Nov. 10, 1942. P. D. GERBER 2,301,269

ART OF MOUNTING PIEZOELECTRIC ELEMENTS

Filed July 1, 1941

Fig. 1.

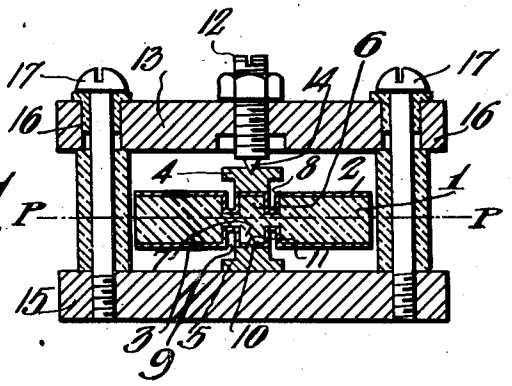


Fig. 2.

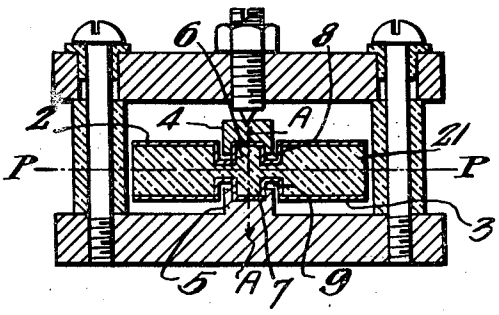
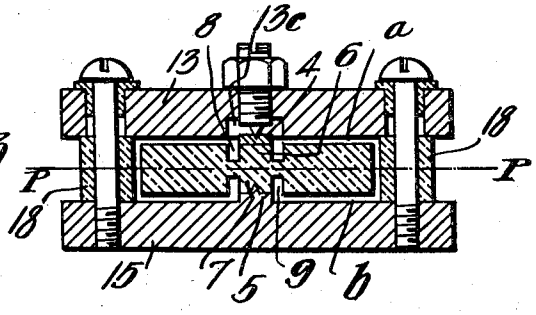


Fig. 3.



Inventor

Paul D. Gerber

By

Attorney

Patented Nov. 10, 1942

2,301,269

UNITED STATES PATENT OFFICE

2,301,269

ART OF MOUNTING PIEZOELECTRIC ELEMENTS

Paul D. Gerber, Woodlynne, N. J., assignor to Radio Corporation of America, a corporation of Delaware

Application July 1, 1941, Serial No. 400,610

10 Claims. (Cl. 171—327)

My present invention relates to the art of mounting piezo-electric crystal elements and, considered from one aspect, constitutes an improvement over the invention described in my copending application Serial No. 348,907, filed July 31, 1940, now U. S. Patent 2,264,692, issued December 2, 1941.

It can be demonstrated that a quartz piezo-electric element of the type that exhibits a shear mode-of vibration has its zone of minimum oscillatory movement in a plane which is centered through all of the minor surfaces of the element. It has previously been recognized that in installations requiring the use of a clamping force it is usually advantageous to apply such force along a nodal plane or along a nodal axis of the crystal element. In an effort to apply this teaching of the prior art to crystals of the shear type, it has previously been proposed to bevel the side edges of the crystal element to a knife edge and to apply the clamping force to the said knife edges. Obviously, when the crystal is operated in such a mounting, it may become fractured or chipped adjacent its thin edges. Of perhaps more importance is the fact that the clamping force in such a mounting is applied to the crystal in the direction or directions in which it vibrates, and the oscillations may, for this reason, be damped to an undesired degree.

The foregoing and other disadvantages inherent in known methods of mounting shear-mode crystals are substantially obviated in accordance with my above identified earlier invention by applying the mounting force to the crystal element adjacent and in a direction normal to its plane of minimum oscillatory movement. In carrying my said earlier invention into effect the opposite electrode or "major" faces of the crystal, or one of them, is provided with one or more cut-away portions which extend into the crystal to a point adjacent its plane of minimum movement, and the clamping, gravitational or other mounting force is applied to the base of the cut-away portion or portions, i. e., in a direction normal to the plane of minimum oscillatory movement of the crystal. In such cases it is desirable that the inner or bottom surfaces of the cut-away part or parts to which the mounting force is applied be substantially flat in order to ensure an even distribution of said force. Since these cut-away parts are quite small and their bottom surfaces are not readily accessible, difficulties may arise in achieving a desired degree of flatness and, in any event the additional surface or surfaces to be lapped contribute materially to the cost of the finished element.

