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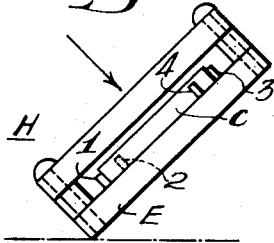
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2,285,143

MOUNTING PIEZOELECTRIC ELEMENTS

Filed Jan. 2, 1940

Fig. 1.



PRIOR ART

Fig. 2.

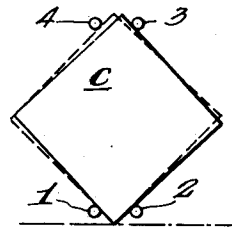


Fig. 4.

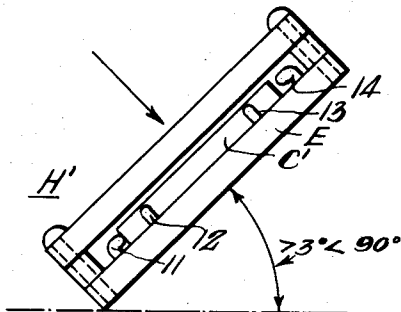
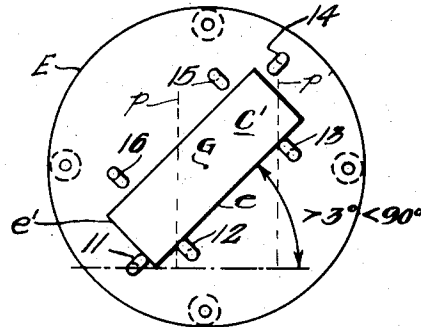


Fig. 3.



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UNITED STATES PATENT OFFICE

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MOUNTING PIEZOELECTRIC ELEMENTS

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9 Claims. (Cl. 171—327)

This invention relates to the piezo-electric art and particularly to the mounting of piezo-electric crystal elements for use as resonators and oscillators.

Recent advances in the art of cutting quartz make it possible to manufacture, commercially, crystal oscillators and resonators having a frequency-characteristic which is constant within ± 10 cycles at any desired "broadcast" or "commercial" frequency. In fact, it now is entirely practical to turn out quartz crystal elements which are accurate to within, say, one cycle per million and this too irrespective of temperature changes over at least a limited range.

The principal impediment to the general adoption of the most rigid standards of accuracy is the practical difficulty incident to the mounting of such nicely cut crystals.

Accordingly, the principal object of the present invention is to provide an improved method and means for mounting a piezo-electric crystal element.

Another and related object of this invention is to provide an improved air-gap mounting which is applicable to both thickness-mode and contour-mode piezo-electric crystals and one wherein the crystal is constrained to remain in or, if accidentally displaced, return to its "normal" position with respect to its retaining pins so that the friction therebetween is of a constant (and hence calculable) minimum value.

Other objects and advantages together with certain details of construction will be apparent and the invention itself will be best understood by reference to the following specification and to the accompanying, wherein:

Figure 1 is a side elevational view of a crystal element mounted in accordance with the prior art in a tilted air-gap holder,

Figure 2 is a plan view, looking in the direction of the arrow, of the crystal and retaining pins of Fig. 1, the crystal being marked with broken lines to visually indicate the problem involved,

Figure 3 is a plan view looking in the direction of the straight arrow of Fig. 4 of a crystal element which has been cut and mounted in accordance with the principle of the present invention, and

Figure 4 is a side elevational view of the crystal of Fig. 3 with the top electrode of the holder in position.

It is now appreciated by those skilled in the art that the ideal crystal-holder would be one wherein there can be no shifting of the crystal

with respect to its electrode or other support and one which at the same time permits perfect freedom of oscillation. Referring to Figs. 1 and 2: In an effort to meet these seemingly contradictory requirements, it has previously been proposed to simply place the crystal C without clamping pressure upon the bottom electrode plate E of a simple air-gap holder H which is provided with retaining pins 1, 2, 3, 4, positioned at spaced points adjacent two diagonally opposite corners of the crystal and to tilt the holder with respect to the horizontal so that there is no pressure upon the crystal but merely the small restraining force incident to the crystal being urged (by gravity) into contact with the lower retaining pins 1 and 2.

It will be observed upon a close inspection of the solid outline of Fig. 2 that in this prior art mounting the edges of the crystal C are in contact not only with the two bottom retaining pins 1 and 2 but also in contact with an upper pin 3. This fact would be of almost negligible moment provided the crystal would remain contiguous this pin 3, but it will not, even during normal operating conditions. Thus, owing either to self-oscillation or to tremors of external origin, the crystal will shift its position so that at one moment it may be vibrating contiguous the pin 3 and at another moment at a point contiguous the pin 4, or at some position intermediate the pins 3 and 4. It is this unpredictable movement of the crystal while oscillating that gives rise to changes in frequency. Such frequency changes may be either in the nature of a "hop" or a "drift" of as much as ten cycles. Another objection to this particular type of mounting and which is encountered most frequently when the crystal is a heavy one and its angle of tilt is large, is that the corners of the element may become wedged between the bottom retaining pins 1 and 2 so that an appreciable damping force is exerted against the crystal.

