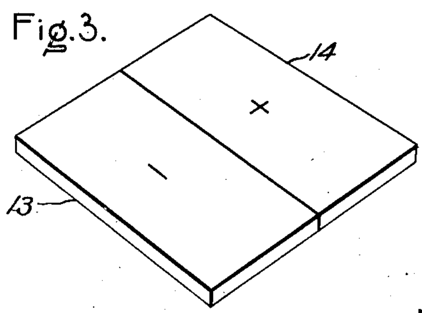


Fig.4.

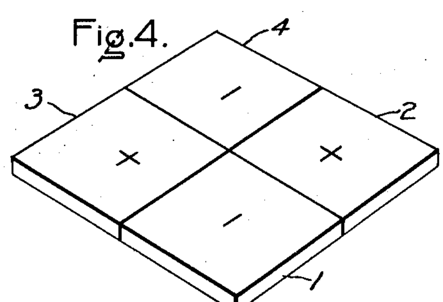
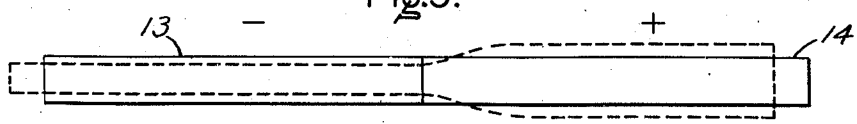


Fig.5.



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by
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UNITED STATES PATENT OFFICE.

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PIEZO-ELECTRIC DEVICE.

Application filed July 14, 1925. Serial No. 43,627.

My invention relates to piezo-electric devices, and has for its principal object the provision of an improved arrangement of parts whereby the free vibration period of a piezo-electric oscillator is maintained substantially constant irrespective of variation in the conditions under which it is operated.

The piezo-electric oscillator comprises a small slab cut from a crystal of quartz or other suitable material in a known relation to its optical and electrical axes. Such a slab is capable of transforming mechanical energy to electrical energy, or vice versa, due to the electrical charges of different polarity produced at the opposite faces of the slab when it is subjected to mechanical stress and to the compression waves set up in the body of the slab when it is subjected to the electrical stress of an alternating electrostatic field. Because of the fact that mechanical resonance in the vibration of the slab is established when the frequency of the alternating electrostatic field, corresponds to the velocity of the compression waves set up in the slab, it is possible to utilize the slab as a means of selecting the frequency at which current is transmitted to or from a circuit. In utilizing the piezo-electric slab for this purpose, however, difficulty is encountered due to the damping effect of the electrodes or supports.

The free vibration period of a piezo-electric oscillator such as a slab or disk of quartz for example, is determined to a large extent by the dimensions of the slab but is affected to some extent by the conditions under which the oscillator is operated. If it were possible to suspend the slab or crystal in air so that it could be made to vibrate freely, a layer of air adjacent the oscillating surfaces of the crystal would vibrate just as though it formed an integral part of the crystal. The resonance frequency of the crystal under these conditions would depend to a large extent on its dimensions and to a lesser extent on the density and elasticity of the air vibrating in unison with the crystal surfaces.

It is of course necessary that the oscillator be provided with some sort of a mounting and it is very desirable that it be protected from dust and moisture by a suitable casing. Variation in the resonance frequency is likely to be produced by change in the position of the casing and slab and by the fact that the casing prevents free movement of the air surrounding the oscillator. These combined effects are not serious at low frequencies but become of great importance at frequencies of a million cycles or more. Utilization of the piezo-electric oscillator is very desirable at these frequencies. Constancy of resonance frequency on these short wave lengths is extremely important for the reason that a variation of less than one per cent may be sufficient to carry the beat note of a heterodyne receiver entirely through the limits of audition, thus rendering the piezo-electric crystal entirely unsatisfactory as a means of frequency control. In accordance with my invention, these difficulties are obviated or minimized by the provision of a piezo-electric slab comprising elements mechanically stressed in opposite directions when subjected to an electrostatic field.