Accordingly, one object of my present invention is to provide a simplified crystal mount of the general character described, and one requiring the minimum work and expense in adapting the crystal to its support.

In the case of crystals of the type wherein the zone of minimum oscillatory movement is along a nodal axis which extends between the major faces of the crystal (instead of along a central nodal plane parallel to said faces) the practice has been to apply the clamping force to the said faces of the crystal adjacent the terminals of its said nodal axis. While such manner of mounting appears to be theoretically ideal, I have observed that as a practical matter the effects of the clamping force are not confined to the nodal axis but operate to damp the vibratory movement of the crystal over a very substantial area surrounding the said axis.

Accordingly, another object of my present invention is to provide an improved mounting arrangement for crystals having a nodal axis and one wherein the damping effects of the clamping force, which is applied along the said axis, are minimized and confined to a limited area about said axis.

The foregoing and other objects are achieved in accordance with my present invention by applying the necessary clamping or other mounting force to the crystal at or adjacent the plane or planes of its electrode faces and by providing the crystal with a relief or groove in the said surfaces surrounding the area or areas to which the mounting force is applied. Thus, I may provide a crystal which is designed to operate in the "thickness, shear-mode" with a relief surrounding the points or areas to which the clamping force is applied and extending inwardly from each of its electrode faces to a plane closely adjacent its central zone of minimum oscillatory movement. In this case though the clamping force is actually applied to the crystal at or on its electrode faces the relief or grooves surrounding the points to which the clamping force is applied prevent the lateral transmission of such force and direct it inwardly to the central plane where its damping effect upon the oscillatory movement is minimum. Similarly, in the case of a crystal designed to operate at a relatively low frequency or "contour, shear-mode" and having its zone of minimum oscillatory movement along a nodal axis which extends between the major faces of the crystal, I provide the crys-

tal with a pair of oppositely located inwardly extending relief areas or grooves surrounding the nodal axis, whereby when the mounting force is applied to the major surfaces of the crystal along its said axis the damping effect incident to the very presence of such force is confined to that limited nodal area of the crystal which is defined by the said grooves.

Certain preferred details of construction together with other objects and advantages will be apparent and my invention itself will be best understood by reference to the following specification and to the accompanying drawing wherein:

Figure 1 is a sectional view showing a metalized quartz crystal having a central nodal plane, said crystal being cut and mounted in accordance with my invention,

Figure 2 is a sectional view showing a metalized node-mounted quartz crystal provided with the pressure relieving means of my invention, and

Figure 3 is a sectional view of a so-called "pressure air-gap mount" embodying my invention.

In Fig. 1, 1 designates generally a quartz piezo-electric crystal element or plate which is provided on its opposite major surfaces with a pair of adherent metal films or coatings 2 and 3, respectively, which comprise the separate electrodes for the device. This crystal 1 when vibrated at a "thickness, shear-mode" frequency has its zone of minimum oscillatory movement in a plane P—P which is centered through all of the minor surfaces of the element. As taught in my earlier filed application, damping is minimized when the force required to mount such a crystal is applied thereto at a point or area adjacent to and in a direction normal to its said plane (P—P) of minimum oscillatory movement. To obtain the same desired effect without the considerable expense of providing the crystal with cut-away portions having flat or finished surfaces against which the clamping or supporting parts bear, I now propose to finish only the outer surfaces of the crystal (prior to the application of its film-like electrodes 2 and 3) and to apply the mounting force to the crystal as through clamping elements 4 and 5 which contact the coated major faces of the crystal at areas 6 and 7 which are circumscribed by relief areas or grooves 8 and 9, respectively. Thus the clamping force though applied to the outer surfaces of the crystal is directed inwardly to the plane of minimum oscillatory movement and cannot spread laterally or outwardly toward the corner zones of maximum oscillatory movement. The diameter of the "risers" 6 and 7 to which the clamping force is applied should preferably be not less than 20 and not more than 90 mils of an inch. Optimum performance was achieved with a 100 kc. contour shear-mode crystal when the clamping force was applied to an area substantially .030 (30 mils) of an inch in diameter.

The grooves or relief areas 8 and 9 may be formed either adjacent the center of the crystal or adjacent its edges as by means of a hollow cylindrical cutting tool, the cutting edge of which has been suitably treated with diamond dust, carborundum or the like.

