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G. M. THURSTON

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PIEZO-ELECTRIC CRYSTAL MOUNTING

Filed Aug. 14, 1929

FIG. 1.

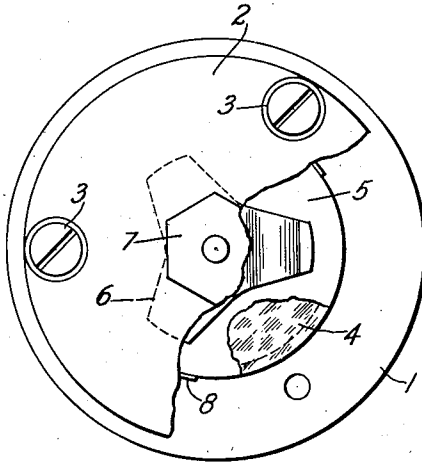


FIG. 2.

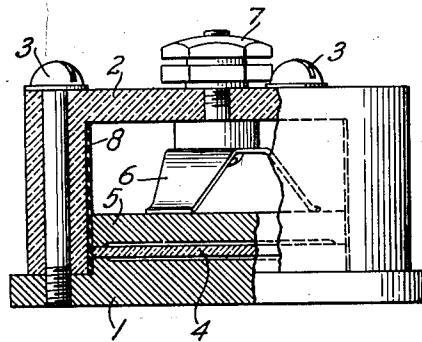


FIG. 3.

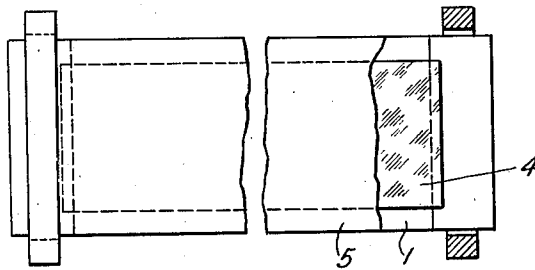
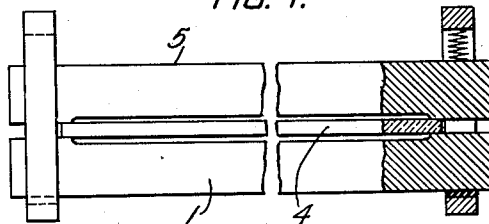


FIG. 4.



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## PIEZO-ELECTRIC CRYSTAL MOUNTING

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This invention relates to the mounting of piezo-electric crystal bodies.

This invention aims to provide a simple, rugged, easily portable, physically stable, mounting for crystal bodies. Since frequency stability is concomitant with physical stability it is a subsidiary object of the invention to provide a mounting for crystal bodies characterized by comparatively great frequency stability under conditions where relative movement of the crystal and its immediately associated structure would tend to promote frequency instability.

The frequency of vibration of crystal bodies is, in addition to other things, a function of the coupling between the vibrating body and the electric circuit. This coupling in turn is a function of the mounting of the crystal body, that is, its position with respect to the electrodes by which connection to the electric circuit is obtained.

In the conventional holders of the prior art in which the crystal body is confined loosely between the electrodes there is a sufficient movement, at the best, to account for frequency changes of the order of 500 cycles per million when the holder is shaken to the extent which would naturally result from use or even from transportation prior to installation. In the use of crystal bodies (for practical purposes a plate-like portion of the natural crystal whose thickness is in general an inverse function of the natural frequency, would be used) in the high frequency, that is, short wave, field that is now becoming popular, this variation would be detrimental to effective use.

In order to fix the position of the crystal body or plate relative to the electrodes, resort has been had to a rigid clamping of the plate at a nodal portion. This has been found practicable where the plate has a conformation of the relatively long bar in which simple longitudinal vibrations in the direction of its length are set up by electrodes placed on its principal faces. A bar vibrating in this manner has quite definite nodal points or lines intermediate its boundaries at which rigid clamping is entirely successful, that is, is not attended by excessive damping.