My invention will be better understood from the following description when considered in connection with the accompanying drawings and its scope will be pointed out in the appended claims.

Referring to the drawings, Fig. 1 shows a section of an oscillator constructed in accordance with my invention; Fig. 2 is a plan view of the oscillator wth a part of the cover removed; Figs. 3 and 4 show composite piezo-electric slabs of different constructions; and Fig. 5 indicates the effect of an electrostatic field on the form of a composite slab similar to that illustrated by Fig. 3.

Figs. 1 and 2 show a piezo-electric member comprising crystals 1, 2, 3 and 4 cemented together in reverse relation at their adjacent edges and supported on an electrode 5 which is mounted on an insulation base 6 and is connected to a terminal 7 through means comprising a screw 8. An electrode 9 located adjacent the upper surface of the piezo-electric member is spaced from the insulation base 6 by a conductive wall 10 and is connected to a terminal 11 through means comprising a screw 12, the electrode 9 being shown in Fig. 2 as partly cut away to expose the piezo-electric member and the electrode 5 which are located in the chamber formed by base 6, wall 10 and electrode 9. In order to simplify the drawing, the electrode 9 has been shown as located at some distance from the piezo-electric member or oscillator. It should be understood, however, that in an actual construction the spacing between the electrode 9 and the piezo-electric member is but a few thousandths of an inch. As indicated more clearly in Figs. 3 and 4, the piezo-electric member comprises a plurality of rectangular crystals cemented together in reverse relation at their edges, the expression "reverse relation" is used throughout the specification and claims to mean that the crystals are so arranged that adjacent areas of opposite polarity are exposed to electrodes 5 and 9 when the member is subjected to mechanical stress and mechanical stresses of opposite sense are produced in adjacent crystals when the member is subjected to an alternating electrostatic field. This usually means that, if two crystals are cut from the same block in exactly the same way, one of the crystals must be turned over before the two crystals are cemented together at their edges.

It is generally believed that twinned crystals or slabs, such as those shown in Figs. 3 and 4 will not oscillate when subjected to an alternating electrostatic field. I have found that such a twinned or composite slab is a very active oscillator at a frequency determined by its thickness, especially if its width is two or more times its thickness. While the exact reason for the operation of such an oscillator is not thoroughly understood it is believed to be due to the fact that the electrostatic charge produced by one part of the oscillator preponderates over that produced by the other part of the oscillator.

Fig. 5 indicates the change in form produced by oscillation of a composite slab. It will be observed that when such a slab is caused to oscillate, one of its parts is under compression and contracted while another part adjacent thereto is under tension and extended. Under these conditions, therefore, a minimum change in the length and width of the slab is produced, the damping effect of the supports and ambient air on the vibration of the slabs is greatly reduced, and the resonance frequency or free vibration period of the slab is maintained substantially independent of change in the position of its supports or casing.

The embodiments of the invention illustrated and described herein have been selected for the purpose of clearly setting forth the principles involved. It will be apparent, however, that the invention is susceptible of being further modified to meet the different conditions encountered in its use and I therefore aim to cover by the appended claims all modifications within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. A piezo-electric oscillator comprising a plurality of crystals attached to one another in reverse relation at their adjacent edges.

2. A piezo-electric oscillator comprising a plurality of crystals having their adjacent edges attached to one another in reverse relation whereby mechanical stresses of opposite sense are produced in adjacent crystals when said oscillator is subjected to an alternating electrostatic field.

3. The method of maintaining constancy in the resonance frequency of a piezo-electric oscillator which comprises simultaneously producing mechanical stresses of opposite sense in different parts of said oscillator.

4. The method of maintaining constancy in the resonance frequency of a piezo-electric oscillator which comprises simultaneously producing a compressive stress in one part of said oscillator and producing a tensile stress in another part of said oscillator.

In witness whereof, I have hereunto set my hand this 10th day of July, 1925.

ALVARADO L. R. ELLIS.