For the purpose of centering the crystal in its holder one or both of the clamping elements (4, 5) may be provided with a small pin 10 which is adapted to be entered in a recess 11, provided for the purpose, adjacent the center of the surface area to which the clamping force is applied. The clamping force in this case is provided by a screw 12 which is threaded in the top plate 13 of the holder and exerts its clamping force against the upper surface of the clamping element 4. The assembly is rendered "self-leveling" by means of a pin or pointed tip 14 on the leading end of the screw 12. The top plate 13 and bottom plate 15 may be constituted of insulating material, or of metal, in which latter case they may be insulated one from the other as by means of insulating grommets 16 surrounding the studs or screws 17 which maintain them in spaced relation.

The crystal assembly shown in Fig. 2 is very similar to the one shown in Fig. 1. The crystal, which is here designated 21, however, is designed to be operated at a "contour-mode" frequency and has its zone of minimum oscillatory movement along a nodal axis A—A which extends between the major or electrode faces of the element. As in Fig. 1, the electrodes for the crystal comprise a pair of adherent metal films or coatings 2 and 3 and the clamping force is applied to the small surface areas 6 and 7 thereon, which are circumscribed by the pressure relieving grooves 8 and 9. The clamping screw 12 in this case exerts its clamping force on an inverted cup-shaped mounting element 4 which fits snugly about the riser 6 at the center of the crystal, a similar part 5 receives the opposite surface section 8 of the crystal. These cup-shaped elements 4 and 5 serve not only to center the crystal but to prevent its displacement in the event that the holder is subjected to shocks or tremors of external origin.

My invention is not limited in its useful applications to metalized crystals, and in Fig. 3 I show my invention embodied in a more or less conventional pressure air-gap holder wherein the electrodes instead of being in the form of adherent metal coatings comprise the spaced top and bottom plates 13 and 15, respectively, of the holder per se. In this case the underside of the top plate may be cut away as indicated at 13c, to provide a clearance space for the upper mounting element 4 which, as in the previously described embodiments of the invention, exerts its force upon the central area 6 of the crystal (31) which is circumscribed by the relief or groove 8. As is standard practice the depth of the air gaps *a* and *b* between the crystal and its electrodes 13 and 15 is determined by the length of the insulating spacers 18 which separate the said plates.

Various other embodiments and 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.

I claim as my invention:

1. Method of mounting a piezo-electric crystal element which comprises applying a mounting force to said crystal at a limited area on an electrode surface thereof, and forming a relief area in said electrode surface adjacent the area to which said mounting force is applied.

2. Method of mounting a piezo-electric crystal element which comprises applying a clamping force to oppositely located areas on the electrode surfaces thereof, and forming a cut-away relief area on each of said electrode faces surrounding the areas to which said clamping force is applied.

3. The invention as set forth in claim 2 and wherein said crystal is of the type that exhibits a shear-mode of vibration and said clamping force is applied to said crystal in a direction normal to its plane of minimum oscillatory movement.

4. The invention as set forth in claim 2 and wherein the oppositely located areas to which said clamping force is applied surround a nodal axis of said crystal.

5. In combination, a piezo-electric crystal element, means for applying a mounting force to said crystal at a limited area on an electrode surface thereof, and a cut-away relief area on said surface adjacent the area to which said mounting force is applied.

6. In combination, a piezo-electric crystal element, means for applying a clamping force to said crystal at limited aligned areas on opposite faces of said crystal, and a cut-away relief area in each of said opposite crystal faces surrounding the areas to which said clamping force is applied.

7. In combination, a piezo-electric element having a nodal axis, means for applying a mounting force to a face of said crystal adjacent a terminal of said nodal axis, and a cut-away relief area in said crystal face surrounding said terminal of said nodal axis.

8. In combination, a piezo-electric crystal element having a nodal axis, means for applying a clamping force to opposite faces of said crystal adjacent the terminals of said nodal axis, and a cut-away relief area in each of said crystal faces surrounding the nodal areas to which said clamping force is applied.

9. In combination, a piezo-electric crystal element having major and minor faces and having a zone of minimum oscillatory movement adjacent a plane which is centered through all of the said minor faces of said crystal, means for applying a mounting force to a major face of said crystal, and a relief area in said crystal adjacent the area to which said mounting force is applied and extending from said major face to a point adjacent said plane of minimum oscillatory movement.

10. In combination, a piezo-electric crystal element having major and minor faces and having a zone of minimum oscillatory movement adjacent a plane which is centered through all of said minor faces of said crystal, means for applying a clamping force to said crystal at opposite areas on the major surfaces thereof, and a cut-away relief area surrounding each of said clamping areas and extending inwardly from said major faces towards said plane of minimum oscillatory movement.

PAUL D. GERBER.