In the use of crystal plates generally adapted for short wave applications whose frequency is principally determined by the thickness, that is, the dimension parallel to the electrostatic stress, there appears to result complex vibrations composed of longitudinal vibrations in several directions together with vibrations in the shear mode. Under these conditions the vibration pattern at the surfaces of the plate is extremely complex and difficult to interpret, although there appears to be a nodal region in the center of the plate. Mechanical clamps arranged to clamp the plate at the center have been tried without much success on account of mechanical difficulties in so supporting the plate in a fixed position.

Applicant has discovered that along the edges of a rectangular crystal plate normal to the optical axis (the plate being cut, as usual, so that it is parallel to the optical axis), although there is nothing that can accurately be described as a node, there is at least comparative quiescence. Rigid clamping at these parts of the plate has been found effective in stabilizing the frequency without material sacrifice of activity. The frequency has been found to change only slightly on account of the clamping itself.

The above method of clamping has been found effective for high or low frequency plates. For manufacturing reasons circular crystal plates have been found more practicable for high frequencies, that is frequencies of the order of 1,000,000 cycles per second and up. It has been found that crystal plates so cut may be successfully clamped around the periphery, the operating conditions being much the same as in the case of edge-clamped rectangular plates.

The invention will be more fully understood by reference to the following detailed description and claims when taken in connection with the accompanying drawing in which:

Fig. 1 represents in plan a crystal plate mounting of the invention, of the specific form in which the plate is circular and is clamped at the periphery, the holder being

partially broken away to expose the interior elements;

Fig. 2 is a partial sectional elevation of the holder of Fig. 1;

5 And Figs. 3 and 4 are plan and elevation views, partly broken away, of an alternative type of crystal plate mounting in which a rectangular plate is clamped at opposite edges.

10 Referring to Figs. 1 and 2 the metal base plate 1 and cover portion 2 of insulating material are rigidly secured together by screw fastening means 3 to provide a protective housing for the circulatory cut piezo-  
15 electric crystal plate 4 which is stimulated into vibration, as in accordance with now well known principles, by electrodes positioned at opposite faces so as to impose an electrostatic stress thereon. The electrodes,  
20 in the specific form of the device here illustrated are constituted by the base plate 1, on the one hand, and by the plate 5 on the other hand. These electrode members are of course of conductive material. The crystal  
25 plate may conform to any of the conventional types so far as concerns its relations to the natural axes or dimensions of the natural crystal from which it is cut. As in all conventional crystals the cutting is such that  
30 the planes of the principal faces, that is, electrode faces, are parallel with the optical axis of the natural crystal. A circularly cut crystal is illustrated in deference to the fact that for very high frequency, as is here principally contemplated, it is sometimes simpler  
35 from a manufacturing standpoint to cut the crystal in that form, as compared, for example, with the perhaps more usual rectangularly cut crystal plate. The base electrode  
40 may be connected to the circuit with which the crystal plate is associated by a conductor not shown. The upper plate 5 may be connected to such circuit through spring retainer member 6 and its screw fastening  
45 means represented generally by reference 7.

In a practical embodiment of this modification of the invention the cover element 2 is constituted by a material known as Isolantite. The lining member 8 may be used  
50 for the purpose of insuring a close fit between the electrode plate 5 and the cover member. If the cover member were constituted by a material subject to working to make it easily conform to specified size and  
55 shape this lining member could be dispensed with. In the practical case it is constituted by a fiber bushing turned down on the inside to make an accurate fit with the electrode.

