Dec. 13, 1938. H. A. CLARKE 2,139,998

APPARATUS FOR MOUNTING PIEZOELECTRIC CRYSTALS

Filed June 30, 1937

FIG. 1.

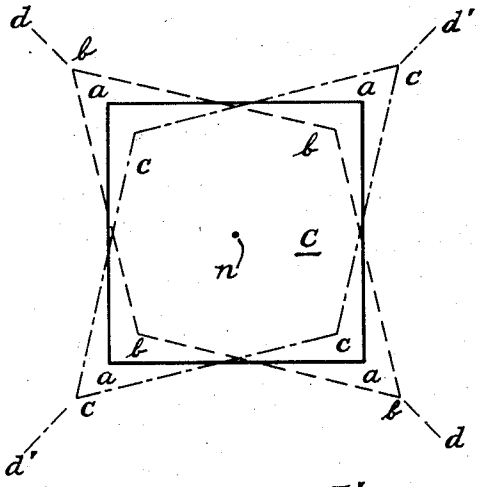


FIG. 2.

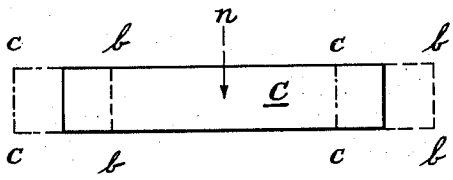


FIG. 3.

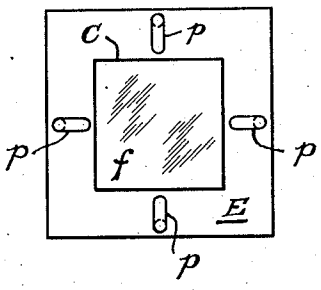


FIG. 4.

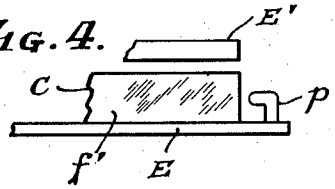


FIG. 5.

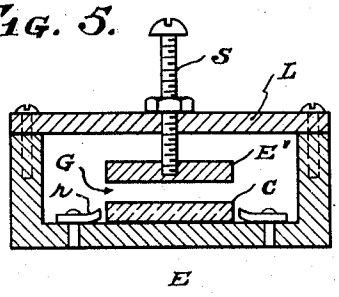


FIG. 6.

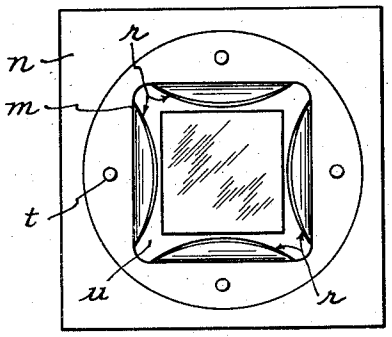
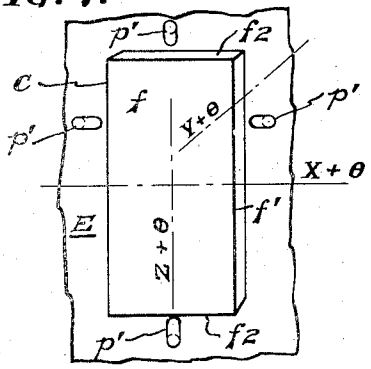


FIG. 7.



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APPARATUS FOR MOUNTING PIEZO-ELECTRIC CRYSTALS

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Application June 30, 1937, Serial No. 151,294

3 Claims. (Cl. 171—327)

This invention relates to the piezo-electric art, particularly to the mounting of quartz oscillators and resonators, and has special reference to the provision of mounting arrangements for "contour-mode crystals" of the type possessing a zero or other low temperature coefficient of frequency.

Bokovoy and Baldwin, in British Patent 457,342 (1936), pages 10 to 12 (U. S. Application Serial No. 71,388, filed March 28, 1936), disclose a method of so cutting piezo-electric "plates" from the mother crystal that the finished elements will possess a natural mode of vibration which is characteristic of the length and/or breadth of the element (i. e., the dimensions, other than thickness). Unlike so-called "thickness-mode" crystal elements and like prior art "contour-mode" elements, such crystals are capable of responding to only relatively low frequencies, say 10 to 1,000 kilocycles per second. Unlike the contour-mode crystals of the prior art, the Bokovoy and Baldwin plate elements are so cut as to exhibit a zero or other low temperature coefficient of frequency.