The above described and other less apparent objections to tilted air-gap mountings are substantially obviated in accordance with the present invention by so arranging the crystal and its retaining members or pins, that the crystal is biased as by gravity in a direction calculated to always urge the crystal into contact with the same retaining pins, and this too in spite of the presence of such counter biasing force as may be generated as an incident to the normal operation of the piezo-electric element.

To this end, referring now to Figs. 3 and 4, a tilted air-gap holder H' is provided as in the

prior art, the angle of tilt of at least the bottom electrode E being less than 90° and more than 3°. In the embodiment of the invention selected for illustration, the bottom electrode is provided with six retaining members which may conveniently be in the form of inverted L-shape pin-like elements 11 to 16, inclusive, similar to those described in U. S. Patent 2,139,998 to Herbert A. Clarke and having inwardly directed rounded and preferably polished ends. At least two of the retaining members, e. g., pins 12 and 13, respectively, are allotted to one side edge *e* of the crystal C' and at least one retaining member, e. g., pin 11, to the adjacent bottom edge *e'*. The other retaining pins 14, 15, and 16 may be spaced in any convenient manner about the other edges of the crystal since their only function is to prevent the crystal from dropping out of its holder if it should be upset in handling.

In accordance with the principle of the invention, the pins 12 and 13 which are allotted to the edge *e* are so spaced with respect to the crystal that they are off-set in different directions from its center of gravity *g*. This is indicated in Fig. 3 wherein a line *p* erected normal to the horizontal and in line with the pin 12 is to the left of the center of gravity *g* of the crystal and a similar line *p'* adjacent the pin 13 is to the right of the said center of gravity. As also indicated in the drawing these pins 12 and 13 should preferably be so arranged that a line drawn between them and parallel to the edge *e'* forms an angle of more than 3° and less than 90° with respect to the horizontal.

When the crystal C' is arranged on the electrode surface E in the manner above described it is apparent that the greater proportion of its weight is to one side (the right) of the bottom retaining pin 12. Thus the crystal will be biased by gravity into contact with all three of the pins 11, 12, and 13. This biasing force is intensified when as shown in Fig. 3, the piezo-electric crystal comprises an oblong element, since in this case an even greater proportion of the weight of the crystal is exerted in the direction of the pins 12 and 13.

It is more or less standard practice to make the supporting electrode surface and the supported crystalline surface as nearly optically flat as possible, with a view to obviating the possibility of the crystal rocking on its support when in operation. To reduce the friction between these two surfaces, it has also been proposed to polish both the crystal surface and the surface of the electrode. This practice is recommended in carrying the present invention into effect. However, it is preferable to provide the crystal surface with a relatively higher polish than that of its supporting electrode, since this modification of the standard practice has been found to reduce the possibility of adhesion between these flat surfaces and also to reduce wearing of the metal incident to the friction between it and the relatively harder quartz surface. To this end the bottom and side surfaces of the crystal are preferably provided with what is known in the art as a "mirror finish," and the electrode surface with a polish which may be defined as a "step or two removed from a mirror finish."

Various other modifications of the invention will suggest themselves to those skilled in the art. Accordingly, 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 is claimed is:

1. In combination, an electrode surface, a piezo-electric element upon said surface, a plurality of spaced retaining members, defining the limits of movement of said element upon said surface, and means for exerting a biasing force upon said crystal in a direction calculated to urge said crystal into contact only with certain selected of said retaining members.

2. The invention as set forth in claim 1 and wherein said biasing force is gravitational in character.

3. The invention as set forth in claim 1 and wherein the intensity of said biasing force is sufficient to maintain said piezo-electric element in contact with said certain selected of said retaining members in spite of the presence of disturbing forces incident to the normal operation of said piezo-electric element.

4. A device of the character described comprising an electrode surface, a piezo-electric element upon said surface, a plurality of spaced retaining members for said element, at least two of said retaining members being mounted adjacent to a common side of said element, said two retaining members being off-set in different directions from the center of gravity of said element and said electrode surface being tilted in a direction calculated to bias said crystal into contact with said two retaining members.

5. The invention as set forth in claim 4 and wherein said piezo-electric element comprises an oblong crystalline body.

6. The invention as set forth in claim 4 and wherein the angle of tilt of said electrode surface is more than 3° and less than 90° with respect to the horizontal.

7. The invention as set forth in claim 4, and wherein a line connecting said two retaining members forms an angle with the horizontal of less than 90° and more than 3°.

8. The invention as set forth in claim 4 and wherein said piezo-electric element comprises an oblong body and said tilted electrode is provided with at least three retaining members against which said element is urged by gravity, at least two of said members being mounted in spaced relation adjacent a common long edge of said element on opposite sides of its center of gravity and at least one of said retaining members being mounted adjacent the bottom short edge of said element.

9. In a device of the character described a quartz piezo-electric element having a polished electrode face, a supporting member having a polished surface contiguous which the polished face of said quartz element is adapted to be moved, said electrode face of said quartz element having a higher polish than the polished surface of said supporting member.

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