60 It should be noted that the two electrodes engage the crystal plate only at the periphery thereof since they are dished in the center so as to leave a relatively narrow and short rim. Furthermore, the crystal plate is rigidly clamped between these electrodes at this  
65 portion, the dimensions and restoring force

of the spring retaining member 6 being such that when the cover and base portions of the holder are rigidly fastened together by screw fastenings 3, the upper electrode 5 is pressed  
70 on to the crystal plate, which abuts the lower electrode, with considerable force. It has been found that if the clamping is made sufficiently rigid to insure an absolute absence of relative movement of the crystal plate and  
75 its immediately associated structure under the stress of operation or of transportation and handling, the frequency will remain stable and the rigid clamping will not be attended by excessive damping, that is, loss  
80 of activity of the crystal plate. Still further the actual clamping of the crystal results in an unsubstantial change of frequency. Slight adjustment of the frequency may be made by changes in the clamping pressure  
85 and/or by shortening of the clamping rim of either electrode so as to change the spacing between the recessed portion of the electrode and the opposed crystal surface. The narrowness of the rim is not critical although for best operation the rims should  
90 clamp the crystal plate over as small an area as possible without danger of crushing the edge of the plate. In the practical case above noted it was approximately one millimeter wide. 95

Figs. 3 and 4 represent, considerably more diagrammatically than in the instance of the modification in Figs. 1 and 2, an adaptation  
100 of the generic principle of the invention to the case of a clamped rectangular crystal plate. The crystal plates are clamped at the parallel edges normal to the optical axis. This is achieved by providing each of the  
105 electrodes 1 and 5 with salient portions which correspond to the peripheral clamping rim of the structure of Figs. 1 and 2. The salient portions on each electrode project from one face of the electrode so that in the assemblage they project inwardly toward the opposite  
110 electrode. These projecting portions are spaced apart on each electrode a distance substantially equal to but slightly less than the dimension of the crystal plate in the direction of its optical axis. This enables them  
115 to engage the marginal portions of the crystal plate and at the same time to keep the electrode out of direct contact with the major portion of the area of the crystal plate. Except as required by the modification of  
120 structure on account of the different shape of crystal plates the crystal plate holder assembly may be the same as is illustrated in Figs. 1 and 2 although, for simplicity, slight differences are to be noted in the illustration. The identifications of the crystal plate and  
125 electrodes, the elements which illustrate the principles of the invention, are the same as those used in these figures. In view of the above pointed out situation no further explanation of this modification is required. 130

What is claimed is:

1. In combination a crystal plate having circular electrode faces, a holder therefor comprising a conductive base portion functioning as one electrode and a cover member of insulating material, an electrode within said holder engaging the plate oppositely to the base portion of the holder, and means between said electrode and the inside top of said cover member cooperating with said base portion to substantially immovably clamp said plate between said electrode and said base portion, said electrode and base portion each having a raised rim-like portion adapted to engage said plate and clamp it at the periphery thereof.

2. A piezo-electric crystal body having opposite faces, electrodes therefor and means including said electrodes for clamping said body to said electrodes along the entire margin of said faces and only at the marginal portions of said faces.

3. In combination, a flat plate of quartz having the planes of its flat faces parallel to the optical axis of the quartz, two similarly shaped electrode plates between which said quartz plate is positioned, at least one of said plates having portions projecting from a face extending toward the face of the adjacent plate and means clamping said plates tightly and holding them rigidly positioned along said projecting portions whereby the remainders of the adjacent faces are held out of contact with each other.

4. In combination, a plate of quartz cut with its face planes parallel to the optical axis of the quartz, similarly shaped flat electrodes adapted to be superposed each on one face of said quartz plate, means engaging opposite marginal portions of said quartz plate to maintain said plate spaced from the flat electrodes over the principal portion of its area, and means clamping the superposed plates along said opposite margins in a rigid assemblage.

5. In combination, a quartz plate, the plane faces of which are parallel to the principal axis of the quartz, electrodes therefor, each of said electrodes having salient portions projecting above one of its electrode faces, said salient portions being spaced apart a distance substantially equal to and slightly less than the dimension of said plate in the direction of its optical axis, and means for clamping said plate between said electrodes with the salient portions of said electrodes engaging said plate at margins of the plate which are substantially normal to the optical axis.

In witness whereof, I hereunto subscribe my name this 9th day of August, 1929.

GEORGE M. THURSTON.