The above-mentioned desired operating characteristic obviates the necessity for expensive and cumbersome temperature-controlled cabinets and auxiliary apparatus incident to the use thereof. However, the commercial acceptance of these crystals has not been as wide-spread as might be expected because available mounting arrangements, regardless of how satisfactory when used with crystals of other "cuts", will damp and otherwise so affect the oscillating characteristics of "V-cut" crystals that their efficiency may be greatly impaired.

Accordingly, a principal object of the present invention is to provide an improved method and apparatus for mounting low frequency piezo-electric crystal elements and particularly "V-cut contour-mode" crystal elements.

Another object of the invention is to provide a holder permitting optimum performance of piezo-electric crystals of the type described, and this too regardless of the position of the crystal with respect to the horizontal.

Another object of the invention is to provide improvements in air-gap holders for low frequency piezo-electric crystals.

Other objects will be apparent and the invention itself will be best understood by reference to the following specification and to the accompanying drawing, wherein

Figure 1 is a diagrammatic plan view of a "V-cut contour-mode" piezo-electric crystal illustrative of certain of its modes of vibration,

Figure 2 is an elevational view of the crystal of Fig. 1 and further illustrates its modes of vibration,

Figure 3 is a top plan view of the crystal of Fig. 1 mounted in accordance with the invention,

Figure 4 is a fragmentary elevational view showing certain details of the mounting of Figure 3.

Figure 5 is a sectional view of an alternative embodiment of the invention,

Figure 6 is a top plan view of the mount of Figure 5 with the top electrode removed, and

Figure 7 is a front elevational view of a "V-cut contour-mode" crystal mounted in a vertical position and in accordance with the invention.

Quartz crystal elements cut in known ways to respond to a fundamental length-mode, or width-mode frequency have a line of zero movement or "nodal axis" running lengthwise or crosswise of the crystal. Such crystals may be mounted in a holder designed to exert a clamping force between points on opposite ends of the nodal axis without substantially impairing the amplitude or frequency of vibration of the crystal. Thus, Eisenhauer in United States Patent 1,743,028 shows an X-cut width-oscillator having a nodal axis which coincides with the optic (Z-axis) of the crystal, supported on a convex surface which touches the crystal only along a crystallographic (Y-axis) and which is maintained in a holder by a clamping device which exerts its force along the said nodal or Z-axis. This method of mounting can not be successfully employed with the "V-cut" contour-mode crystals of the Bokovoy and Baldwin disclosure for the reason that the line of zero movement in such crystals is along the thickness rather than along the length or width dimension. It would appear that a holder designed to exert a clamping force between the top and bottom electrode surfaces along this nodal axis would be satisfactory in the case of V-cut crystals. Such crystals, however, are extremely sensitive and it has been found that if the clamping surfaces are made large enough to ensure rigidity, excessive damping occurs and, on the other hand, if they are small enough to obviate excessive damping the friction between the clamp and the crystal tends to cut or to "drill" the surface of the vibrating element.

Attempts to mount V-cut contour-mode crystals without clamping pressure as on a flat electrode surface containing pins positioned adjacent the corners of the crystal to limit its movement have also proved unsatisfactory princi-

pally for the reason that in these crystals the maximum movement is adjacent the corners. Further, the usual straight pin rubbing against the sides of the crystal may create sufficient friction to inhibit optimum amplitude of oscillation.

The present invention is predicated upon a proper analysis and appreciation of the manner in which V-cut contour-mode crystals vibrate. These movements are extremely complex but the principal movement may be broadly described as a complete extension and contraction of the physical length of the crystal, measured along each of its principal diagonals, for each full cycle of its fundamental frequency.

This is illustrated in Figs. 1 and 2 wherein the solid lines *a* define a major surface of a square V-cut contour-mode crystal C when it is in the "idle" position, for example, either when not in use or at that moment of zero displacement along its diagonals *d* and *d'*. During one-half of a complete cycle of displacement the crystal expands along one diagonal, say line *d*, and a complementary contraction takes place along the other diagonal *d'*. During the next half cycle the crystal contracts as measured along *d'* and expands as measured along *d*. In Fig. 1 the shape of the crystal at the maximum of its expanding movement along diagonal *d* is indicated by the broken lines, and the shape of the crystal at the maximum expanding movement along diagonal *d'* is shown by the dot-and-dash boundary lines. Similar lines in Fig. 2 represent this movement as viewed along a minor surface of the crystal.

There is a "line of zero movement" or "nodal-axis", here marked N, which extends through the "thickness" or "$Y+\Theta$" dimension from opposite mid-points on the major faces of the crystal. As previously set forth, the prior art dictates the application of clamping force along the nodal axis but experiments with crystals of the type described indicate that clamping force, however applied, inhibits optimum performance and is therefore to be avoided.

The present invention contemplates a method of mounting a piezo-electric crystal without the application of any clamping force, the only force applied to the crystal being a result of its being brought into contact with one or more retaining members which are normally spaced from the edges of the element, but which may contact its minor surfaces at points remote from the corners of the crystal. Thus, referring to Figs. 3 and 4 and assuming the crystal to be mounted horizontally, the retaining members may be constituted of inverted L shape pin-like elements *p* secured to the bottom electrode E and having rounded ends directed inwardly toward, but normally not touching, the central portion of each minor face *f'* of the crystal. Should the crystal be moved against one or more of these retaining members (as by self-vibration, or by tremors of external origin) the restraining force incident to such movement is applied to the crystal in a direction normal to its nodal axis at points remote from the corners. Such manner of mounting permits the crystal to alternately expand and contract along its diagonals, as described in connection with Figs. 1 and 2, and further ensures minimum friction at the actual points of contact.

The necessary second or top electrode, shown at E', Figs. 4 and 5, is preferably circular and may be secured to a screw S to permit of various adjustments of the air-gap G between its surface and the top electrode face of the crystal. In Fig. 5, the crystal C is shown mounted on the base of a metal container which constitutes the bottom electrode. The cover L through which the adjusting screw S extends is of insulating material.

Referring to Figs. 5 and 6, instead of the pins *p*, a single retaining member *m* may be employed. As illustrated, member *m* comprises a metal sheet *n* cut away at its central portion and having rounded edges *r* on the cut-away portion bent inwardly and upwardly and terminating adjacent but not touching the central portions of the minor surfaces of the crystal. As shown in both Figs. 5 and 6, the metal sheet *n* from which the retaining member *m* is cut or stamped may be secured to the bottom electrode as by pins or rivets *t*. Since flanges *r* do not protrude above the surface of the crystal, member *m* may itself constitute the bottom electrode, in which case the central portion *u* is not cut away but forms the surface upon which the crystal rests.

As disclosed by Bokovoy and Baldwin "V-cut contour mode crystals" may be of various shapes. Thus, it is sometimes desirable to provide an oblong crystal, for example, of the length-width ratio shown in Fig. 7. Further, it is sometimes desirable to mount such crystals in a vertical position. While such crystals oscillate in substantially the same manner as described in connection with the square crystals of Figs. 1 to 6, inclusive, it is not always necessary or desirable to position the retaining members adjacent the exact center of the long minor faces *f'* of the blank when it is supported on one of its shorter minor faces *f*[2]. Satisfactory operation is provided when the retaining members, here designated *p'*, are placed no nearer the corners than one-third of the distance between adjacent corners. So mounted, the pins do not lie directly on a line drawn at right angles to the edges of the crystal through the nodal axis; however, the crystal in pivoting on the retaining member upon which it rests has less distance to travel before it reaches one of the side retaining members (and hence will strike it with less force) than would be the case if the retaining pins were positioned exactly at the mid-points of the long minor faces of the crystal.

In Fig. 7 the crystal has been marked to indicate the relative position of its various axes. Here, the long dimension of the crystal blank is along a $Z+\Theta$ axis, the width dimension, along an $X+\Theta$ axis, and the thickness dimension, along a $Y+\Theta$ axis. The long dimension of the crystal may, however, be along the $X+\Theta$ axis and the width along the $Z+\Theta$ axis without necessitating any change in the position of the retaining members.

Various modifications of the invention will suggest themselves to those skilled in the art. It is to be understood, therefore, that the foregoing is to be interpreted as illustrative and not in a limiting sense, except as required by the prior art and by the spirit of the appended claims.

What I claim is:

1. In a device of the class described, an electrode surface, a piezo-electric crystal on said surface, said crystal having a nodal axis normal to its major faces, and means for limiting the range of movement of said crystal, said means comprising a plurality of retaining members nor-

mally spaced from the edges of said crystal and extending from points remote from the corners thereof in a plane normal to said nodal axis.

2. The invention as set forth in claim 1 and wherein said crystal is substantially square and said retaining members are positioned to contact said crystals at points along its edges substantially mid-way between the corners thereof.

3. The invention as set forth in claim 1 wherein said crystal is of oblong contour and said retaining members are respectively positioned to contact said crystal at points no nearer the corners than one third of the distance between adjacent corners.

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